SDB

ON-THE-ROAD DRIVING BEHAVIOR

and

BREATH ALCOHOL CONCENTRATION

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16. Abstract

Unobtrusive measures of nocturnal driving performance were obtained on public highways at 42 rural sites on Thursday, Friday, and Saturday nights from approximately 10:30 P.M. to 3:00 A.M. Special data acquisition and recording systems were developed to obtain analog records of speed and lateral position electronically. The roadside survey team was located approximately one mile downstream from the observation window. An analog record of speed was also obtained near the survey site as drivers were directed to a stop by a law enforcement officer.

The survey team obtained measures of breath alcohol concentration (BAC) from 1,663 motorists, as well as interview data concerning biographical variables, drinking patterns, and driving record. BACs of .10 or higher were found in 4.6% of this 100% sample of the nocturnal weekend driving population.

Interview results confirmed that young male motorists are an important population-at-risk, but older male and female liquor drinkers are also prevalent. A double standard exists regarding attitudes toward beer and liquor, especially among younger males. Driving performance measures indicated that drivers with .08-.149 BAC react with caution to unexpected situations, but are less able to smoothly come to a stop when directed to do so. Legal constraints which affected field activities are described and implications for roadside research are discussed.

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TABLE OF CONTENTS

LIST OF TABLES

Tables in Text

Tables in Appendix D

LIST OF FIGURES

Chapter 1

SUMMARY

"Is the highway driving behavior of motorists with high BACs discriminably different from that of motorists with zero or low BACs?" The present research project was addressed to this question, as well as to whether or not such discriminable differences -- if obtainable -- are also related to the motorist's reported drinking patterns and driving history.

The specific task consisted of devising and testing unobtrusive means of detecting drivers with high breath alcohol concentrations (BAC) while they were actually using the highways. Ideally, the resulting techniques would be amenable to eventual implementation for enforcement purposes. Thus, the present research is aimed at the longer range goal of reducing alcohol-involved crashes on the highways by providing means of improving early on-road detection and intervention with regard to high risk, high BAC drivers.

1.1 BACKGROUND AND RATIONALE

Epidemiologic and experimental studies have provided the two different types of data used as a basis for inferring the contribution of alcohol to highway crashes, i.e., that alcohol degrades a driver's capabilities -- and consequently his actual driving performance -- such that the probability of his being involved in a crash increases enormously as his BAC increases. If this inference is correct, then alcohol-induced changes in driving behavior should be manifest in some fashion; accordingly, they should be amenable to systematic observation and recording. However, few if any empirical data are available to provide direct support for this assumption. That is, no controlled study is known to have been conducted previously to obtain systematic but unobtrusive data on the actual influences of alcohol upon real-world driving behavior in its natural environment. The present study was designed to begin filling this gap.

The background of the basic problem and of the present approach is briefly reviewed in the body of this report in terms of: (1) outlining the dimensions of the problem; (2) examining the epidemiologic evidence, with particular emphasis on roadside research surveys and studies of motorists convicted of driving while intoxicated (DWI); and (3) summarizing the relevant findings from both laboratory and driving experiments involving induced intoxication. However, space limitations here permit only a brief summary of the most important points concerning the dimensions of the problem.

1.1.1 Dimensions of the Problem

In pragmatic terms, the crux of the problem is the acknowledged need for increased efficiency of detecting and identifying alcohol-impaired drivers prior to any crash involvement. The current probability of detection and arrest for DWI in the United States is so low that the perceived risk of being caught for "drunken driving" cannot be expected to function very effectively as a deterrent. The average patrol officer apparently arrests only two drinking drivers for DWI per year. It can be assumed that only one of these two DWI arrests initially came to the attention of the officer as a direct result of his own observation and judgment, whereas the other one came to his attention inadvertently -- by being involved in a crash which the officer subsequently investigated. On the basis of reviewing the few studies concerned with the cues officers use in deciding to stop a suspected DWI driver and the cues they then use in deciding to arrest stopped suspects, it is currently unrealistic to expect police officers to be highly accurate in judging which drivers should be arrested for DWI, even after the drivers have been stopped as a result of erratic driving or having been involved in a crash. Thus, police patrol officers need techniques (including electronic instrumentation systems) that can help them increase the probability of detecting and stopping alcohol-impaired drivers. The availability and use of such techniques would increase their confidence in stopping and arresting for DWI -- in a manner analogous to using radar unobtrusively to obtain and record speed data in order to arrest drivers exceeding the speed limit. Accordingly, in the present project, we have attempted to: (1) validate cues police say they are now using; (2) find other relevant cues the police may not be aware of; (3) determine a possible cluster of cues that in combination would increase the hit rate; and (4) take the first step in devising instrumentation to measure speed and lateral movement unobtrusively.

1.1.2 Objectives

To quote from the work statement in the RFP, "the purpose of this study is to determine the relationship between breath alcohol concentration (BAC) and a driver's behavior in situ, i.e., under actual driving conditions. The major objectives of this study are threefold:

(1) to identify specific driving behaviors that are associated with different levels of BAC that may lead to accidents, as a basis for new countermeasure developments;

(2) to determine the potential for improving the on-the-road detection of intoxicated drivers by the police using visual observation procedures, sensing aids, or automated classification methods; and

(3) as an initial step to assess the utility and validity of existing laboratory and simulator approaches to determining the effects of alcohol on 'real-world' driving behavior.

In an attempt to meet these objectives, our original research plan was designed in terms of the following, very specific requirement in the RFP work statement: this project will involve "observation, from a fixed roadside site, of 'natural' (uninfluenced) driver behaviors and/or driver responses to traffic events (stimuli)". These two types of situations were termed: non-intervention and intervention, respectively.

Data obtained in <u>non-intervention situations</u> which would discriminate the alcohol-impaired driver would have greater utility for the potential user (e.g., law enforcement officers), since the driver's behavior would not have to be manipulated by the observer in order to collect such data. This advantage over intervention situations is appealing both legally and logistically. An electronic system was designed to remotely sense and record speed and lateral movement of cars traversing straight segments of rural roadway for the non-intervention samples of driving behavior.

The <u>intervention situations</u> were more challenging and have higher probable validity and payoff. We had originally designed a number of intervention situations based on the results of experiments which showed alcohol impairment of the ability to divide attention effectively. However, due to the legal developments discussed in the subsection, it became absolutely impossible to use any of these situations on the public highways. Consequently, our closest approximation was the so-called "secondary site" where drivers were directed to stop by a law enforcement officer.

Despite the necessary modifications in our original approach to achieving the three specified objectives, even the less complex non-intervention and intervention situations that we used provided a unique opportunity to conduct extensive developmental research on the basic problem under actual field conditions.

1.1.3 Legalistic and Technical Constraints

A number of changes and limitations on our research design and field procedures were necessitated by two major, unexpected developments during the early phase of the present project (discussed below in section 2.3). These emergent legal problems centered on two issues involving roadside research surveys: (1) concerns regarding the possible invasion of privacy and personal rights; and (2) concerns regarding the authority on which motorists are stopped at "roadblocks" and the basis for any ensuing arrest for DWI. Four aspects of the resulting solution to these legal problems should be mentioned.

First, all vehicles passing through the point of our intended roadside research survey must be stopped, and all such vehicles must be checked for defective equipment. Thus, we were forced to obtain a much larger, 100% sample than we had anticipated.

Second, we were explicitly prohibited from using any manipulated intervention situations that might cause the motorist to overreact. After extensive pilot investigations of the technical feasibility of nocturnal observation of in-car behavior using low level light intensification units (discussed in Appendix A) in conjunction with an intervention stimulus, we were forced to abandon such efforts for technical as well as legalistic reasons.

Third, due to the previous restriction, it became necessary to limit ourselves to the available, observable behaviors of the vehicle. This limitation necessitated obtaining a very large sample of non-intervention behaviors, rather than a small controlled sample of responses to a contrived, but constant intervention situation.

Fourth, it became necessary to take steps to insure privacy and confidentiality of interview information, even if provided voluntarily. One resulting loss was that we could not check the official motor vehicle record of an individual to compare his self-reported driving record with his actual file of crashes and convictions for motor vehicle violations.

Despite these restrictions, reductions, and delays, it was still possible to obtain a usable sample of driving behavior on the actual highways, in conjunction with subsequently obtained interview and BAC data.

1.2 METHODS AND PROCEDURES

The 42 roadside research surveys were conducted on Thursday, Friday, and Saturday nights from 10:00 pm until 3:00 am throughout most of the State of Vermont during the months of July through October in 1974.

The survey sites required a two- to three-mile section of low traffic-flow rural road with relatively straight and level segments at either end separated by a hill or curve. The first straight segment (i.e., the primary site) was visually isolated from the second (i.e., the secondary site) to permit unobtrusive measures of speed and lateral movement before drivers could detect the police and the activities at the interview site. Measures of speed were also recorded at the secondary site as the drivers were directed to a stop by a law enforcement officer. Data obtained at the interview site included a defective equipment check, BAC measures, and responses to an interview questionnaire.

1.2.1 Primary Site Performance Measurement System

The data collection system at the primary site was designed to measure and record both speed and lateral position and to place code pulses on a magnetic tape record to designate the beginning and end of the observation window. These code pulses were computer-compatible and were used during data retrieval operations to start and stop data processing. The sensing equipment had a range of approximately 1,000 feet, with some variation due to environmental conditions.

The primary site system can be described in terms of three subsystems. First, the speed measurement subsystem consists of a doppler radar antenna, electronic circuitry to amplify the signal, and a four-channel FM magnetic tape instrumentation recorder. The second subsystem consists of electronic circuitry which integrates the radar signal to determine a car's distance from the radar antenna and forms code pulses which were recorded on another channel of the magnetic tape. The third subsystem includes a video camera, electronic circuitry for converting the video signal to an analog voltage representing lateral position, the FM magnetic tape recorder for storing this signal, and a video tape recorder for recording the video image.

1.2.2 Secondary Site Performance Measurement System

The data recording system for secondary site performance measures is considerably simpler than that needed at the primary site. The performance measures of interest here were speed and speed change as drivers came to a halt near the law enforcement officer.

As at the primary site, a doppler radar antenna was used to measure speed. Since the maximum range at the secondary site was only about 500 feet, no signal amplification was required and the signal could be recorded on a standard cassette tape recorder.

Code pulsing was not used on these data records. Rather, the necessary code pulses were computer-entered manually as the speed signal was processed by the PDP-12 computer.

1.2.3 Breath Testing and Interviewing Procedures

Two interview forms and two breath-testing devices were used to obtain the maximum relevant information in the minimum amount of time and with least inconvenience to the public. Each driver was asked to submit to a breath test on a portable Alcohol Screening Device (ASD) while he was still in his car. He was then asked to enter the interview trailer to complete a "long form" questionnaire (approximately 12 minutes interview time) and another breath test if the trailer was not full or if his initial BAC reading was at or above .08. If the trailer was fully occupied and his BAC was below .08, he was asked to complete a "short form" interview (6 key questions). This procedure allowed us to obtain identifying information and a BAC estimate from all passing motorists. The short questionnaire also afforded an alternative for individuals who were especially adamant or reticent about participating in the survey, and it may have been helpful in keeping the refusal rate relatively low.

1.3 RESULTS

The three categories of data obtained in the present roadside research project are: (1) breath alcohol concentration; (2) interview data; and (3) performance measures. The results summarized below include the following: (1) interview data from the long interview form with particular emphasis on male motorists; (2) results from the performance measures for all motorists with usable data records; and (3) BAC measures from a Breathalyzer test for respondents who participated in the long interview form and BAC measures obtained with the portable ASD for motorists who received the short interview form (for the driving performance measures).

1.3.1 Breath Alcohol Concentration

BAC data were available for 95% of 1,757 motorists stopped. The 94 missing cases include 4.8% who refused the Alcohol Screening Device test at carside, 2.2% who refused to participate in the interview at carside, and 0.3% who refused the Breathalyzer test in the trailer.

Fifty-eight percent of the 1,663 motorists tested had detectable alcohol. A total of 14% had BACs of .05 or higher. Legally impairing BACs of .10 or higher were found in 5% of the motorists, with 1% being at .15 or higher. The two breath alcohol determination methods were compared by means of regression analysis performed on the obtained BAC values. A significant correlation coefficient of .87 was obtained for the two breath testing devices. It was determined that the ASD ratings tended to be higher than the Breathalyzer readings which indicate a consistent trend for the ASD to overestimate the BAC relative to the Breathalyzer. It was concluded that statistically the two devices were virtually identical in their determinations of BAC in the critical mid-region of the scale. However, certain limitations were noted regarding broader application of the prototype ASDs.

1.3.2 Interview Data

The following summary presentation is organized in terms of biographical variables, drinking variables, and driving variables.

1.3.2.1 Biographical Variables

Regarding sex, 79% of all motorists were male, whereas 90% of those who were legally impaired were male. Proportionately more than twice as many males (11%) as females (5%) were found with BACs of .10 or higher.

Regarding age, approximately 20% of the male motorists were aged 20 or younger, 40% were aged 24 or younger, and 60% were aged 29 or younger. The vast majority (80%) of legally impaired male drivers were in their 20's and 30's (29-39 years of age). Impaired female motorists were more often between 30 and 59 years of age.

Regarding marital status, most male motorists were either married or single (91%), but 5% were divorced, 3% were separated, and 1% were widowed. Among those legally impaired, both the divorced and separated categories were proportionately over-represented, with respectively 11% and 10% at .10 or higher. The highest proportion of female motorists also were married or single (79.5%), but 13.1% were divorced, 3.2% were separated, and 3.9% were widowed. Female motorists showed trends of relationships between BAC and marital status which were similar to their male counterparts, but the differences were not statistically significant in this population.

Regarding educational level, no differences between BACs as a function of education level attained were found for male motorists. However, these differences were significant for female motorists. The data suggested that females with relatively low educational levels (0-8 years) and relatively high degrees of educational attainment (college degree or graduate work) had either very low BACs (below .049) or quite high BACs (above .10).

1.3.2.2 Drinking Variables

Three categories of drinking variables are summarized: (1) typical patterns of alcohol use; (2) most recent alcohol use prior to being stopped for the roadside research survey; and (3) knowledge concerning the amount of alcohol considered personally safe to consume prior to driving.

1.3.2.2.1 Typical Patterns of Alcohol Use. When given a choice, beer is clearly the preferred beverage among male motorists. Among legally impaired male motorists, beer drinkers were proportionately over-represented (76%). When examined in terms of age, the proportion who prefer beer is extremely high among the younger drivers (88% for 14-17 year olds and approximately 72% for 18-24 year olds); however, the proportion who prefer beer gradually decreases with increasing age.

Female motorists generally prefer liquor to the other beverages (64%), and this reported beverage preference is supported by the amounts and frequencies of each of these beverages which females reported drinking. The frequency and quantity of consuming usual amounts of beer and more than usual amounts of beer were not indicative of measured BACs for female motorists. However, the data indicated that female respondents who report usually consuming three shots or more of liquor or who drink their usual amounts of liquor once a week or more tend to have higher BACs.

Regarding beer consumption for male motorists, there was a tendency for the proportion of legally impaired motorists to increase with increases in the self-reported usual number of bottles consumed. In terms of age, the relatively heavier and more frequent beer consumption is found among the younger male motorists.

Regarding liquor consumption for male motorists, patterns of relations emerge which are generally similar to those described above for beer. It is particularly striking that almost 40% of male motorists who reported drinking more than their usual amounts of liquor at least once a week were legally impaired while driving at the time of our roadside surveys.

1.3.2.2.2 Most Recent Alcohol Use. Regarding the elapsed time since the last drink, 97% of the legally impaired male respondents reported having consumed alcohol during the previous three hours, and 72% reported drinking within the previous hour. Of all those male motorists who reported drinking within the previous hour, 24% were legally impaired. These data suggest the advisability of efforts to increase the elapsed time between drinking and driving, at least for male motorists.

Regarding location at which the last drinking had occurred, nearly half (46%) of legally impaired male drivers had been drinking at a bar. Drinking at a bar was especially prevalent among the 18-29 year old respondents. It was also found that a relatively large proportion of motorists with moderate BACs reported they had been drinking at home prior to being stopped at the survey site. These data were somewhat unexpected since data collection occurred between 10:00 P.M. and 3:00 A.M.

1.3.2.2.3 Knowledge Concerning Alcohol Use and Driving. The data indicated male motorists generally report that they feel they can consume a higher number of bottles of beer than shots of liquor within an hour and still drive safely. Furthermore, those who felt they could drive safely after five or more bottles of beer comprised about half of those who were legally impaired. The strongest believers in this double standard are the younger drivers from age 18 to 29.

1.3.2.3 Driving Variables

One of the most persistent unanswered questions in this general problem area concerns the continued driving at higher BACs after one has been previously convicted of DWI. Regarding self-reported DWI conviction during the previous three years, 11% of male motorists reported having had one or more, and almost 3% reported having two or more. Nevertheless, despite previous punishment and inconvenience for this very behavior, those male drivers with one or more DWI convictions during the previous three years comprised 19% of all those who were legally impaired, and those with two or more DWI convictions comprised 5%. Conversely, among those motorists reporting one or more DWI conviction, 18% were legally impaired, and among those reporting two or more DWI convictions, 20% were legally impaired. In comparison, among those reporting no previous DWI convictions, 10% were legally impaired. Thus, proportionally twice as many male motorists already convicted of at least one DWI violation during the previous three years were actually driving again at BACs of .10 or higher--in violation of the very same DWI law. This striking disproportion is especially discouraging since an intensive alcohol countermeasure program had already been operating in Vermont for approximately three years--the same period of driving history being sampled among these motorists in the present study. The proportional over-representation of those with previous DWI experience may be interpreted as an indication of the ineffectiveness of legal countermeasures, as well as the serious persistence of the misuse of alcohol.

1.3.3 Performance Measures

The results of the analyses of driving performance measures presented a few interesting clues to differences in the driving performance of motorists at different BACs. The measures of lateral position did not result in statistically significant differences among BACs. However, the data did suggest the possibility of individuals at very high BACs (.15 and above) may drive somewhat closer to the centerline. The standard deviation of the lateral position also suggested the motorists in the highest BAC category have greater deviation from that lateral position, but again the data did not reach statistical significance.

Regarding speed while driving through the primary site data observation window, a significant negative correlation was found between the entering speed and BAC while a significant positive correlation was found between the mean speed and BAC. Analyses of standard deviation of speed, maximum speed, time of maximum speed, minimum speed, time of minimum speed, mean acceleration, standard deviation of acceleration, maximum acceleration, time of maximum acceleration, maximum deceleration, and time of maximum deceleration were not significantly correlated with BAC. An analysis of variance test of the entering speed data did not show statistically significant differences among BACs, but the data did exhibit the linear trend suggested by a correlation. Specifically, motorists with no measurable BAC entered the primary site at a mean speed of 50 mph, while motorists with BACs above .10 entered the primary site window at roughly 45 mph.

Analysis of variance performed on the primary site mean speed also did not reach statistical significance, although motorists with .00 BAC drove through the site at an average 46 mph while motorists with BACs of .10 or higher had a mean speed of 49 mph.

The speed and speed change measures obtained at the secondary site observation window showed a slight negative correlation between BAC and mean acceleration, standard deviation of acceleration, and a small positive correlation between BAC and the time at which maximum acceleration occurred (in terms of seconds following the first data acquisition). Significant correlations were not obtained between BAC and secondary site entering speed, maximum acceleration, maximum deceleration, or time of maximum deceleration. Analyses of these performance measures by BAC categories revealed significant differences among BAC categories for standard deviation of acceleration (both positive and negative acceleration), maximum deceleration (or negative acceleration), and mean acceleration.

The data for standard deviation of acceleration indicated that motorists with BACs of .15 and above had the lowest fluctuation in this measure of velocity change. The N for this BAC category was rather small in the final analysis and these data should be considered suggestive rather than conclusive.

The maximum deceleration measure also indicated lower momentary peak G forces for motorists in the highest BAC category. Furthermore, the generated maximum acceleration parameter (momentary peak increase in velocity) indicated a significantly lower level of acceleration for these motorists.

The speed change between primary site and secondary site was also calculated from the performance data. Specifically, the entering speed at secondary site was subtracted from the mean speed at primary site for each motorist. The resulting Ns for these data were unfortunately small, since this calculation required valid primary site speed data and secondary site speed data as well as BAC. The analyses did not show significant differences among BAC categories, but the mean speed difference for motorists in the very important .08 to .149 BAC region suggested that these motorists decreased their speed between primary and secondary site to a much greater extent than did motorists at other BACs.

Taken together, the performance data suggested that motorists with BACs between .08 and .149 entered the primary site observation window at a relatively high speed (perhaps the best indication of their "normal" driving), decreased speed significantly before entering the secondary site (a cautionary response to an unusual situation), and had less smooth stopping behavior than did drivers at other BACs.

INTRODUCTION

"Is the driving behavior of motorists with high BACs discriminably different from that of motorists with zero or low BACs?" The traditional answer is both affirmative and categorical; it also forms the implicit basis upon which most enforcement is accomplished. However, there is increasing reason to believe that this traditional answer reflects an oversimplification of the problem. For example, not all high BAC drivers necessarily manifest discriminably deviant behaviors, especially if they are aware of being observed by the police. Furthermore, enforcement officers do not always use the same criteria for surveillance, detection, and identification of high BAC drivers, with the consequence that many go unapprehended. Finally, a patrol officer is relatively limited in his opportunities to observe deviant driving since the single most successful method consists of following a potential violator for a while, a procedure which is costly and inefficient in terms of the magnitude of the problem because the officer can follow only one or two cars at a time.

The present research project was addressed to this question. The specific task consisted of devising and testing unobtrusive means of detecting high BAC drivers while they were actually using the highways. Ideally, the resulting techniques would be amenable to eventual implementation for enforcement purposes. Thus, the present research is aimed at the longer range goal of reducing alcohol-involved crashes on the highways by providing means of improving early on-road detection and intervention with regard to high risk, high BAC drivers.

2.1 BACKGROUND

The contribution of alcohol to highway crashes has been inferred from two different types of data: epidemiologic and experimental. On the one side, alcohol has been seriously implicated in fatal and serious injury crashes -- after the fact -- by epidemiologic studies (recently reviewed by Carr, Borkenstein, Perrine, Van Berkom, & Voas, 1974; Hurst, 1973, 1974; Perrine, 1974a, 1975; Stroh, 1972, 1974; and Zylman, 1971, 1974). On the other side, influences of alcohol upon driving and driving-related behavior have been systematically observed using experimental subjects performing contrived psychophysical, sensory-motor, and driving tasks in laboratories and on driving ranges (reviewed recently by Barry, 1973, 1974; Huntley, 1973a, 1974a; Moskowitz, 1973b, 1974; and Perrine, 1973a, 1974d, 1974e). From these epidemiologic and experimental studies, it has frequently been inferred that alcohol degrades a driver's capabilities -- and consequently his actual driving performance -- such that the probability of his being involved in a crash is greatly increased.

If the assumption is correct that alcohol does degrade a driver's capabilities and performance, then alcohol-induced changes in driving behavior should be manifest in some fashion; accordingly, they should be amenable to systematic observation and recording. However, few empirical data are available to provide <u>direct</u> support for this assumption or for the inferential leaps from post hoc epidemiologic sleuthing and from precise experimentation under artificial conditions. That is, no controlled study is known to have been conducted previously to obtain systematic but unobtrusive data on the <u>actual</u> influences of alcohol upon real-world driving behavior in its natural environment. The present study was designed to begin filling this gap.

In the remainder of this subsection, the background of the basic problem -- which is the background for the present approach -- is briefly reviewed. It is organized in terms of: (1) outlining the dimensions of the problem; (2) examining the epidemiologic evidence, with particular emphasis on roadside research surveys and DWI studies; and (3) summarizing the relevant findings from both laboratory and driving experiments involving induced intoxication.

2.1.1 Dimensions of the Problem

In pragmatic terms, the crux of the problem is the acknowledged need for increased efficiency of detecting and identifying alcohol-impaired drivers <u>prior</u> to any crash involvement. It is generally and non-critically recognized that through no fault of their own, the traditional procedures used by police are inaccurate and inadequate -- and therefore are inefficient and very costly. This point is sufficiently important, sensitive, and germane to warrant a brief summary of the widely scattered data concerning the dimensions of the basic real-world problem. These data are organized below in accordance with the nature of the problem, that is, beginning with the incidence of alcohol-impaired drivers in the population-at-risk and the probability of detection, then following the usual sequence of necessary decisions from initial detection, and contact, to the decision of whether or not to arrest.

2.1.1.1 The Probability of Detection and Arrest for DWI

Most states now have DWI legislation based on the assumption that a person is too impaired to drive safely if his BAC is .10 or higher. In terms of absolute numbers, Borkenstein (1968) has estimated that legally impaired motorists comprise approximately 78 out of 10,000 drivers on the road. In proportional terms, candidates for a DWI conviction are estimated to comprise from 0.5% to 10% of the driving population-at-risk, depending upon the particular circumstances, but are generally accepted to comprise between 2 and 3%, on the average. However, only a very small number of these DWI candidates are ever actually identified and arrested. Borkenstein (1968) surveyed 100 police jurisdictions throughout the U.S. and found that on the average, these patrol officers arrest "only" two drinking drivers for DWI per year per officer. At this rate, Borkenstein estimates that the frequency of DWI violations ("drivings at BACs of .10% or higher") is 2,000 for each arrest.

A recent attempt to estimate the probability of arrest for DWI is based upon a police-patrol experiment and a roadside BAC survey conducted in Kansas City (Beitel, Sharp, & Glauz, 1975). Using Bayesian theory, a well designed sampling schedule, and a specified patrol route on two 4-lane, two-way through streets with high traffic volumes, the investigators determined that the probability of arrest with a BAC of .10 or higher was .0058 (or about 1 in 200). However, the probability of being arrested for drunken driving increased to approximately .01 (1 in 100) using only the data from the four (out of seven) officers who made all but one of the DWI arrests. The highest observed probability of arrest for DWI was approximately .02 (1 in 50), occurring at the BAC class interval of .20 to .24. By contrast, the probability of being arrested for DWI with a

BAC of .04 or less was only about 1 in 100,000. As the authors have noted, "since these probabilities are predicated on passing a police officer who is also watching for a drunken driver, the threat of apprehension in general is actually much less (Beitel et al., 1975, p. 114)." Taken in conjunction with Borkenstein's (1968) survey of police jurisdictions, it is clear that the perceived risk of being caught for "drunken driving" cannot be expected to function very effectively as a deterrent.

2.1.1.2 The Reasons for Police Contact

The next question concerns the basis upon which the one DWI arrested is selected from the 2,000 DWI candidates, in Borkenstein's (1968) terms. Motorists who have been convicted of DWI comprise a group of rather mixed composition in terms of the reasons they initially drew the attention of the police. The three major reasons are: (1) self-selection, by being involved in a crash which is investigated at the scene; (2) police initiative, based upon observation of deviant or erratic driving by an officer; and (3) citizen initiative, in which a third party civilian reports the driver to the police. Crash involvement led to about one-third of the DWI arrests in several studies of the urban-suburban experience (Hyman, 1968b; Shupe & Pfau, 1966), as opposed to almost half (47%) of DWI arrests in a study of rural experience (Perrine, Waller, & Harris, 1971). Erratic driving led to the overwhelming majority (58%) of arrests in the large-sample urban study (Shupe & Pfau, 1966), as opposed to 44% in our rural study. Complaints filed with the police by another citizen led to 9% of DWI arrests in our study (Perrine et al., 1971). Thus, by extrapolating from the Borkenstein survey and from the Perrine, Waller, and Harris study, we can assume that only about one of the two DWI arrests per year per officer initially came to the attention of the officer as a direct result of his own observation and judgment.

2.1.1.3 The Cues for Stopping Suspects

The next question is of particular relevance for the present research: "On the basis of what observed cues or information does the patrol officer decide to stop a driver for a potential DWI arrest?"

Traditionally, officers use some combination of the deviations from normal driving behavior listed in "The Drinking Driver" manual of the California Highway Patrol (e.g., driving unreasonably fast or unreasonably slow, driving in spurts of speed, frequent lane changing with excessive speed, improper passing, overcontrol in passing, driving too close to edge of road, approaching signals unreasonably fast or slow, stopping or attempting to stop with uneven motion, etc.). However the hit rate using these cues in rural traffic is very low. For example, Waller (1971) estimates that even in the Vermont ASAP, which had an intensified enforcement program, officers could only identify 1 out of 10 deviant drivers correctly based upon observation or from following the car for about half a mile. And even though the specially trained ASAP troopers were averaging one arrest for every 42 hours of patrol time, Waller estimates that they were only arresting 1 out of 200 impaired drivers who were going by them. Therefore, even with an average of one arrest per 42 hours, the remaining 199 impaired drivers were still proceeding at an elevated risk of crashing.

Although conducted under vastly different circumstances involving *high flow urban traffic*, the patrol officers in the Kansas City study (Beitel et al., 1975) made 116 vehicle checks for suspected drunken driving (nearly one per hour in addition to the 22 DWI arrests). Of the vehicles manifesting erratic behavior, 16% were driven by a legally impaired driver, whereas the investigators estimated that only 6% of the observed drivers had BACs of .10% or higher. The investigators therefore inferred that "a drunken driver is about 3 times as likely to display erratic driving behavior as a sober driver (or, at least, one not subsequently placed under arrest for DUI)" (Beitel et al., 1975, p. 115).

One of the major goals of the present research is to provide information and means to aid in reducing the number of previously undetected drivers who are at elevated BACs and risk of crashing, especially in low traffic-flow areas.

2.1.1.4 The Cues for Arresting Stopped Suspects

The next question concerns the accuracy of identifying the alcohol-impaired driver once he is stopped, either by the police for observed deviant driving or by his having been involved in a crash which is investigated at the scene. "What is the likelihood that such a driver will then be correctly identified and arrested for DWI?" (Since the use of pre-arrest alcohol screening devices is permitted in only a few U.S. jurisdictions, their utility in aiding the officer in deciding whether or not to arrest the stopped motorist is excluded from the present discussion.) First, regarding crash involvement, those drivers who are actually arrested for DWI must represent a relatively small proportion of all drivers who had been drinking and were involved in investigated crashes since several studies have found substantial underreporting of alcohol involvement by the police (e.g., Goldberg, 1951; Waller, 1971).

Even when special attention is focused upon identifying intoxicated drivers by use of clinical signs, accuracy is usually less than would be expected by chance. For example, in tests of 100 individuals accused of DWI, Laves (1955) found that among those with BACs of .10 to .15, slightly more than half swayed perceptibly in the Romberg test, but less than 25% showed changes in any of his other measures of motor performance. However, an even smaller degree of success was reported by Prag (1953) on the basis of another 100 persons charged with DWI; he reported no indications of swaying in the Romberg test at BACs below .20. Little improvement over a chance level of correctness has been reported for other neuromuscular tasks (such as finger-to-finger, finger-to-nose, picking up small objects, walking under observation) until BACs in excess of .20 are reached; and far fewer than 1% of drivers tested at roadblocks have been found in this higher BAC range (Borkenstein, Crowther, Shumate, Ziel, & Zylman, 1964; Carlson, Chapman, Clark, Filkins, & Wolfe, 1971; Perrine et al., 1971). Even the highly trained physicians in Coldwell's study (1957) were unable to achieve the chance level of correct identification when observing behavior on the clinical tests only; whereas combined observation of performance on the clinical tests and on driving a gymkhana were necessary for the physician to reach approximately two-thirds accuracy.

There is reason to believe that experience in using various clinical signs as tests of alcohol impairment is more effective in Finland, as indicated by several recent large scale studies by Penttilä and his associates (Penttilä & Tenhu, 1971; Penttilä, Tenhu, & Kataja, 1972a, 1972b). On the basis of 16 relatively standard clinical observations and measurements obtained in almost 7,000 cases by trained physicians, these investigators determined high positive correlations between BACs and the Romberg sway test with eyes closed and to a lesser degree with eyes open, as well as a walking test with eyes closed. In addition, the Romberg with eyes closed was apparently successful in identifying about 75% of "intoxicated drivers." However, as the investigators themselves have indicated, there is reason to believe that the trained physicians may well have biased their judgment of intoxication since they knew in all cases that the police had already performed examinations of their own before referring the suspected drunken drivers to the physician for further testing. It should also be noted that the highest correlation coefficient obtained was only 0.48, but it was highly significant statistically with such a large sample.

The results of these kinds of studies indicate that it is currently unrealistic to expect police officers to be highly accurate in judging which drivers should be arrested for DWI, even after the drivers have been stopped as a result of erratic driving or having been involved in a crash. In fact, there is evidence that the officers themselves realize these limitations and respond accordingly. For example, only 20% of convicted DWIs in the Perrine, Waller, and Harris study fell in the lowest BAC category of presumptive impairment (.10 to .15), whereas 54% of all legally impaired drivers tested at the roadside surveys were found to be in this category (Perrine et al., 1971). Considered in conjunction with Borkenstein's (1968) finding that the average officer arrests only two drivers per year for DWI, this relatively low arrest rate probably represents some combination of the officer's inability to detect and then identify impairment correctly (until a very high BAC is reached) and of his reluctance to become involved in one of the most thankless and tedious aspects of highway law enforcement (i.e., processing a DWI charge, especially if a jury trial is requested) unless he has a high degree of certainty that a conviction will result from his efforts. Thus, police patrol officers need techniques (including electronic instrumentation systems) that can help them increase the probability of detecting and stopping alcohol-impaired drivers. The availability and use of such techniques would increase their confidence in stopping and arresting for DWI -- in a manner analogous to using radar as an aid in arresting speeders.

Consideration of the rest of the steps in the chain of events from the decision to arrest the driver for DWI to the outcome of the court proceedings is beyond the scope of the present discussion. However, careful and very detailed investigation of the administration of justice in DWI cases in the State of Vermont during 1969 has been conducted by Little (1972).

From the above discussion concerning the dimensions of the problem, it is clear that anything which will help the police increase initial detection and subsequent identification of alcohol-impaired drivers would represent a necessary and desirable improvement. Accordingly, in the present project, we have attempted to: (1) validate cues police say they are now using; (2) find other relevant cues the police may not be aware of; (3) arrive at a possible "group" of clues that, in combination, would increase the hit rate; and (4) take the first step in devising instrumentation to measure speed and lateral movement unobtrusively.

2.1.2 Epidemiologic Evidence Concerning the Problem

The high manifest concern in Western societies for detecting and identifying the high BAC driver implies that he poses a serious threat of some sort; and indeed he does -- at least in general terms. A number of epidemiologic and field studies thoroughly implicate high BACs in serious highway crashes. Most evidence for inferring this alcohol contribution to highway crashes has been obtained by examining the distribution of BAC either among drivers involved in actual crashes (both fatal and non-fatal) or among drivers using the highways but not involved in crashes at the time (on the basis of roadside surveys). Only those aspects of such studies which are particularly germane to the present research are briefly reviewed in this subsection, namely: the distribution of BAC in the driving population, among fatality crash-involved drivers, and among DWI drivers; and the relation of biographical, driving, and drinking variables to alcohol-involved crashes.

2.1.2.1 The Distribution of BAC

A number of roadside research surveys have been conducted as part of case/control studies since Holcomb's classic study (1938) in Evanston and have ranged across the major types of driving experience in the United States -- from metropolitan areas (e.g., the Manhattan study; McCarroll & Haddon, 1962) and urbanized areas (e.g., the Grand Rapids study; Borkenstein et al., 1964, 1974), to rural areas (e.g., the Vermont study; Perrine et al., 1971). These studies have been recently reviewed by Carr et al. (1974), Hurst (1970, 1973, 1974), Perrine (1974a, 1975), Stroh (1972, 1974), and Zylman (1971, 1974).

Estimates of the BAC distribution in the driving population come from two types of roadside research surveys: case/control studies and non-case/control studies. The estimates obtained from the case/control studies (i.e., the Toronto, Manhattan, Grand Rapids, and Vermont studies) are deliberately biased in favor of non-crash-involved drivers who assumedly have the same exposure as the drivers who crashed at the sites and times which were used to determine the survey points. The non-case/control studies involve survey points which do not necessarily correspond to previous crashes, but rather are selected for other reasons, such as an attempt to describe the driving population in a particular area on the basis of a 24-hour saturation sampling procedure (the Evanston study), or simply to describe the nighttime driving population (e.g., Carlson, 1972). It is noteworthy that for general descriptive purposes, the results from both types of studies are essentially the same: a relatively small proportion of the on-road driving population is found with presumptively impairing BACs, that is, in excess of 0.10.

To the extent that we can generalize from the relevant studies in order to characterize alcohol and the driving population, we can expect that at any give time, between 80 and 90% of drivers have no alcohol, that 5 to 10% have low BACs (.001 to .049), that 3 to 10% have medium BACs (.050 to .099), that 0.5 to 3% have high BACs (.100 to .149), and that up to 1% have extremely high BACs (.150 or higher). Very little detailed information is available about this highest BAC range, primarily because such cases are statistically quite rare. For example, among approximately 1,100 non-involved drivers tested in the Vermont study, only two (0.17%) had BACs in the .200 to .250 range, and none was found above this range. Similarly, among almost 7,600 non-involved drivers tested in the Grand Rapids study, only 4 (0.05%) were in the BAC range from .200 to .250, and none was found above this range.

Regarding alcohol and fatal crashes, the general findings are that about 45% (ranging from 40 to 55%) of all fatally injured drivers have legally impairing BACs (.10 or higher) and that a surprisingly large proportion of these drivers exceed the highest BACs found in the population-at-risk (Filkins, Clark, Rosenblatt, Carlson, Kerlan, & Manson, 1970; Neilson, 1965, 1967; McCarroll & Haddon, 1962; Perrine et al., 1971; Waller, King, Nielson, & Turkel, 1969). More specifically, if we were to construct a composite of all assumedly responsible driver fatalities in non-pedestrian crashes (i.e., all drivers from single-vehicle crashes, as well as from about two-thirds of the multiple-vehicle crashes according to the McCarroll-Haddon classification system), we would find that about 50% were legally impaired with BACs of .10 or higher.

Regarding drivers arrested for DWI, the BAC distributions are strikingly similar in a number of studies conducted in the United States (Beitel et al., 1975; Hyman, 1968b; Perrine et al., 1971; Shupe & Pfau, 1966; Yoder & Moore, 1973). The general findings from these studies is quite clear; the vast majority of drivers arrested for DWI are found to have BACs in the extremely high range (.15 or higher) and therefore can be presumed to have been very "drunk." The average (median) BAC for the arrested DWIs in all but the first study (Beitel et al., 1975) is slightly above .20. An extremely small proportion of arrested DWIs are found with BACs less than the minimum amount for legal impairment (.10), and a relatively small proportion (4 to 18%) are found with BACs in the lower range for legal impairment (.100 to .149). Hyman (1968b) has determined that two-thirds of the DWI drivers were found with BACs between .185 and .280. The highest BACs reported among the DWI drivers in three of these studies was .40. Thus, it is clear that the vast majority of drivers arrested for this particular violation are being appropriately labeled as "driving while intoxicated" or "driving under the influence." It is also clear from the sheer magnitude of the majority of BACs among this group that a large proportion of DWIs must surely qualify as being labeled "problem drinkers" or "alcoholics." This statement becomes even more meaningful when modified by the facts that: (1) DWIs convicted in the lower half of the impairing range (from .100 to .199) tend to be younger, on the average, than those in the upper half (.200 or higher), and (2) that repeat DWI offenders tend to have significantly higher mean BACs (.200) than first offender DWIs (.190) (Yoder & Moore, 1973).

The probability of being involved in a crash has been calculated as a function of BAC distributions by several investigators, notably Hurst (1970, 1973, 1974). Most specialists generally agree that high BACs are associated with high probabilities of being involved in a crash. More specifically, the results of several case/control studies indicate that a person driving with a BAC of .10 or higher is at least six times as likely to be involved in a crash as a person driving with a zero BAC (recently reviewed by Hurst, 1973, 1974; Perrine, 1974a; 1975; and Zylman, 1974). In fact, a case/control study generally conducted on the same roads as the present research found that drivers with a BAC of .10 or higher were at least seven times as likely to be responsible for a fatal crash as drivers with zero or low BACs (Perrine et al., 1971). Furthermore, using the relative hazard curve, Perrine et al. (1971) estimated that a driver with a BAC of .20 (namely the average BAC found among convicted DWIs and among fatally injured drivers who would have been eligible for a DWI conviction) would be at least 100 times more likely to be responsible for a fatal crash than if he had not been drinking at all.

2.1.2.2 Biographical Variables, Crashes, and Alcohol

The personal variables most frequently studied at the epidemiologic level are those which are relatively obvious and/or relatively straightforward and easy to obtain either from official records or from brief interviews. For the same reasons, these variables tend to have the highest potential utility for subsequent administrative and/or countermeasure purposes. The relevant variables tend to fall into three general classes, the first of which is essentially demographic and the second two of which are essentially behavioral: (1) biographical background variables (sex, age, etc.); (2) driving variables (driving history and record, and drinking-and-driving patterns); and (3) drinking variables (in particular, patterns of alcohol use in terms of quantity, frequency, and variability of consumption).

A number of studies have found significant relations between crashes, alcohol, and the following biographical variables: sex, age, marital status, and occupational level. Regarding sex, drinking-and-driving problems are clearly a predominantly male domain. In fact, by contrast to approximately equal representation in the adult population, males are over-represented in most aspects of driving which are relevant for the present project: males comprise a larger proportion of licensed drivers (about two-thirds), a larger proportion of drivers sampled during roadside surveys (about 80%), a larger proportion of fatally injured drivers (about 90%), and virtually all convicted DWIs (about 98%) (Clark, 1972, Clark, Compton, Douglass, & Filkins, 1973; Perrine et al., 1971).

Regarding age, the general finding is that younger drivers with alcohol who get into trouble on the highways do so at lower average BACs than do their middle-aged counterparts (Perrine et al., 1971; Rosenberg, Laessig, & Rawlings, 1974; and Voas, 1974). However, two extremely important additional factors must also be considered, namely, crash involvement and exposure (Carlson, 1973; Zylman, 1973). In fact, Carlson (1973) concludes that the high crash involvement of drivers 16 to 25 years of age corresponds to the high degree of night driving which he feels is the most significant single modifier variable after BAC itself. Thus, the apparent over-representation of youth in the subpopulation of fatally injured drivers -- both with and without alcohol -- is partially attributable to their lifestyle which involves night driving for recreational purposes.

Regarding marital status, married drivers are under-involved in drinking-and-driving problems relative to unmarried drivers (single, divorced, separated, or widowed) when drivers under age 25 are excluded from analysis. Divorced and separated male drivers are especially over-involved in drinking-and-driving problems, as well as in alcohol usage in the nocturnal driving population (Carlson, 1972; Cosper & Mozersky, 1968; Hyman, 1968a, 1968b; Perrine et al., 1971; Zylman, 1968).

Regarding occupational level, several studies have found that drivers from the lower level are over-represented among those who have drinking-and-driving problems, especially DWI convictions. This pattern becomes even more pronounced when younger drivers (under age 25) are excluded from analysis.

A number of studies have found significant relations between alcohol, selected biographical variables, and the following driving variables: previous crashes, citations, suspensions, experience, and exposure. Regarding previous crashes, several investigators have found that drivers with alcohol-related problems (alcoholics, DWIs, and fatally injured drivers with high BACs) have a higher incidence of crashes than random samples of the driving population (Clark, 1972; Filkins et al., 1970; Perrine et al., 1971; Rosenblatt, 1971). Regarding driving convictions, several studies have indicated their utility as a more sensitive measure of deviancy than crashes (Clark, 1972; Filkins et al., 1970; Perrine et al., 1971). Regarding license suspensions, results similar to those for driving citations have been obtained in several studies (e.g., Perrine et al., 1971).

Regarding drinking variables, very few studies are available in which such data were obtained from drivers, especially in conjunction with BAC data. The extent of the drinking pattern information ranges: (1) from quick and simple questions about drinking only on the day of the survey (whether or not; if yes, where and when; e.g., Carlson, 1972; Clark et al., 1973); (2) to studies in which questions were asked about potentially very sensitive alcohol topics (such as, frequency of "getting high" and of exceeding one's capacity, driving after drinking, having alcohol problems, hangovers, and blackouts; Borkenstein et al., 1964, 1974a); and (3) to studies in which very detailed questions were asked about frequency and quantity of usual consumption of the major alcoholic beverage types as well as typical occasions and places of drinking (Perrine, 1971a; Perrine et al., 1971). Reviews and subsequent analyses of some of these studies have been presented by Cosper and Mozersky (1968), Hurst (1973, 1974), and Perrine (1974a, 1975).

The Vermont study (Perrine et al., 1971) is the most relevant for the present project and also contains the most extensive alcohol data for the widest range of the driving spectrum. Furthermore, the Vermont study has the unique advantage of being able to validate aspects of reported drinking patterns by comparing them with actual BACs in samples of driver fatalities, control drivers sampled at roadside surveys, and "clear record" control drivers (also sampled at roadside surveys), as well as DWIs. The QFI (quantity-frequency index) data are most relevant for present purposes; these data were compared and cross-tabulated with selected biographical variables and driving variables, as well as with obtained BACs. However, because of current space limitations, only a brief composite summary across all four samples of drivers is presented here.

One particularly noteworthy finding concerning type of beverage was reported in the Vermont study (Perrine et al., 1971). Frequent and excessive use of beer was highly correlated with BACs of 100 mg% or higher. Thus, relative to fatally injured drivers with no alcohol, over twice as many with high BACs were reported to drink beer daily; and relative to control drivers with no alcohol, almost twice as many with high BACs reported that they drink beer daily. Among those who reportedly drank beer, 67% of DWIs and 80% of fatalities with high BACs were reported to drink it daily.

Regarding QFI and <u>sex</u>, the proportion of males to females increased as quantity and frequency of alcohol consumption increased. Regarding QFI and <u>age</u>, a surprisingly large proportion of the very young (i.e., teenage) drivers could be categorized as heavy and frequent drinkers; and the quantity of alcohol typically consumed apparently decreased with increasing age. Regarding QFI and <u>marital status</u>, the proportion of married drivers decreased significantly as reported alcohol consumption increased. Although no significant differences were observed with <u>occupational level</u>, there was some evidence that drivers with heavy QFIs were more likely to have had a greater number of <u>job changes</u> during the five-year period immediately preceding the interviews.

Regarding QFI and <u>drinking-and-driving patterns</u>, two generalizations were offered as evidence that the BAC sampled at one point in time during the study was a reliable indicator of usual patterns of driving after drinking: (1) the higher the self-reported frequency of driving after drinking, the heavier and more frequent the usual alcohol consumption, and vice versa; and (2) the lighter and less frequent the usual alcohol consumption, the lower the self-reported frequency of driving after drinking, and vice versa.

Regarding QFI and driving patterns, no clear-cut patterns of differences beyond those of the basic distributions were obtained from cross-tabulations of crashes or license suspensions by QFI. However, when convictions for driving violations were cross-tabulated by QFI, substantial deviations from the basic distributions within each sample were found, especially among roadblock control drivers. Specifically, control drivers with higher QFIs tended to have more citations in the previous five years than control drivers with lower QFIs. It was concluded that the number of previous citations was worth further examination as a basis for identifying drivers who may have an elevated likelihood of receiving a DWI or other moving citation.

From the analyses of the alcohol consumption data, it was also concluded that these QFI variables are in fact useful in differentiating across the spectrum of drivers. Further indications of the utility of these variables were provided by the relation of the reported alcohol consumption data (QFI) to the actual consumption data (BACs) and to the driving variables (both self-reported and official record-check information).

Even further evidence of this utility resulted from a discriminant analysis of twelve selected variables. The four variables which were statistically significant in discriminating between the clear-record drivers and the DWI drivers were, in order of importance: (1) the number of convictions for driving violations, (2) occupational level, (3) frequency of beer consumption, and (4) quantity of liquor consumption. On the basis of a discriminant function using these four variables, 95% of the clear-record drivers and 87% of the DWIs could have been correctly classified. Thus, it was possible to determine classification "hits" and "misses" on the basis of a weighted function which incorporated components from an individual's driving record, from his socio-economic status, and from his reported patterns of alcohol use.

2.1.3 Alcohol Experiments on Driving-Related Behavior

In behavioral terms, the basic problem concerns those aspects of driving performance which are differentially impaired by alcohol; more specifically, those alcohol-induced changes in driving behavior which would serve to differentiate motorists with high BACs from motorists with zero or low BACs. In addressing this problem, it is necessary to understand specifically which aspects of driving-related behavior are actually impaired by alcohol. The most dependable information bearing on this question has been obtained from systematic experiments conducted either in the laboratory or on closed-course driving ranges.

Since the present research did not involve experimental manipulation of stimulus conditions, only those aspects of behavior which are most directly and unequivocally related to on-road driving are considered. This task is greatly simplified by the existence of a number of reviews published in recent years, to which the interested reader is referred. By far the most comprehensive review of the alcohol and behavior literature is Wallgren and Barry's two-volume work (1970). An innovative attempt to classify and integrate the research findings concerning alcohol effects upon human performance was published recently by Levine, Greenbaum, and Notkin (1973). Their effort was designed in part to categorize the existing literature into task groups in order to determine whether or not the effects of alcohol differ as a function of different types of tasks. However, of the literature surveys specifically concerned with alcohol experiments and driving-related behavior, the earliest and one of the most extensive was written by Carpenter (1962) and was followed by a more specialized article a few years later (Carpenter, 1968).

In an attempt to remedy the absence of comprehensive up-to-date reviews of the growing body of relevant literature, the "Vermont Symposium on Alcohol, Drugs, and Driving" was conducted in October 1972. One of its specific aims was to provide systematic, evaluative reviews of the eight major aspects of these two problem areas, with each review written by a specialist in that area . Four of these reviews are relevant for the present project. Behavioral aspects assumedly relevant for on-the-road driving performance were divided among three of the specialists. Thus, influences of alcohol upon neurophysiological, neuromuscular, and sensory aspects of behavior were reviewed by Perrine (1973a, 1974e). Moskowitz (1973b, 1974) considered alcohol influences upon sensory-motor aspects of behavior, visual perception, and attention. Barry (1973, 1974) was concerned with alcohol influences upon memory, learning, cognition, motivation, emotion, and mood. The fourth paper was concerned with alcohol influences upon closed-course driving performance (Huntley, 1973b, 1974a). These and some of the other reviews were published in a special issue of the Journal of Safety Research in September 1973, but all the reviews, proceedings, and other material from the Vermont Symposium have recently been published in one volume (Perrine, 1974b). It should also be noted that a review of experiments concerned with alcohol influences upon performance in driving simulators was presented earlier at a related symposium by Heimstra and Struckman (1972). These five papers constitute the immediate background for a very recent survey of alcohol experiments on driving-related behavior published in 1972 and 1973 (Perrine, 1974d).

On the basis of these literature reviews, the following aspects of driving-related behavior appear to be consistently and unequivocally *impaired by alcohol*: compensatory tracking, choice reaction time, and divided attention (or time sharing). Alcohol impairment of these aspects is reflected in the following observable variables: steering reversal, lateral position, speed changes, speeding, and braking. All these variables are directly relevant to the present project, are influenced by alcohol, and have been systematically studied in closed-course experiments (Huntley, 1973a, 1974a). The specific use of these variables is discussed below under the rubric, "performance measures."

2.2 OBJECTIVES

To quote from the work statement in the RFP, "the purpose of this study is to determine the relationship between breath alcohol concentration (BAC) and a driver's behavior in situ, i.e., under actual driving conditions. The major objectives of this study are threefold:

(1) to identify specific driving behaviors that are associated with different levels of BAC that may lead to accidents, as a basis for new countermeasure developments;

(2) to determine the potential for improving the on-the-road detection of intoxicated drivers by the police using visual observation procedures, sensing aids, or automated classification methods; and

(3) as an initial step to assess the utility and validity of existing laboratory and simulator approaches to determining the effects of alcohol on 'real-world' driving behavior."

In an attempt to meet these objectives, our original research plan was designed in terms of the following, very specific requirement in the RFP work statement: This project will involve "observation, from a fixed roadsite, of 'natural' (uninfluenced) driver behaviors and/or driver responses to traffic events (stimuli)." These two types of situations were termed: non-intervention and intervention, respectively.

Data obtained in non-intervention situations which would discriminate the alcohol-impaired driver would have greater utility for the potential user (e.g., law enforcement officers), since the driver's behavior would not have to be manipulated by the observer in order to collect such data. This advantage over intervention situations is appealing both legally and logistically. However, the aspects of behavior which drivers are likely to manifest under such natural, non-manipulated circumstances are limited to those which occur most frequently in the particular setting being investigated. Therefore, they may not include those responses which are especially sensitive to alcohol effects and which are therefore of greatest danger and validity, i.e., responses to unexpected or unfamiliar events (Lovibond & Bird, 1970). Nevertheless, within the constraints of non-intervention format, the likelihood of detecting alcohol-associated impairment can be increased by observing the driver in non-steady state driving situations, such as negotiating a curve or braking for a stop sign. We had originally planned to use the latter for our non-intervention situation, but its use was precluded by subsequent legal and technical developments (discussed in the following subsections). Consequently, we were ultimately reduced to using straight segments of rural roadway for the non-intervention samples of driving behavior (criteria for site selection are discussed below in Chapter 4).

The intervention situations were more challenging; they also have higher probable validity, pay off, and heuristic value. We had originally designed a number of intervention situations based on the results of experiments which showed alcohol impairment of the ability to divide attention effectively. However, for reasons discussed in the next subsection and in Appendix A, it became absolutely impossible to use any of the intervention situations on the public highways. Consequently, the closest approximation of our planned intervention situations was the so-called "secondary site" at which point the motorist encountered the assumedly unexpected (but not unusual) situation in which a state police trooper was signaling him to stop near the police cruiser on which the emergency light was flashing brightly (see Chapters 3 and 4 for further details).

Thus, our original approach to achieving the three specified objectives had to be modified during the course of the present project as a result of unexpected legal and technical problems. Nevertheless, even the less complex non-intervention and intervention situations we were reduced to using provided a unique opportunity to conduct extensive developmental research on the basic problem under actual field conditions.

2.3 LEGALISTIC CONSTRAINTS

Roadside research must be conducted within the framework and constraints of existing laws and highway safety principles. The cooperation and support of the appropriate state and local officials must be obtained well in advance of actual field operations (Borkenstein, Perrine, Van Berkom, & Crowther, 1974b; Carr et al., 1974; and Perrine, 1971a). Accordingly, a number of formal briefings were held for the relevant officials (the names of the most pertinent agencies and/or individuals are cited above in Acknowledgements) in order to provide them with accurate firsthand information concerning the proposed research procedures. In addition, numerous personal visits and telephone discussions were used to maintain liaison and to provide detailed information concerning specific questions raised by a given individual.

Far more attention and effort was necessary to obtain and maintain this liaison and cooperation than in previous projects. It should be noted that the present project was undertaken in an atmosphere increasingly dominated by the public unfolding of the Watergate story -- leading into an election year. Thus, even though enthusiastic verbal assurances of continued support had been obtained from the most relevant officials prior to submitting our proposal in May 1973, it became necessary by fall of 1973 to start an intensive education and persuasion program to enlist official support as we prepared to become operational.

All this unanticipated background and liaison activity apparently became necessary as a result of two major developments. The first was the growing concern regarding the invasion of privacy and personal rights, a concern which was occurring not only here in Vermont, but also throughout the entire nation. Increasing opposition to roadside surveys was apparently developing throughout the country based on the fear that such activities might invade an individual's right to privacy or, at the very least, might constitute undue harassment of the motoring public. We were able to cope with those concerns successfully by assuring the relevant officials that the present project: (1) was being conducted strictly for research purposes, not for enforcement; (2) would not inconvenience motorists to any significant extent; and (3) would enlist the participation of motorists on an explicitly voluntary basis. The latter point was especially important because of mounting concern that no coercion even be implied in an attempt to encourage motorists to participate in the roadside research survey.

The second development resulted from a court case in Vermont stemming from a roadblock conducted by Project CRASH, the Vermont Alcohol Safety Action Program. A motorist who was arrested for DWI during the course of the ASAP roadblock filed a motion to dismiss the DWI charges on the basis of legalistically questionable procedures used in making the arrest. In the resulting court order, the judge ruled that "the 'roadblock' used by the Project CRASH in the instant case was without lawful authority and all evidence seized as a result ought to be suppressed... (and further)... that the arresting officer did not have 'probable cause', to detain or otherwise stop the Respondent's vehicle..." As a result of this ruling in February 1974, there was understandably little enthusiasm for supporting our attempts to conduct roadside research surveys in Vermont.

A number of helpful officials were nevertheless sufficiently interested in the potential merits of our research program to pursue a legal solution to the newly emerged problem. For example, the Commissioner of Motor Vehicles requested an opinion from the Attorney General concerning the legality of arresting for DWI if a roadblock is established for other authorized reasons, such as checking registration and/or defective equipment on all vehicles traveling the highway at the particular time and place. Such a roadblock is specifically authorized by state statute, and therefore would constitute a "proper stop." The opinion eventually issued by the Attorney General's office was in essence that at such a legally authorized roadblock, a stopped motorist could subsequently be arrested for DWI if the law enforcement officer at the scene observed behaviors indicative of alcohol intoxication, even though the motorist had not been stopped initially for precisely that reason. Once these important legal issues had been resolved, we were able to proceed with the roadside survey component of the present project with the full support and cooperation of the necessary state officials. However, the resulting solution to the legal problems forced a number of changes and limitations on our research design and field procedures.

First, all vehicles passing through the point of our intended roadside research survey must be stopped and all such vehicles must be checked for defective equipment. Therefore, it was necessary to establish contact with a much larger sample (indeed, statistically speaking, with a "population") than we had anticipated. One result was the development and use of an abbreviated version of our questionnaire.

Second, we were explicitly prohibited from using any manipulated intervention situations that might cause a motorist to overreact.

Third, since we were forced to abandon the intended manipulation of stimulus conditions necessary for the detailed study of a small number of specific individuals who had received the experimental conditions, it was necessary to limit ourselves to the available, observable behaviors of the vehicle. This limitation necessitated obtaining a very large sample of non-intervention behaviors, rather than a small controlled sample of responses to a contrived, but constant intervention situation.

Fourth, it became necessary to take steps to insure privacy and confidentiality of interview information, even if provided voluntarily. One resulting loss was that we could not check the official motor vehicle record of an individual to obtain his actual driving record of crashes and convictions for motor vehicle violations.

Despite these many restrictions, reductions, and delays, it was still possible to obtain a usable sample of control-use driving behavior on the actual highways, in conjunction with subsequently obtained interview and BAC data.

2.4 TECHNICAL FEASIBILITY OF NOCTURNAL OBSERVATION OF IN-CAR BEHAVIOR

Part of the initial work undertaken in this project was an investigation of methods and instrumentation to obtain data on in-car behavioral differences of drivers at various BACs. It seemed likely that in-car behaviors such as posture, head position, reaction to an off-the-road light stimulus, etc., might indicate different intoxication levels and should be considered as possible clues for detection of DWI. Since data collection was scheduled for the hours of 9:00 pm to 3:00 am, and was to be accomplished "unobtrusively," special methods were needed to record these behaviors.

It was decided that the best way to gather this kind of information was to film individuals as they approached and passed a roadside observation point and then to analyze that filmed record for observable differences between drivers at various BAC levels. Since it was necessary to be completely unobtrusive to the drivers, use of any bright light or standard photographic procedures was precluded. Therefore, a number of special techniques were considered to collect this kind of infomation, including infrared (IR) film, IR light sources, and light intensification units. A thorough investigation of these special techniques and equipment revealed a number of insurmountable problems as explained in Appendix A. Thus, due both to legalistic and technical problems, our desire to obtain measures of in-car driver behaviors had to be abandoned.

Chapter 3

METHODOLOGY

The practical necessity of abandoning the off-the-road light stimulus "intervention" situation and recording in-car driver behavior (see Section 2.3 and Appendix A) were disappointing developments which eliminated aspects of this project felt to be unique and possibly important. Visual observation of lateral position and single measurement of speed were seen as rather paltry returns for the cost and effort necessary to carry out roadside survey research. Therefore, attention was turned to developing a system capable of obtaining analog information on each car's speed and lateral movement and recording these data in computer-compatible form.

3.1 GENERAL APPROACH

Although the controlled stimulus intervention was not possible, it seemed conceptually valid to view the unexpected disruption of normal driving behavior by a law enforcement officer signaling drivers to stop as an intervention situation. Thus, each roadside survey had a built-in intervention component that could be used to obtain performance measures during this unusual highway situation. An analog record of speed change as cars are directed to a stop was an obvious and potentially important measure of interest.

It was also evident that data recording equipment should be used some distance away from and out of sight of the survey area in order to obtain performance measures of "normal" driving behavior in as unobtrusive a manner as possible. Thus, the data collection environment was seen as a two- to three-mile section of road with relatively straight and level segments at either end separated by a hill or curve. This situation would permit measurement of both normal and intervened driving behavior.

Preliminary investigation of traffic radar systems revealed that the signals available from a doppler radar antenna could be recorded on both an FM instrumentation recorder and a relatively inexpensive cassette tape recorder. Furthermore, electronic evaluation of the radar signal indicated that the output contained characteristics possibly indicative of both speed and lateral movement. However, attempts to derive this information from the doppler signals was only partially successful. Telephone consultations with radar manufacturers and electronics experts in branches of the armed services to get their advice on the problem merely evoked comments of no knowledge about the matter or the statement that the requested information was classified. Since neither time nor funds would permit further exploratory work in this regard, attention was turned to using the output of video cameras to obtain lateral movement data.

A notable spinoff of the earlier efforts to couple a videotaping system with a light intensification unit was the determination that the characteristics of silicon diode equipped cameras include excellent sensitivity and lack of ghosting around bright light sources. Investigation also revealed that appropriate circuitry could be developed to obtain lateral movement data from the camera's raster sweep when vehicle taillights were recorded. (A description of equipment design is presented in Section 3.2). Thus, it was apparent that both speed and lateral movement measures could be recorded in real-world environments as indicators of vehicle performance.

Measures were obtained of both normal driving behavior and performance following an unexpected intervention by a law enforcement officer. Normal driving behavior was unobtrusively recorded at locations out of view of the interview site in an observation area which will be referred to as the primary site. Driving behavior which immediately followed the unexpected intervention of normal driving by the officer were recorded in the vicinity of the interview trailer and will be termed secondary site data. Data obtained at the interview site included a defective equipment check, BAC measurements, and responses to an interview questionnaire.

3.2 PERFORMANCE MEASUREMENT SYSTEMS

The equipment needed to record lateral movement required a moderate size truck to transport it, a 110-volt power supply, and was relatively expensive. Since speed and speed change were deemed to be the more important performance measures as drivers are directed to a halt, it was decided to record speed at the secondary site and measure both speed and lateral movement at the primary site.

3.2.1 Primary Site

The data collection system at the primary site was designed to measure and record speed and lateral position and to place code pulses on a magnetic tape record to designate the beginning and end of the observation window. These code pulses were computer compatible and were used during data retrieval operations to start and stop data collection. The computer program was written to start and stop the tape transport while computation was processing. Thus, the system was designed to permit virtually automatic data retrieval.

The primary site system can be described as three subsystems. First, the speed measurement subsystem consists of a doppler radar antenna, electronic circuitry to amplify the signal and a four-channel FM magnetic tape instrumentation recorder. The second subsystem consists of electronic circuitry which integrates the radar signal to determine a car's distance from the radar antenna and forms code pulses which were recorded on another channel of the magnetic tape. The third subsystem includes a video camera, electronic circuitry for converting the video signal to an analog voltage representing lateral position, the FM magnetic tape recorder for storing this signal, and a videotape recorder for recording the video image.

Since both the speed measurement and code pulse subsystems use the radar signal and are functionally integrated, they are described as a unit. The subsystem for measuring and recording lateral movement is described separately.

3.2.1.1 Speed and Code Pulse Electronics

This subsystem uses a stationary doppler radar antenna as a speed detector. The output of the radar antenna is a low amplitude sine wave whose frequency is proportional to the speed of the automobile being observed (~30 hz/mph). This signal is amplified and recorded on the FM analog instrumentation recorder to provide a continuous record of the car's speed during the time it is in the observation window. Signal amplification is necessary because the amplitude of the radar signal decreases with increasing distance of the vehicle and, at approximately

750 feet, the signal to noise ratio of the untreated signal is unacceptable.

The amplified signal is also integrated to provide a voltage proportional to the car's distance from the radar antenna. At specified distances, coding pulses are recorded on one channel of the recorder to specify the beginning and the end of the observation window. The integration network can be adjusted to alter the code pulse timing depending on the operating environment and length of the observation window. The maximum distance was limited by the signal-to-noise ratio and was approximately 1200 feet.

A block diagram of the system is shown in Figure 1. The speed and code pulse electronics function in the following manner. A tapeswitch is placed across the road at the location of the radar antenna. When a car trips the switch, the integrator begins rising as a function of speed as the car proceeds away from the radar antenna. The rate of rise for the integrator output voltage is adjusted to specified feet per volt based on a calibrated electronic signal simulating 25 mph.

The output voltage of the integrator inputs a series of three comparators whose reference voltages are set to match specified distances from the radar antenna. As the integrator output reaches the reference voltage of the first comparator, the comparator output is switched, causing the code pulse board to produce a train of pulses which are recorded and which signal the beginning of the data window to the computer. When the reference voltage of the second comparator is reached, the code pulse board produces a train of pulses signifying the end of the observation window. When the last comparator is switched, the integrator is stopped and reset to ground and the recorders are automatically stopped until the next car enters the observation window.

Since the doppler radar antenna does not lock on to a car, the code pulse board was designed to produce a pulse train indicating aborted data if a second car entered the observation window before the first car completed the course. A short delay is provided for enabling the abort circuitry so that the rear wheels of an automobile do not cause an abort when they cross the tapeswitch. After an abort, the integrator is manually reset and the system is once again ready to record.

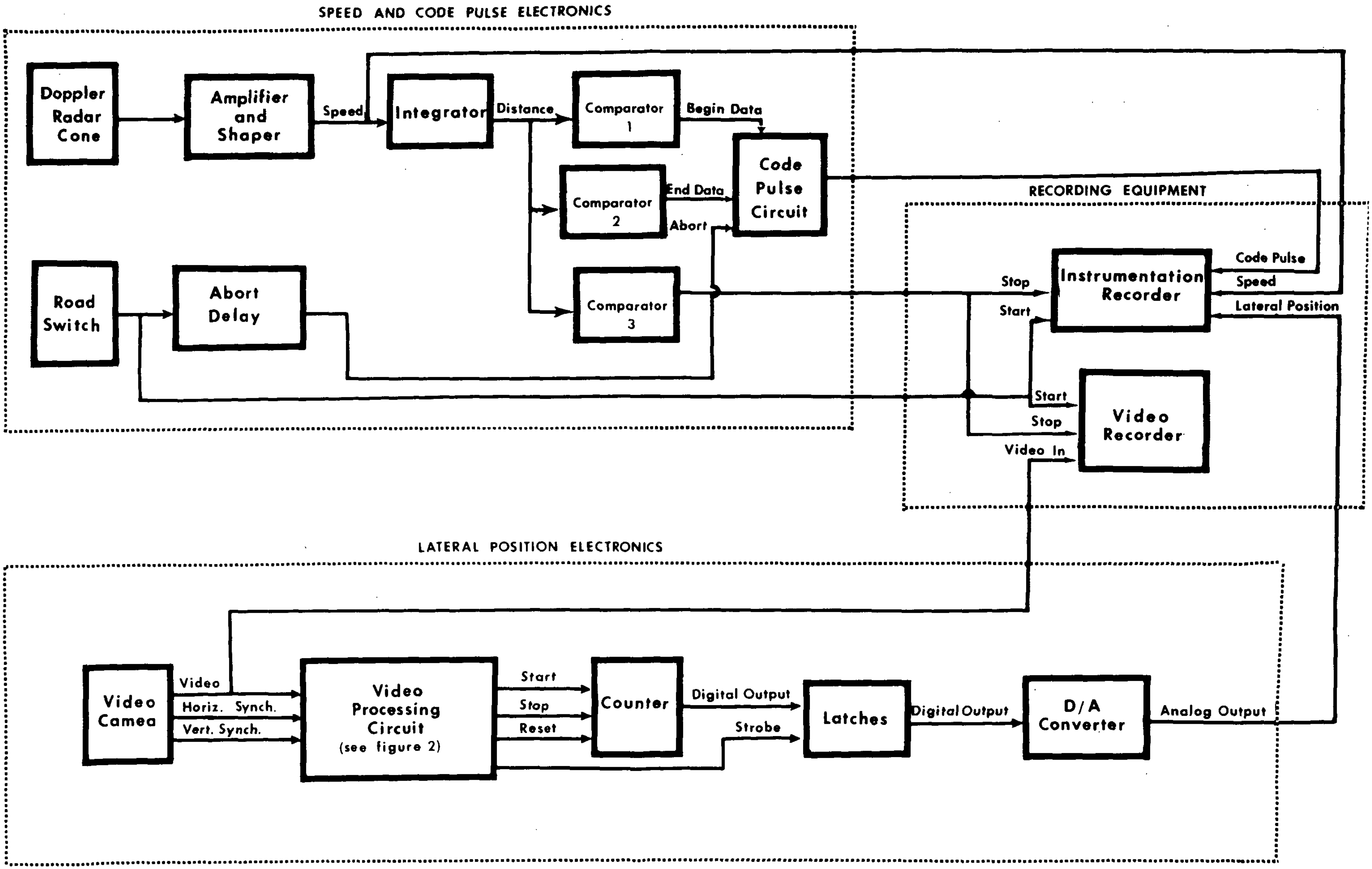

Figure 1: System Flow for Primary Site Data Acquisition

The code pulse board has two further provisions. An abort signal can be triggered manually to cancel a particular data run when another car enters the observation window from the opposite direction while data are being recorded. This provision was necessary because neither the radar signal nor the video signal can be locked on to a given car; thus, data records made with two vehicles in the observation window are not interpretable.

A pulse train denoting automobile braking activity is also manually triggered by an observer. A button is pushed when the brake lights come on, and again when they go off.

3.2.1.2 Lateral Position Electronics

The design of the lateral position measuring subsystem uses a fixed video camera on the road edge to view the rear lights of a car as it travels away from the camera. The rear lights appear as positive going pulses superimposed on a low voltage level background produced by the ambient nighttime light.

The camera develops a complete picture by scanning horizontally from left to right, one line at a time and from top to bottom. A total of 525 lines comprise the complete picture. Every other line is scanned on each vertical sweep and on the next sweep the interstitial lines are scanned so that a particular horizontal line is written on every second vertical sweep.

The camera produces a vertical synchronization pulse at the beginning of each vertical run, and a horizontal synchronization pulse at the beginning of each horizontal scan. The frequency of the vertical synchronization pulses is 60 Hz. Since 262.5 horizontal scans are produced for each vertical scan, the horizontal synchronization pulse frequency is 15,750 Hz. It takes approximately 63 microseconds to complete a single horizontal scan. With the camera fixed, the time between the appearance of the horizontal synchronization pulse denoting the beginning of a horizontal scan and the positive going taillight pulse will vary as the car's lateral position varies. Thus, this time interval increases as the car moves toward the right side of the road and the camera image.

Figure 2 shows the electronic circuitry for the video signal. The

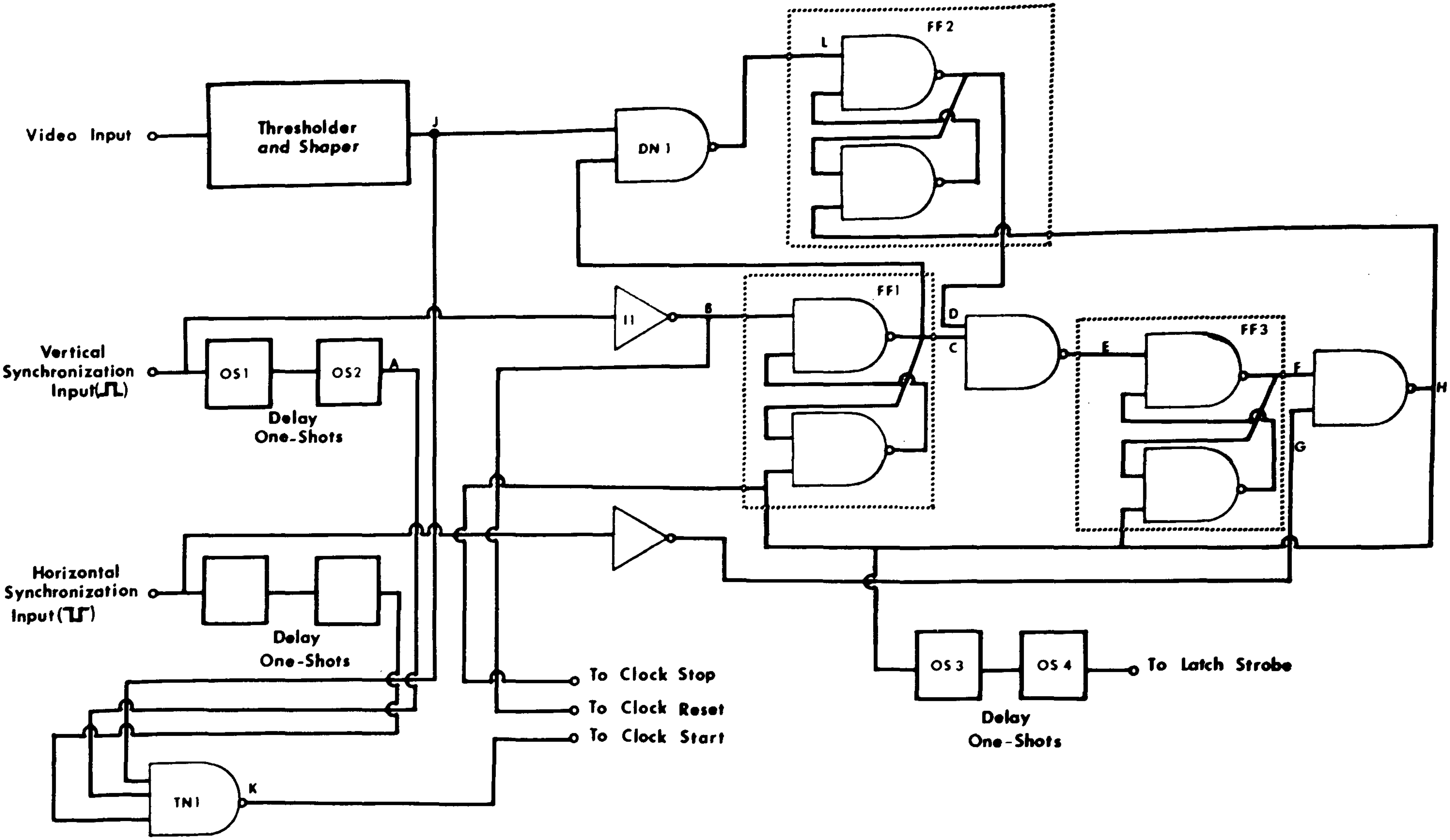

Figure 2: Video Processing Circuit

incoming signal is processed through an adjustable video thresholding circuit. Appropriate adjustment of the circuit assures that the automobile taillights can be discriminated from the background light in various conditions (i.e., full moon vs. new moon; cloud vs. no clouds). Pulses with amplitudes above the threshold value fire a monostable multivibrator (one shot) which shapes the video pulses so each has the same pulse height and width; these being compatible with the transistor-transistor logic (TTL) used in the electronics system.

Since the thresholding circuit considers any pulse above a given amplitude to be a taillight, the active screen area has been reduced slightly to assure that noise spikes which appear around the synchronization pulses are not mistaken for taillights. This is accomplished by triggering serial one shots with the synchronization pulses. Thus, there is a short delay between the vertical synchronization pulse and the time when point A goes positive, determined by one shot-1 (OS1). The pulse width of one shot-2 (OS2) is set to return to low a short time before the next vertical synchronization pulse is due. The same process applies for the horizontal synchronization pulses.

In this manner, one of the three inputs to the triple NAND gate-1 (TN1) is held down for short intervals before and after the synchronization pulses appear. During this time period, the state of the output of the thresholding circuit will have no effect on the output of the triple NAND gate.

The time interval between the horizontal synchronization pulse and the taillight pulse is measured by a clock which starts at the beginning of the horizontal sweep and stops at the appearance of a taillight pulse. The clock counts at 8 MHz, producing eight pulses per microsecond with the highest count (63 microseconds) being 504. The clock output code is Binary Coded Decimal, with 11 bits sufficing to describe the largest possible count.

The clock starts, stops, and resets on negative going TTL pulses. Once started, it stops on the first pulse to the stop input. Succeeding stop pulses have no effect, but a succeeding start pulse will restart the clock from the last count unless it is reset. When the clock has been properly reset, it will again start from zero.

The clock output is then converted to an analog signal whose value is proportional to the time interval between the fixed viewing field edge and the taillight pulse, thereby indicating the car's lateral position. This process is accomplished once per vertical scan or 60 times per second. The analog value is updated and recorded as a function of time, and a record of the lateral position is obtained.

The typical taillight is large enough to appear on more than one horizontal video line, but the time interval need be counted only once per vertical sweep since the car will not move significantly during the 15 microseconds needed to complete the sweep. Furthermore, recounting only adds to the total number of counts, and thus increases the amount of processing needed without adding accuracy.

The sequence of events in one vertical sweep cycle is as follows. The positive going vertical synchronization pulse goes through inverter-1 (I1) causing a negative going pulse at point B. This resets the clock to zero and writes flip flop-1 (FF1) so that point C goes positive and remains positive. At this time, point D is low, E is high, F and G are low, and H is high. The horizontal synchronization pulse going negative causes point G to go positive, but since F is negative, H will remain unchanged.

When the first positive pulse from the thresholding circuit appears (i.e., the first sweep line with taillights present), the coincidence of three positive inputs to the triple NAND gate cause point K to go negative, supplying a stop pulse to the clock. These stop pulses will appear twice on every horizontal line where the taillights appear. Since point C is high, the output of dual NAND gate-1 (DN1) at point L will go low when J goes high for the first time. With both C and D high, point E goes low, thereby writing FF3 and causing point F to go high and remain high.

On the next horizontal synchronization pulse, point G goes high causing a negative pulse at point H. This starts the clock, rewrites FF1, FF2, and FF3 and returns points F, D, and C to their low states to prevent the next horizontal synchronization pulse from causing start pulses at the clock. This process is inhibited until the appearance of the next vertical synchronization pulse. Finally, one shot-3 (OS3) is fired starting a 100 microsecond delay until one shot-4 (OS4) is fired. By this time the clock has been stopped and a count proportional to the lateral position of the automobile is present at the clock outputs (designated "latch outputs" in Figure 1). One shot-4 (OS4) strobes the latches whose outputs are converted into an analog signal by the digital-to-analog (D/A) converter. The result is a voltage proportional to the car's road position. This voltage will remain unchanged until the latches are strobed again during the next vertical sweep of the video camera. Thus, the car's position is updated 60 times a second and recorded on the FM tape.

3.2.2 Secondary Site

The data recording system for secondary site performance measures is considerably simpler than that needed at the primary site. The performance measures of interest here were speed and speed change as drivers came to a halt near the law enforcement officer.

As for the primary site, a doppler radar antenna was used to measure speed. Since the maximum range at the secondary site was only about 500 feet, no signal amplification was required. Furthermore, since the frequency of the radar signal is within the auditory range, it could be recorded on a standard cassette tape recorder. The recorder used for this purpose was capable of recording the necessary frequency range and has a standby mode. The radar signal could be monitored with the recorder's built-in speaker and the recorder started and stopped at the appropriate times.

Code pulsing was not used on these data records. Rather, the necessary code pulses were computer-entered manually as the speed signal was processed by the PDP-12 computer.

3.3 BAC MEASUREMENTS

Sampling schemes have generally been used in roadside surveys to select participants from the traffic flow (e.g., stop every fifth car) to circumvent traffic congestion, permit reasonable processing time, and limit the number of crew members needed. Although a partial sample approach is methodologically sound and desirable from a research point of view, growing legal concerns about roadside surveys may preclude such approaches in the future. The present project was directly affected by legal concerns which are discussed in the Sampling Considerations section (4.1), but it should be noted here that every car approaching the survey site had to be stopped for the current project. This requirement posed a minor logistical problem in that it was not possible to fully process every driver who was stopped. Although traffic flow is rather light on rural Vermont roads at the hours the survey was scheduled, it is impossible to spend 10 to 15 minutes with each motorist.

Two major alternatives appeared to be available to handle this situation. (1) Every approaching car could be stopped and given a rapid check for defective equipment. The research crew could then request selected individuals to participate in our research survey based on the usual type of sampling scheme. (2) Every motorist could be asked to complete a very short questionnaire which would require no more than 2 or 3 minutes of his or her time.

The first of these alternatives seemed guaranteed to cause considerable problems with irate citizenry. If every motorist were stopped by a law enforcement officer, but only selected numbers of those individuals were requested to participate in the study, it seemed very probable that the refusal rate would be high and that those individuals asked to participate would undoubtedly be upset by seeing others not similarly requested. The second alternative was also undesirable for a number of reasons. The amount of data that could be gathered in a 2- or 3-minute interview would be very meager relative to the effort and potential problems involved in doing roadside survey research. Furthermore, breath testing devices of certified reliability, fast turnaround time, and reasonable cost were not available.

A compromise solution seemed possible by using prototype breath testing units being tested by the Transportaion Systems Center for the National Highway Traffic Safety Administration (NHTSA). These Alcohol Screening Devices (ASD) are solid-state, portable units with rapid purge times between breath samples, and they do not require ampoules, breath sample storage devices, etc. Although the ASDs are still being tested and are not yet available commercially, they seemed to be well suited for use as a pre-screening device in this project. Their use would assure that all motorists with relatively high BACs would be asked to provide a Breathalyzer sample and participate in a full interview (10 to 15 minutes), while individuals with zero or low BACs could be quickly processed with a shorter interview (1 to 2 minutes).

A request to use four ASDs was granted and the dual processing scheme was employed. During the course of the study, approximately 1700 people were processed who volunteered to submit to the ASD breath test. Of these, approximately 700 also volunteered to provide a Breathalyzer (Model 900) sample in the interview trailer.

3.4 INTERVIEW SCHEDULES

Previous research, both in Vermont (e.g., Perrine, 1974i; Perrine et al., 1971) and elsewhere (e.g., Borkenstein et al., 1964, 1974a; Carlson, 1972, 1973; Clark et al., 1973; Filkins et al., 1970), has revealed significant relations between driving with positive BACs (especially with high BACs) and a number of biographical, driving, and drinking variables. Several case/control studies have also provided evidence that self-reported drinking patterns obtained from drivers interviewed at roadside surveys are highly congruent with the respective BACs measured at the particular occasion of the survey (Borkenstein et al., 1964, 1974a; Perrine et al., 1971). Accordingly, the present project was designed to include interviews in order to obtain biographical, driving, and drinking information to enable relating responses on some of the established variables to the measured BACs, trip information, and instrumentation data from the primary and secondary sites.

Although the interview schedules for the present project were specifically tailored to meet the constraints of the particular field conditions and special goals, most of the individual items had been developed and thoroughly tested in previous research. Many of the specific topics in the interview schedules had been first used in the "Control Site Interview" (presented in Appendix 10.07, Perrine, 1971a) developed for the roadside surveys conducted in Vermont during 1967 through 1969 (Perrine et al., 1971).

The final version of the "Vermont Roadside Research Survey" used in the present project (see Appendix B) also included a number of items designed to provide specific information concerning prior driving experience, as well as origin and destination of the particular trip and familiarity with both the vehicle and the particular road. In addition, several drinking-and-driving attitude items were included. As soon as possible after the motorist had left, the interviewer was required to rate the respondent's comprehension and credibility on 5-point scales printed on the last page of the form.

The interview schedule had been considerably reduced in size as a result of several pretests in order to obtain the maximum relevant information in the minimum amount of time (not to exceed 12 minutes). However, it was also necessary to develop an abbreviated form to be used at roadside when the traffic flow exceeded the processing capability of our interviewers and led to an appreciable backlog of cars. The resulting "short form" (see Appendix C) consisted of the minimum number of key questions (N=6) necessary to permit general identification of the respondent and to enable basic comparison with the "long form" respondents.

It should be noted that our interview schedules obtained the basic core information necessary for international comparisons, as agreed upon by the national delegates who participated in a series of working conferences under the auspice of the Organization for Economic Cooperation and Development (OECD) and several other agencies. The outcome of these conferences have been presented in several publications (Borkenstein et al., 1974b; Carr et al., 1974; Stroh, 1972, 1974).

Data from the interviews were manually coded in the field onto the interview forms and were later keypunched onto computer card decks. These card decks were then input to the University of Vermont's Xerox Sigma-6 computer where they were translated onto disc files for subsequent analysis. Two separate data files were maintained, one for the long form interview data and one for the short form data.

All statistical tables presented later in this report were generated by the Statistical Package for the Social Sciences (SPSS).

3.5 DATA REDUCTION OF PERFORMANCE MEASURES

Performance measures from the primary observation site were recorded on video tapes and multi-channel analog tapes. Data on the analog tapes consisted of lateral position information taken from a video camera image of the subject car's taillights, speed data from a doppler radar, and a series of pulse codes which served to identify the start and stop of the sample. Video tapes containing the actual visual image recorded at the primary site also served as a means of retrieving lateral position information. Thus, two complete records of lateral position data were maintained; one in the form of the raw video image and the other in the form of the analog signal obtained through the electronic circuitry designed for the video signal. Data from the secondary site consisted of doppler speed information recorded on audio tape cassettes.

The large quantity of data recorded in analog format required considerable time to be converted to digital information and appropriately reduced and analyzed. The procedures to accomplish the necessary data reduction are presented in Section 4.4. It is simply noted here that the data reduction procedures were designed to obtain a number of usable parameters. For example, the speed data produced measures of maximum and minimum speed, the time at which the maximum and minimum speeds occurred, the maximum and minimum acceleration, the time of maximum and minimum acceleration, the mean and standard deviation of speed, the mean and standard deviation of acceleration, and the entering speed at each site window. Thus, a reasonable number of performance parameters were obtained from a massive quantity of analog information.

Chapter 4

ENVIRONMENT AND PROCEDURES

It is difficult to describe the field operations and data retrieval procedures of the current project adequately without employing the art of cinematography. Concepts of communication between primary site, secondary site, and survey area; descriptions of equipment setup, calibration runs, coordination of data between sites; placement of stopping policeman, equipment check policeman, greeter, guides, short form interviewer, and long form interviewers; and procedures employed to match videotape records with analog tape data lose some sense of reality when descriptive prose replaces dynamic activity.

To a large extent, the operating environment and procedures used were constrained by a number of concerns and requirements expressed by State and local officials. Some of the problems encountered in this regard reflect a growing nationwide concern about invasion of privacy and protection of civil liberties. This concern was most explicitly stated in opposition to the possible use of equipment capable of "seeing" inside a vehicle under cover of darkness (discussed in Section 2.3). One State's Attorney flatly stated that such activity would be considered illegal in the county he served. A similar attitude probably would be held by many individuals and, quite frankly, the authors of this report had serious concerns about using light-intensification units even as we were testing the devices. Since observation of in-car behaviors proved to be technically impossible, the legal considerations surrounding that approach became moot for this project.

A more general concern about roadside surveys caused serious problems for this project, many months of delay, and had a direct effect upon subsequent field activities. In previous Vermont roadside survey research, immunity from prosecution had been granted for participants whose BAC was above the legal limit if they accepted a ride home from the research crew. Attempts to operate the present survey under similar guidelines were rebuffed on the grounds that a law enforcement officer could not be asked to work in a situation which was contrary to his oath and duties. Furthermore, it was decided that any activity which included law enforcement work must be part of their usual and official duties. In other words, the police could be employed in the roadside survey only if (1) they stopped <u>every</u> vehicle for a defective equipment and/or license and registration check and (2) they could arrest stopped motorists for DWI.

This position was taken just before field activities were scheduled to begin and was precipitated by a judicial ruling that such roadblock activities could not constitute "probable cause" for DWI arrests. Since there was considerable controversy over that decision, the Vermont Commissioner of Motor Vehicles formally requested an "opinion" from the Attorney General's office concerning the legality of arresting for DWI at roadblocks established for other purposes. The Vermont Commissioner of Public Safety would not authorize use of State Police until that opinion was formulated since it directly affected the functions of that Department.

The resulting opinion, which has been upheld in a more recent court case, was that DWI arrests could be made at roadblocks legally established under Vermont statutes for the purpose of checking equipment, operators' licenses, and vehicle registration if the attending law enforcement personnel observed behaviors indicating intoxication. This decision cleared the way for State Police to work with us and, at the same time, underscored the importance and significance of research designed to define and quantify real-world driving behaviors which differentiate the drinking driver from the sober driver.

4.1 SAMPLING CONSIDERATIONS

The original design specified that data collection would occur between 9:00 P.M. and 3:00 A.M. on Thursday, Friday, and Saturday nights. However, the first weekend of field operations revealed that traffic flow was too heavy before 10:00 P.M. and could not be processed on a total sample basis without causing long queues and short tempers. Consequently, operations generally began between 10:00 P.M. and 10:30 P.M. Data were also collected one Sunday night in an area near the New York border where many Vermont college students cross the state line for Sunday night entertainment.

Sites which afforded acceptable traffic flow were generally used twice, with one and one-half to two months between visits. This procedure was adopted to limit the number of sites needed and the probability of repeatedly stopping the same motorists, while also minimizing inter-site differences. One site was used three times, 13 sites were used twice, and 13 sites were used once.

4.2 SITE SELECTION

Selection of potential survey sites began with review of traffic flow maps obtained from the Vermont Department of Highways. These maps show average daily traffic flow for many major routes throughout the state. Based on these maps, six sites were chosen to record traffic flow on the days and during the hours of scheduled data collection. These traffic counts revealed little relationship between traffic flow during the scheduled survey times and the information shown on the traffic flow maps.

A list of drinking establishments was also obtained from the Vermont Liquor Control Board and a series of detailed maps showing the locations of individual buildings, including bars, was supplied by the Department of Highways. This information was useful in locating areas that might be presumed to have a higher than average number of drivers with elevated BACs. For example, locations between bars and population centers were particularly noted.

The selected locations were then used as a basis for canvassing the state to determine suitability of physical requirements and also to select additional sites in a given area. Attempts were made to locate at least five desirable sites within 30 miles of a town to minimize driving time and to assure alternatives in case one or more sites were unavailable or unusable.

The physical considerations for site selection were important both in terms of equipment constraints and space needs for processing motorists at the interview area. The primary site observation window required at least one-quarter mile of straight, level, unlighted road with an adequate shoulder for parking the equipment truck off the roadway. This observation window had to be followed by a curve, hill, or other obstruction to isolate it visually from the secondary site.

The secondary site required another straight and level road for about 600 feet for measuring speed and speed change as motorists were directed to a halt. In addition, space was needed to park the police cruiser off the edge of the road at the stopping point. The maximum distance between the primary site and secondary site was limited by the radio communicator range to approximately 1.5 miles (depending on terrain). Finally, sites were required that had few or preferably no roads, driveways, or other turnaround areas between the primary and secondary observation windows.

The interview site had to be established near the secondary site so motorists could be directed to the police officer doing the equipment check. The size of the interview site was also a major consideration since the activities there had to be efficient and well synchronized to permit rapid processing. Minimum requirements were: (1) space was needed for the equipment checkpoint; (2) a distance of about 30 feet between the trooper who checked equipment and the civilian who explained the project and obtained the ASD sample; (3) a location near the site exit for short form interviewing; and (4) a parking area for at least four cars and the interview trailer. Furthermore, the interview site had to be arranged to minimize the chance of an accident and maximize flow and coordination. Figure 3 shows a typical site.

These constraints made site selection a difficult and tedious process. Inquiries of local police for their recommendations of potential sites having moderate traffic flow and high probability of stopping drivers who had been drinking were not very helpful. They occasionally recommended what proved to be "good" sites, but more often their suggestions were less accurate than our own predictions.

It should also be noted that public cooperation was excellent in permitting use of farmyards, gas stations, parking lots, etc. for interview sites. The only adamant refusal was given by a beer distributor.

4.3 FIELD OPERATIONS

Activities for data collection generally began on Thursday morning with transport of equipment, vehicles, and personnel to the locale of that weekend's field activities. Following motel registration, the field coordinator usually made final inspection of the sites chosen for data collection and, when necessary, confirmed prior conversations with

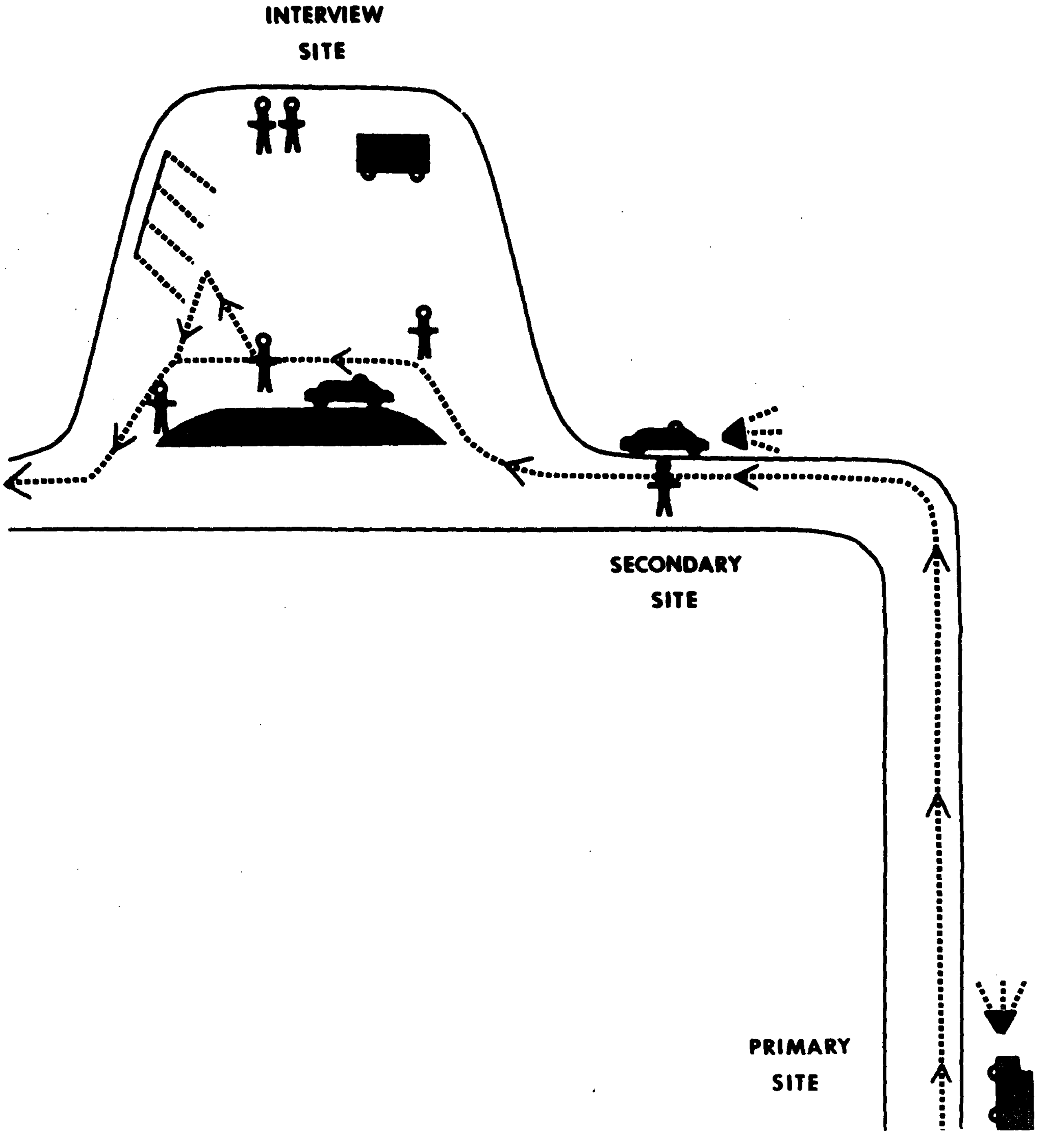

Figure 3: Typical Survey Site Layout

property owners regarding the use of their land for the research work that weekend. The equipment operator carried out a routine check of primary site equipment to assure that it was operating correctly, while other team members cleaned the interview trailer and purchased supplies.

4.3.1 Preparation for Data Collection

Two hours before scheduled departure for the survey site, the crew would meet to discuss activities for the evening. Interviewers who had not worked on the project previously were trained during this time, and the police officer who was to perform the equipment check was briefed on his duties. The ASDs were calibrated and forms were coded. The equipment forms were sequentially numbered and organized to match the sequential coding procedures at the primary and secondary sites. The roadblock serial number was entered in the first three spaces of the "Respondent Number" on the equipment check and interview forms. The remaining spaces were left blank for later insertion of the motorists' unique codes. At approximately 9:30 P.M. the research team would leave for the site.

The equipment truck was driven directly to the primary site while the interview trailer and other vehicles were stationed at the interview site. Equipment was prepared for operation as soon as radio communication was established between sites. Figure 4 shows the equipment truck with the tripod mounted video and radar equipment.

4.3.1.1 Primary Site Preparation

After the equipment truck was properly parked on the road shoulder, a power generator was placed as far off the road as possible and started. All truck-mounted equipment and power supplies were turned on to warm up, and the tripod with radar antenna and video camera was placed on the road edge in front of the truck.

The tripod placement was carefully measured and adjusted each night to minimize site to site variation. While this procedure was not crucial for the radar signal, it was important that the video camera be precisely aligned with the roadway.

The camera was positioned four feet from the road edge and aligned horizontally be means of a bubble level. A light was then placed on the

Figure 4: Equipment Truck with Radar and Video Tripod

road edge 200 feet from the camera. A small circle permanently affixed to the video monitor in the equipment truck was used as a sight for aiming the camera at the light. One equipment operator observed the video monitor and instructed the other operator how to move the camera so that the light was properly aligned in the circle. These procedures placed the roadway in the same location on the video screen each night. Figure 5 shows the interior of the equipment truck.

After the light was removed from the road edge, the integrator circuit was calibrated to convert the radar speed signal to distance so the recorded code pulses would accurately define the observation window. The integrator was first zeroed with a potentiometer control to eliminate drift. An oscillator signal simulating 25 mph was then input to the integrator and, since the time interval between two of the comparators was known for this speed, the rate could be adjusted to set the correct time interval for firing the code pulses. Figures 6 and 7 show the control board and recording system.

4.3.1.2 Interview Site Preparation

While the primary site was being prepared, the interview site was also made ready for data collection. The trailer was unhitched from the tow car, stabilized with frame jacks, and the wheels were chocked. The storage battery was connected to supply 12-volt current and the Breathalyzers were warmed up. Coffee was brewed and cookies were made available.

Team members working outside were given reflectorized vests, flashlights, and clipboards containing the appropriate forms. The interviewers and the Breathalyzer operator distributed interview forms and pencils.

4.3.1.3 Secondary Site Preparation

Completion of preparatory procedures at both the interview and primary sites was confirmed by radio communication. The law enforcement officer who would be stopping cars then moved his cruiser approximately 100 feet down the road from the interview site and parked at the road edge. The team member accompanying him positioned the radar antenna and connected it to the cassette tape recorder. At the same time, the other law enforcement officer and the field coordinator drove their vehicles

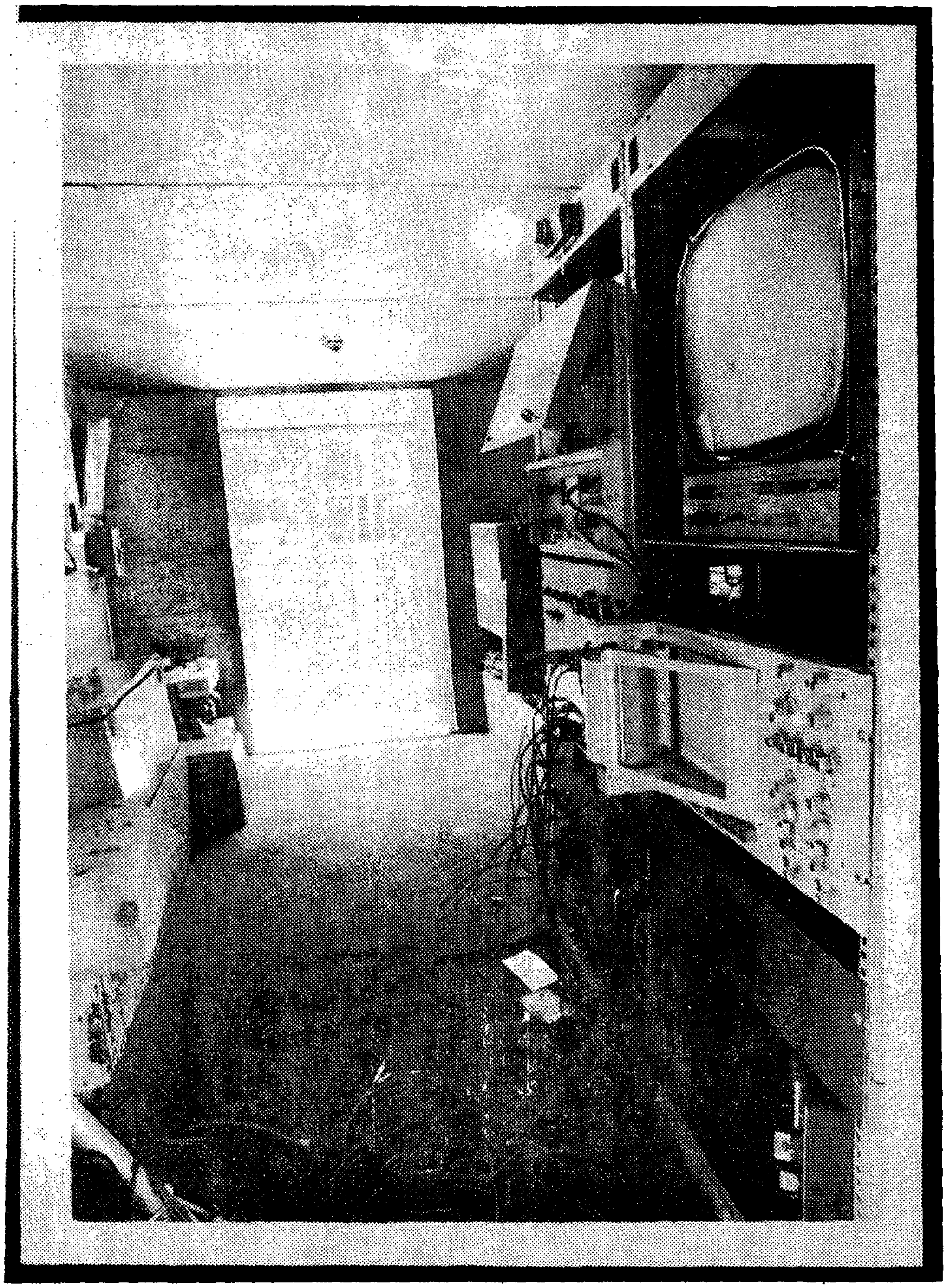

Figure 5: Interior of Equipment Truck

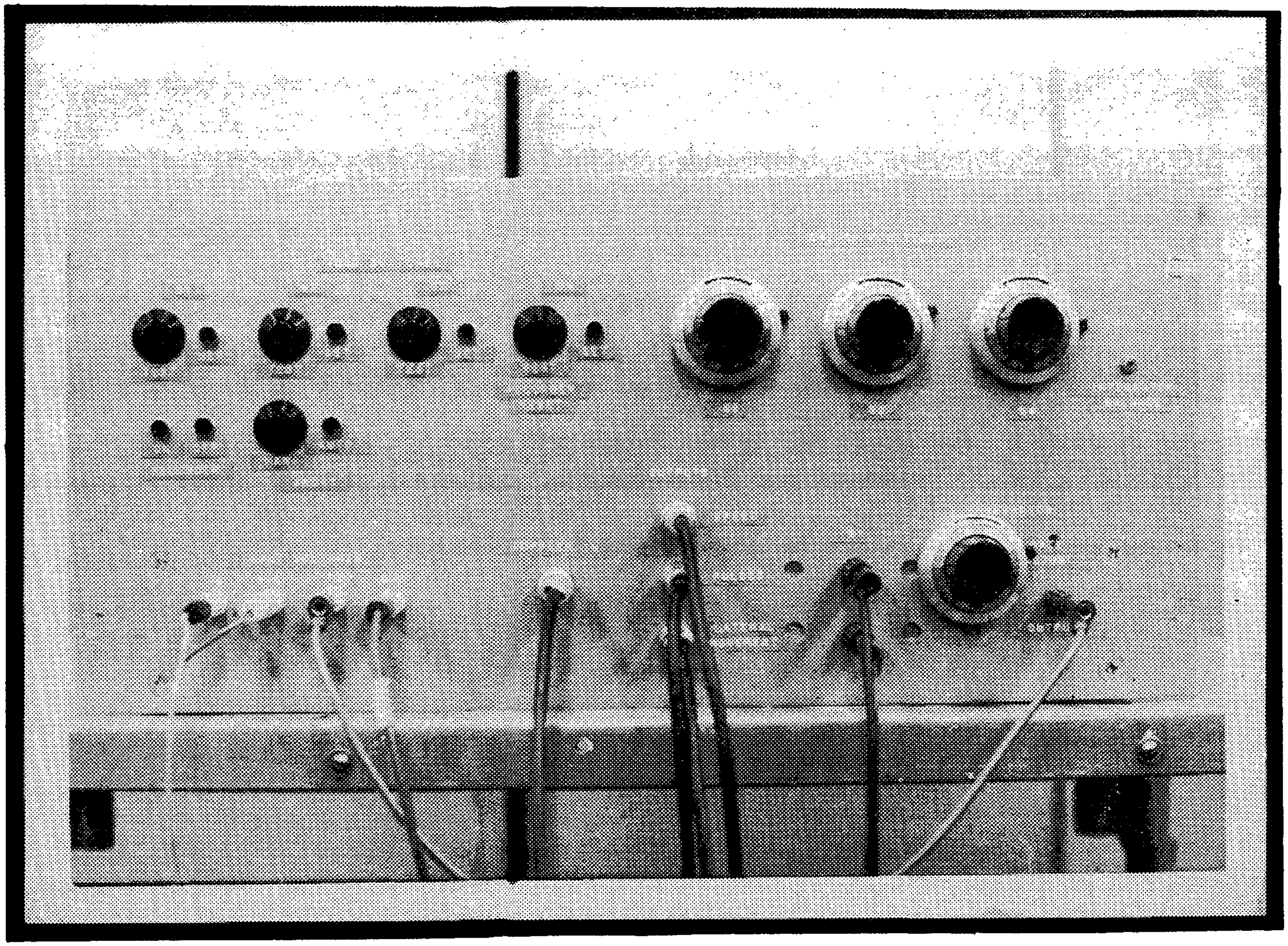

Figure 6: Data Acquisition Control Board

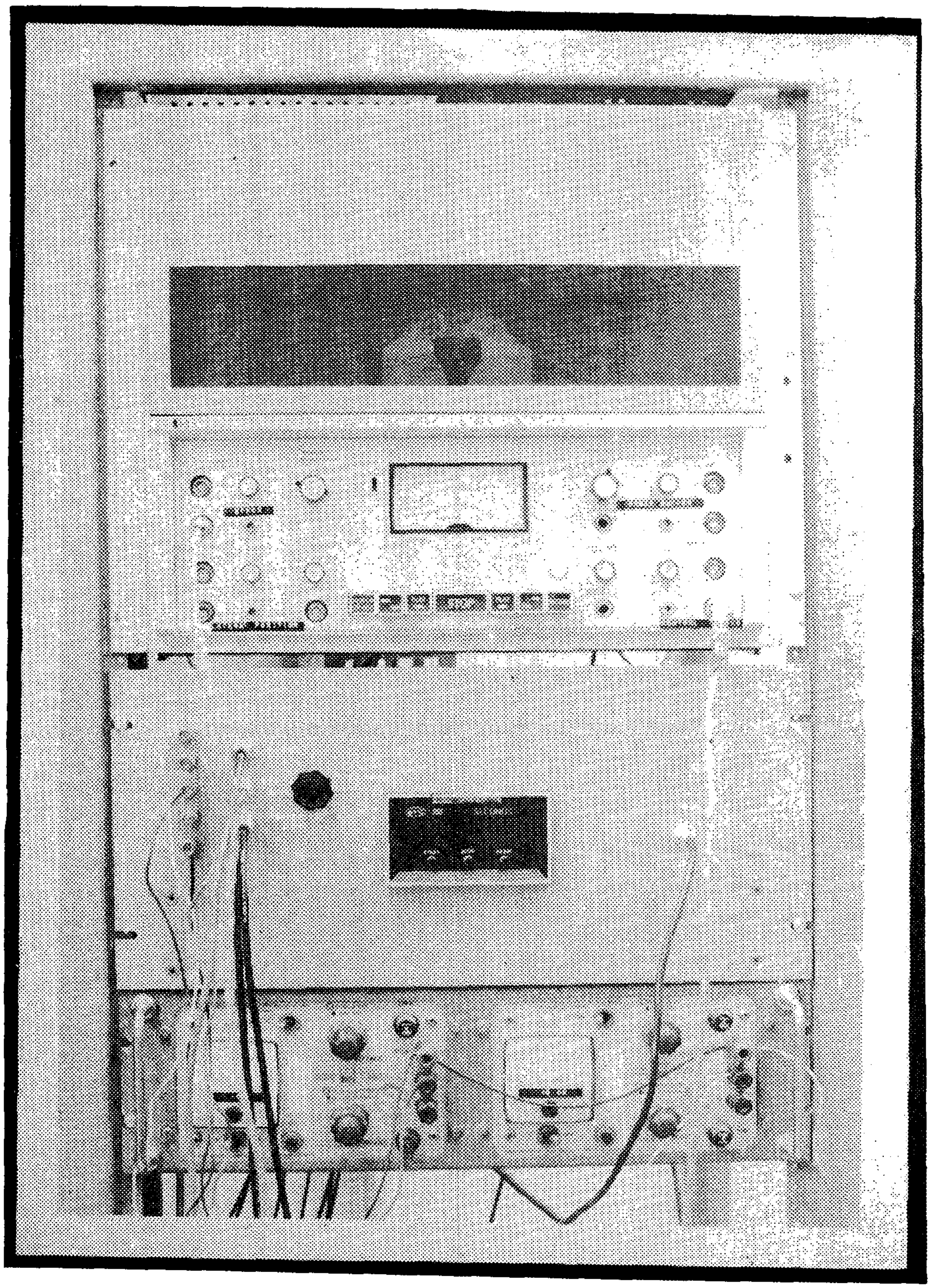

Figure 7: Analog Recorder and Timing Clock

to the primary site to make a standardization run through the primary observation window.

4.3.2 Standardization Run

A standardization run was accomplished by having the field coordinator drive a car equipped with a tracking sight through the primary observation window. The sight was arranged so the car would be positioned in the center of the lane when the driver aligned marks on the windshield and fender with the centerline of the road. Thus, the analog tape record of the standardization run indicated the road characteristics for that particular site. This record could then be used to interpret lateral movement of cars relative to the "true track" of the road.

Upon arrival at the primary site, the officers stopped all traffic for a few minutes while a tapeswitch, with baseplate removed to eliminate noise, was nailed to the road surface and the standardization run was completed.

The standardization run was made at approximately 30 mph since this was found to be optimal for accurate tracking of the centerline of the road. The field coordinator and officer then returned to the interview site and data collection commenced.

4.3.3 Data Collection Procedures

The data collection procedures can be explained by describing the activities which occurred and the communication links used as a motorist was processed. The reader may also wish to refer to Figure 3, which depicts the relative positions of data acquisition points and the processing sequence used.

4.3.3.1 Primary Site

The data collection equipment at the primary site was automatically activated when a vehicle crossed the tapeswitch. The equipment operators in the truck monitored the functioning of the data collection equipment and observed the car while it was in the primary observation window. If another car traveling in the same direction entered the primary observation window while the car being recorded was still within it, an abort pulse was automatically placed on the data tapes when the second vehicle tripped the tapeswitch. However, if a second car entered the observation window from the opposite direction while the observed car was still in it, the equipment operator manually triggered an abort switch to place the appropriate pulses on the data tape. In order to maintain correspondence between primary and secondary site data, the primary site operators maintained a sequential record of each vehicle and the tape footages when it entered the observation window. The car number was communicated to the secondary site. For example, when a car left the primary observation window, the equipment operators would radio to the secondary site, "Car number 86 has just left primary observation window and his data are recorded."

4.3.3.2 Secondary Site

The secondary site operator would note on his code sheet that car number 86 had made a non-aborted run through the primary observation site and would then turn on his recording equipment. The car's speed was recorded at the secondary site as the driver was directed to a halt by the law enforcement officer. The secondary site equipment operator also recorded whether good or aborted speed data had been collected at this site and, when possible, noted the license plate number of each vehicle passing his station. The officer directed the stopped driver to a second officer at the interview site and informed the driver that he was to proceed there for a routine defective equipment check.

4.3.3.3 Interview Site

As the driver entered the interview site, the second police officer introduced himself, explained the routine equipment check, and asked to see his operator's license. The officer then made the appropriate recordings of defective equipment and noted the license plate number on the form. Again, it should be noted that these forms were also sequentially numbered to maintain data correspondence with the primary and secondary sites. When he was finished with the equipment check, he briefly informed the driver that the Vermont State Police were cooperating with a research team collecting very important information for highway safety and asked the driver to move ahead to the "greeter" located about 30 feet away.

The greeter briefly described the research operation to the driver and made it clear that participation was voluntary. In addition, he was given a letter signed by the Governor of Vermont which also noted that participation was voluntary and urged motorists to participate. The greeter then requested the driver to give a breath sample on the ASD. The ASD reading and the license plate number were recorded on a small piece of paper and placed under the windshield wiper of the car.

If there was room in the interview trailer at this point and/or if the driver had a medium to high BAC, he was asked to drive over to the interview trailer where someone there would explain the rest of the procedures and help him to be quickly on his way. If the interview trailer was full and his breath sample showed little or no alcohol, he was directed to the short form interviewer stationed a few feet away.

4.3.3.3.1 Short Form Interviewing. The short form interviewer removed the piece of paper under the windshield wiper and noted the license plate number and ASD reading on the short interview form. The driver was asked the questions on the short interview form (see Appendix C) and was directed back onto the roadway.

4.3.3.3.2 Long Form Interviewing. Drivers who were fortunate enough to arrive when the interview trailer was not full or who had high BACs were directed to the area of the interview trailer.

After the driver parked his vehicle, a "guide" removed the paper containing the license plate number from under the windshield wiper, attached it to a long interview form he carried, and requested the driver to accompany him to the interview trailer. The guide also answered any questions that the driver might have had at this point and assured him that the interview he was about to participate in would be strictly confidential and for research purposes only.

As the driver stepped into the interview trailer, the guide introduced him to the Breathalyzer operator who was given the long interview form with the ASD and license plate number slip attached. The Breathalyzer operator obtained a breath sample from the driver and then introduced him to an interviewer. The Breathalyzer operator gave the interview form with the slip bearing the ASD reading and license plate number paperclipped to the back of it, to the interviewer. The operator then returned to the Breathalyzer and recorded the BAC reading and the license plate number on another piece of paper.

Upon completion of the interview, the driver was permitted to leave if his BAC was below .10 (the legal limit in the State of Vermont). After the driver departed, his Breathalyzer reading was given to the interviewer. At this time the license plate number, ASD reading, and Breathalyzer reading were recorded on the interview form.

If the driver's BAC was .10 or above, the Breathalyzer operator informed the field coordinator while the interview was in progress. The field coordinator determined whether the driver had passengers and, if so, explained to them that someone else would have to drive the car. Passengers willing to drive were requested to show their operator's license and provide a breath test. Fortunately, no instances arose in which a passenger claimed to have a valid operator's license and to be sober, but refused to show the license or give a breath test. Upon emerging from the trailer, the legally impaired driver was informed of his condition and the new driving arrangements by the field coordinator.

A driver who was alone and had a BAC above .10 was required either to lock and leave his car and accept a ride home with a crew member or wait at the interview site until breath tests indicated a BAC below .10.

Drivers with BACs between .05 and .09 were informed of their "dangerous" level before they returned to their car. They were warned that should they be involved in an accident or be arrested for a traffic violation, their present BAC level could be used against them.

4.4 DATA RETRIEVAL PROCEDURES

Despite our intentions to automate data retrieval and processing, a number of problems developed which made data retrieval a time-consuming task. In particular, considerable hands-on work was needed to get the vehicle performance information off the instrumentation tape and into the computer.

4.4.1 Interview Data

The interview data presented the fewest and least severe problems of all the types of data in this study. As was previously mentioned, the hand-coded interview forms were keypunched onto card decks which served as input to the computer. The SPSS programs permitted automatic checking for clerical and keypunch errors (e.g., punching a letter where a number was required), and the on-line disc files could be edited to correct these errors after a reference to the original interview form. Random checks on the degree of correspondence between the numerical data on the disc file and the interview forms revealed very few errors. It may be concluded that the data bases from which the statistical tables were eventually produced are valid and reliable.

4.4.2 Transcription of Performance Data

The first requirement for analyzing the recorded video and doppler analog signals to retrieve lateral position and speed information was conversion of all data to digital format. The procedures for retrieving primary site and secondary site data presented independent challenges requiring somewhat different procedures and are described separately in the two following subsections.

4.4.2.1 Primary Site Data Transcription

Data from the primary site presented some processing problems, and it was only through considerable work that reliable data were retrieved. The original analog tapes collected at the primary site should theoretically contain all the information needed: speed, lateral position, and start/stop pulse codes for sampling control. However, it was found that the lateral position data were not as reliable or free from noise as was necessary. This problem was traced to a variety of sources operating independently and in concert, including 110-volt generator noise and voltage fluctuations, equipment malfunctions, and moisture and other environmental effects.

Fortunately, the staff was concerned and the Contract Technical Manager (CTM) anticipated that the video lateral position data could be a problem. To guard against a loss of these data, our CTM urged that independent video tape records also be made of the movement of the cars' taillights. Given these video tapes, lateral position data could be recovered in the laboratory utilizing a video detector, which is available commercially.

No subject identification information was directly coded on any tape, but careful written records of the tape footages were kept at the primary and secondary sites (see Section 4.3.3). These records enabled matching at a later time of physical sections of the primary and secondary site tapes with the appropriate interview and equipment check information.

Primary site doppler speed pulses were transcribed from the original primary site analog tapes and were directly connected from the FM tape recorder to a Schmidt trigger clock channel input of a PDP-12 computer. Speed data consisted of the number of doppler pulses recorded in 0.1-second intervals.

The start/stop data collection pulses on the original analog tapes were of generally good quality; however, since these codes were essential for accurate digitizing of the analog signal, a manually operated pulse generator was also used. The start/stop data collection pulse channel of the FM tape recorder was connected to a storage oscilloscope and monitored by the PDP-12 operator. The manually operated pulse generator was directly connected to another PDP-12 clock channel input. When the correct pulse code appeared on the oscilloscope, the PDP-12 operator manually entered an identical pulse into the computer, either to begin or to terminate PDP-12 data collection.

The video tape recording machine (VTR) was used to retrieve lateral position information from the video record. The VTR was coupled to a video detector which provided the filtering and control functions necessary for the processing of the VTR composite video signal. The video detector is designed to detect peak contrasting video information in a display, in this case the rear lights in the primary site data window. Two outputs are available from the video detector:

1. A <u>display output</u> which, when connected to a standard 512 line video monitor, superimposes a white area on the video picture. This white area is the active area of the display for peak contrast detection. The display output permits variable limiting of the active area of peak contrast

detection, both in size and position on the video monitor. By observing the video monitor, the VTR operator can position the active area of detection on the left rear light of a videotaped data vehicle and adjust the size of the active area so as to include only the left rear light. By manipulating an X-Y axis positional control, the VTR operator moved the active area of detection so as to effectively "track" the left rear light as the car moved through the data window. These control features ensured that no extraneous light source (e.g., street light, distant light on horizon, etc.) would interfere with acquisition and processing of accurate vehicle lateral position data. This device and procedures enabled successful processing and analysis of several nights of data collection that had previously been irretrievable due to extraneous light sources in the primary site data window.

2. A <u>signal output</u> provides an analog signal compatible with the PDP-12's A/D conversion channel. This signal output was digitized to obtain lateral position data. The left taillight was of high contrast to the ambient light and the video detector system produced a signal which represented the position of the vehicle with respect to the left side of the recorded visual field. That is, the signal was directly proportional to the horizontal position of the vehicle's left taillight in the video display (absolute left of field = 0 VDC; absolute right of field = + 1 VDC). This voltage range was preselected and fixed so as to be compatible with PDP-12's A/D conversion capabilities.

Another important function of the video detector is variable peak contrast sensitivity which served to filter those lateral position data which had been resistant to signal processing. The signal-to-noise ratio of the active area of detection could be varied so as to maximize contrast between the vehicle's left taillight and the ambient background light. This enhancement of the active area of detection enabled the accurate processing of lateral position data regardless of adverse atmospheric conditions (e.g., fog, bright ambient background light, etc.)

In order to effect reliable synchronization between lateral position and speed records, the VTR tape and original analog speed tape were set at the footage marks recorded during original data collection. Precise positioning of the two tape records was accomplished by monitoring the individual lateral position and doppler speed signals with an oscilloscope. That point on each tape where the machine had changed from standby mode to record mode could easily be located by monitoring the respective electronic signals. Using this method, precise and consistent synchronization of lateral position and speed records was possible.

After the two independent tape records had been screened and synchronized, the tape machines were started simultaneously. Upon seeing the start pulse on the oscilloscope, the PDP-12 operator manually entered the correct pulse into the PDP-12 to start data collection. While observing the video monitor, the VTR operator positioned the whited-out active area on the monitor display over the data vehicle's left taillight and, with the use of the X-Y positional controls, tracked the left taillight as the data vehicle proceeded through the primary site data window.

When the PDP-12 operator observed the stop pulse on the oscilloscope, he generated a manual stop pulse, which stopped the PDP-12 data collection sequence. The speed and lateral position data summaries were then transferred from the memory of the computer to digital LINC tapes. Each summary of speed and lateral position data occupied four blocks of 256 12-bit words on the LINC tape and the computer produced typed messages indicating which blocks of the tape the information was stored on. This information was used during transmission of the data to a Xerox Sigma-6 computer for archiving and analysis.

4.4.2.2 Secondary Site Data Transcription

The secondary site speed data were recorded directly from the doppler radar onto an audio tape cassette, and changes in speed were represented as changes in frequency of an audio tone. The data forms for the secondary site listed tape footages and license plate numbers, and noted if a particular car's data were good or aborted. A data trial was considered aborted when more than one car was in the radar observation window at one time. These aborted runs could be readily discerned from unaborted trials by the characteristic tone patterns recorded on the cassette tapes. If more than one vehicle was in the data window, tones of differing frequencies could be heard from the tape, and it was also possible to discern whether these patterns were caused by vehicles moving toward or away from the radar cone. Thus, the tape footage records, license plate numbers, and the characteristic patterns of tones could be used in the laboratory to locate and identify specific cars, and then BAC and other information could be matched to the secondary site speed data.

Computer processing of the secondary site speed data proceeded in a somewhat different manner from primary site data. No pulse codes were recorded on the cassettes, and it was necessary for the operator to signal the beginning and end of data collection manually with a set of buttons connected to the PDP-12 computer. The cassette recorder was started a few seconds before the beginning of a data trial, and when the doppler tone first became audible (i.e., the vehicle was entering the secondary site observation window), the operator pushed a button signaling the start of data collection. When the doppler tone disappeared (i.e., the vehicle had stopped), another button was pushed signifying the end of data collection. At this point, the speed information collected was transferred to LINC tapes for archiving and later transmission to the Xerox Sigma-6.

Special assembly language programs for the PDP-12 were written to process the secondary site speed data. The doppler tones were fed into one of the PDP-12's Schmidt trigger clock channels and the manually fired pulse codes indicating the beginning and end of a run into another channel. The same basic format used for the primary site speed data was used for the secondary site speed data. The number of doppler radar pulses occurring in a 0.1-second interval was recorded, and this was directly proportional to the speed of the car. Thus, the secondary site speed data was a history of speed sampled in 0.1-second intervals. Programs written for the Sigma-6 integrated this history and produced plots of secondary site speed as a function of distance and time. Distance in this case is referenced to the point of acquisition by the doppler and not to carefully defined points on a measured course, as was the case with the primary site data.

4.4.3 Computer Processing of Performance Data

All data collected in the field were processed by both the Psychology Department's PDP-12 laboratory computer and the University of Vermont's Xerox Sigma-6 timesharing computer. The overall flow of data from raw data tapes created in the field to the final statistical summaries is diagrammed in Figures 8 and 9.

Information on lateral position was preprocessed through a video detector (described in subsection 4.4.2.1) before being fed into the PDP-12 computer. Secondary site speed data was in the form of an audio signal whose frequency was proportional to speed of the car and required no preprocessing. Special assembly language programs on the PDP-12 computer created LINC tapes consisting of digitized video and speed information for every car passing through the primary site observation window, and the PDP-12 computer translated these data into digital format in the following ways. Pulse codes recorded at the primary site indicated the start and stop of collection of speed and video-based lateral position information. Lateral position information was digitized by a direct analog-to-digital (A/D) conversions at 0.1-second intervals, and speed data were tabulated by counting the number of doppler radar pulses which occurred within a corresponding 0.1-second interval. These data were then transferred in digital format to LINC tapes for data transmission to the Sigma-6 at a later time.

The secondary site speed data were also processed by counting the number of doppler radar pulses occurring within a 0.1-second window to form a history of speed. These data were stored in digital form on LINC tapes.

The second major phase of data processing (see Figure 9) consisted of transmission to the Xerox Sigma-6 computer for the ultimate purpose of statistical analysis of these data. Utility programs on the PDP-12 and the Sigma-6 computers enabled the transfer of data between the two machines over telephone lines at a 4800 BAUD rate, and binary tapes were created on the Sigma-6 as a result of these transmissions. The binary format of these tapes optimized the speed and accuracy of the transmission process but would be unacceptable in format as a basis for further statistical

DATA RETRIEVAL ON THE PDP-12

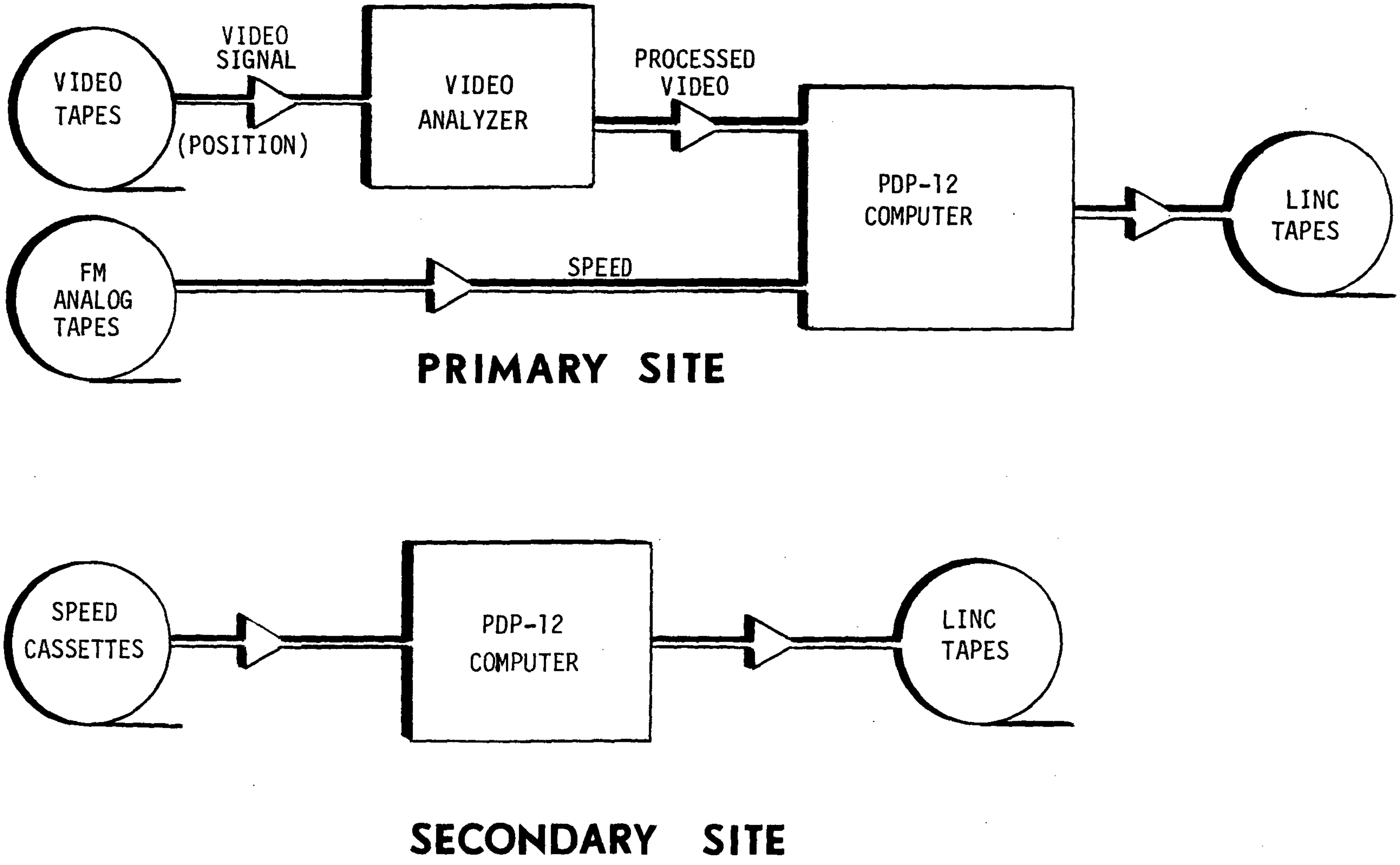

Figure 8: Data Retrieval on the PDP-12

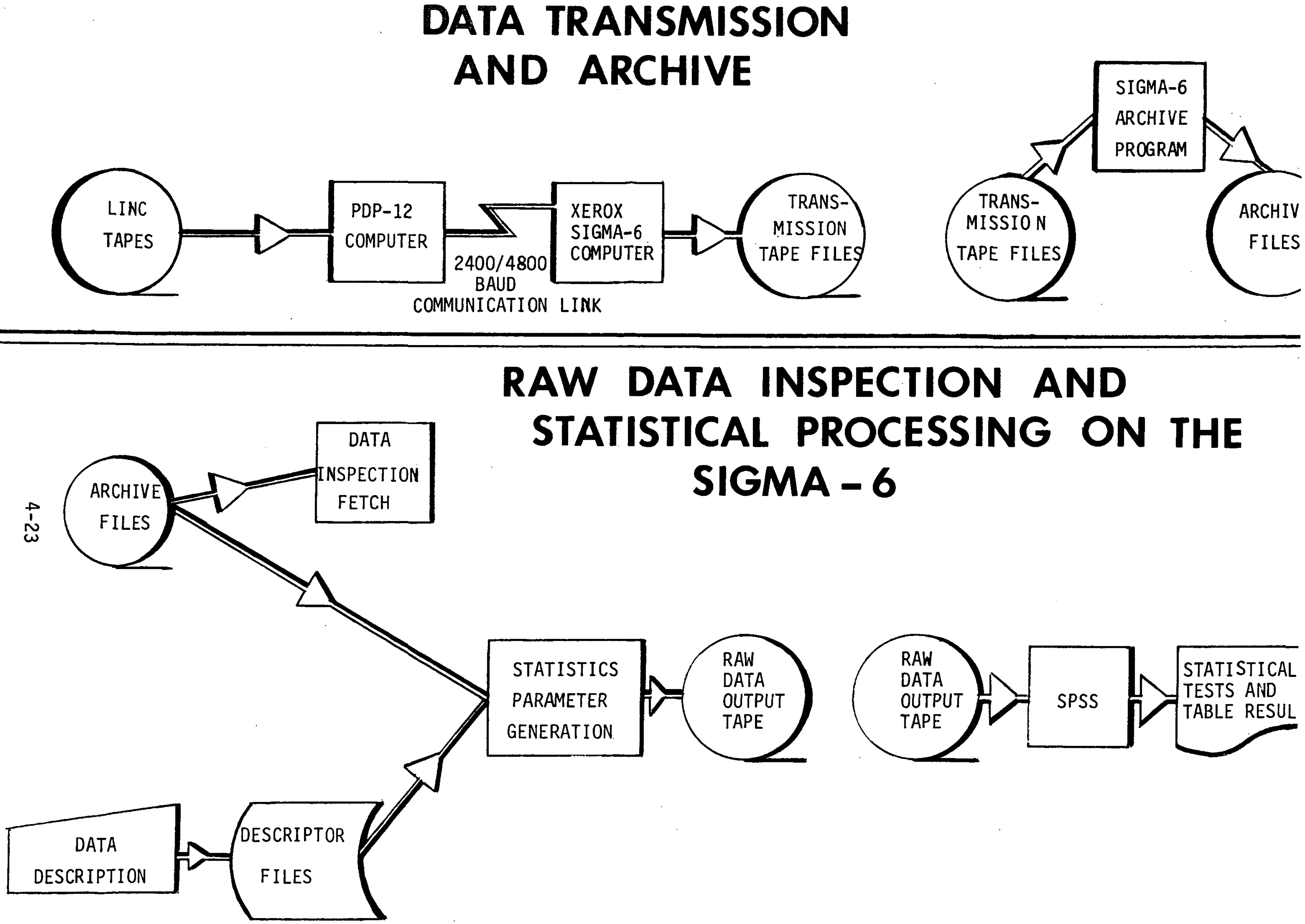

Figure 9: Data Processing Procedures

processing. For this reason a translation or "archiving" process was developed to place these tapes in a more readable and efficient format. The archived data formed the basis of the statistical parameter extraction process.

Before any statistical operations were performed, the data in the tape archive files were checked for errors that may have occurred during the rather lengthy and involved transmission and archiving process. This inspection process was implemented with a package of routines called FETCH. These FETCH routines enabled the listing of raw data as well as the production of graphic plots of the raw data. Bad data sets discovered through FETCH were retransmitted and archived so that the final set of archived data files were as error-free as possible.

The archived files of raw data formed part of the input to the statistical parameter generation routines whose functions were to reduce the extensive raw data for each subject into a few statistics which would summarize the salient characteristics of the driver's performance. These generated statistics were always linked to descriptor information so that subsequent analyses could be made with respect to BAC, roadblock number, etc. The descriptive data were entered manually into descriptor files which, along with the raw data archived tapes, formed the input to the statistical parameter generator programs (see Figure 9).

Although separate parameter generators were used for primary and secondary site data, there were some common conceptual and program elements shared by the two programs. These similarities centered on problems of noise in the speed data. Noise in the speed data consisted of spikes and dropouts in the speed history which falsely indciated sudden bursts of extreme speed or complete cessation of motion: situations patently impossible. These problems were due to difficulties inherent in doppler radar electronics, and they originally posed a serious difficulty to data analysis. Given bursts of noise in the speed record, statistics such as maximum and minimum speed and maximum and minimum acceleration (defined as changes in speed as a function of time) would be totally invalid. Furthermore, the computation of a distance function, defined as the integration of speed over time, would be erroneous and lead to problems in the interpretation of lateral position. Because of parallax in the optics of the video system, estimated lateral position was closely related to the distance of the car from the television camera. Consequently, errors in the estimation of distance would invalidate road position information. Noise in the speed record could be localized easily by visual inspection, but this technique would be totally impractical for the large volume of speed data to be processed.

An automated technique was developed to detect and eliminate noise in the speed record. This algorithm involved the computation of a polynomial regression equation and the subsequent exclusion of data points falling radically outside the estimates derived from this equation. This heuristic effectively screened speed data for noise without eliminating fine structure. Several other analytic techniques were evaluated to filter out spikes and dropouts including Fourier analysis and power spectrum analysis. Given the relatively small number of data points in a series to be filtered (e.g., 75 to 180), these techniques did not yield useful data as output; valid data points which should have been included in a series were often excluded and vice versa.

An alternative technique was developed for filtering data using a polynomial regression approach combined with several heuristics to decide upon the inclusion or exclusion of a given data point in a time series for computation of summary statistics. This technique combined the speed of automatic decision making for inclusion or exclusion while retaining many of the positive judgmental aspects of human decision making.

This heuristic scheme operated as follows. Incoming data consisted of an array of speed values in miles-per-hour sampled at 0.1-second intervals. The output consisted of summary statistics on mean and standard deviation of acceleration, minimum and maximum acceleration, and the times corresponding to these minimum and maximum points. The screening process for the decision to include or exclude a given speed data point in the computation of summary statistics was based upon least squares regression procedures. A working array of X values corresponding to time was created parallel to an array of Y values or speed measurements. An initial scan was made to eliminate very high or very low speed values from further computations, such that speeds greater than 90 mph or less than 5 mph eliminated that pair of X and Y data points from further calculations. A third order polynomial regression equation was then fitted to these X and Y values, and the raw regression weights and standard error of estimate obtained. An array of predicted Y values ($\hat{Y}$) was then computed and a comparison made between the observed and predicted Y values. If any observed Y value deviated more than 1.5 standard errors from the predicted value then that pair of X and Y values was excluded from further computations. This regression process was repeated until either 5 polynomial regressions had been computed (i.e., 5 passes of the data through the filter) or until the number of points eliminated from the arrays by the filtering process was 10% or less of the original number of points before the regression was performed. Thus, each pass through the filter eliminated deviant values and reduced the size of the data arrays.

The value and the operational function of the heuristics were determined empirically. The order of the polynomial regression equation was fixed at three after some empirical work since this order represented a good compromise between eliminating dropouts and spikes while still including valid data points. Higher order polynomial equations tended to eliminate points which should have been included (based on visual inspection criteria) while lower order equations tended to include obvious dropouts and spikes as valid data points. Closely related to and interacting with the choice of the degree of the polynomial was the size of the tolerance judged acceptable for a point to be excluded from the predicted regression line. If the tolerance was too large invalid points would be included, and if tolerance was too small fine structure in the data would be lost. An empirical criterion of ± 1.5 standard errors was chosen, because it was most effective for the third order equations used. A maximum of 5 passes of the regression filter were used if a criterion of 10% or less attrition rate of points was not reached first. Typically, the regression filter will converge on the 10% or less criterion in two or three passes of the regression program so the need for five or more passes of the regression filter was rarely required.

Statistics generated from both speed and lateral position data are based on filtered speed (and hence distance) functions, and reflect the most error free parameters possible given the high volume of data to be processed. It should be pointed out, however, that the heuristic process is NOT a perfect filter. Some invalid data can still be included into computations, but test runs have indicated that this rate of error is 5% or less. Statistics obtained from the filtered speed data can be interpreted with confidence, and errors introduced by the filtered data will be considerably less than other sources of error in the system. Descriptions of the parameters generated for the primary and secondary speed data are tabulated and described in Table 1 along with descriptions of lateral position statistics.

The statistical parameters and descriptor variables were placed together on a raw data output tape for subsequent processing by the Statistical Package for the Social Sciences (SPSS).

Table 1

Statistical Parameters for
Driving Performance Data

Primary and Secondary Site Speed[1]

1) Maximum and minimum speed
2) Time of maximum and minimum speed
3) Maximum acceleration and deceleration
4) Time of maximum acceleration and deceleration
5) Mean and standard deviation of speed
6) Mean and standard deviation of acceleration
7) Entering speed

Primary Site Lateral Position Statistics[2]

1) Mean and standard deviation of vehicle from standard calibration track signature
2) Individual track signature parameters for vehicle

[1] All statistics based on filtered speed function.

[2] Distance function for the computation of lateral position statistics based on an integrated and filtered speed function.

Chapter 5

RESULTS AND DISCUSSION

Three categories of data were obtained in the present roadside research project: (1) breath alcohol concentration; (2) personal interview data; and (3) instrumented measures of driving performance. The analyzed data in these three categories are organized and presented in this chapter in terms of the following headings: (1) breath alcohol concentration; (2) interview data; and (3) performance measures.

It must be noted that the number of cross-tabulations and analyses which could be done on the collected data are staggering. Since time and concentration are always finite, effort was directed to those questions and hypotheses which were primary to the goals of the project. Accordingly, the results presented in this report were deemed to be the most important and/or the most interesting. Those data which we felt to be of paramount importance are found in the body of the text while additional information which may be of interest to some readers is presented in the appendices.

In order to maximize the readability and utility of this report, a number of decisions were made concerning which variables, cross-tabulations, and specific analyses should be reported and in what organizational format. The first decision concerned whether to present the simple tabulations of responses to all interview questions. It was decided that the response frequencies and percentages for the multiple choice questions in both the long and short interviews should be presented along with the questions. These data can be found in Appendices B and C for the long and short interviews respectively. Data regarding obtained BACs are presented in Table 2 of this chapter.

Second, a decision had to be made about the basic population of interest. Since male motorists are the most important population-at-risk and also comprised over 79% of the total number of long interview participants, many of the cross-tabulations of interview data for this population are found in the text. In most cases, the comparisons made for the male motorists were also made for the female respondents and these data can be found in the appendices.

Third, it is noted that a sex segregation was not followed for any comparisons involving the performance data. It was decided that both maximum N and maximum utility of these data could be served best by analyses which included all motorists.

Fourth, the BACs reported for interview data are based upon BACs obtained with the Breathalyzer. With regard to the performance data, the Breathalyzer BAC was used in cases for which both Breathalyzer and ASD BACs were obtained. The performance measures for motorists who submitted only to the short interview and ASD breath test are included in the data base with the appropriate ASD reading. As noted in Section 5.1.2, the ASD and Breathalyzer readings were highly correlated so comparisons based upon BACs obtained with the ASD only are reasonably accurate measures of breath alcohol concentrations and their use in lieu of a Breathalyzer reading is justified.

5.1 BREATH ALCOHOL CONCENTRATION

Two different chemical tests were used to obtain breath alcohol concentrations: the Breathalyzer (Model 900) and the Alcohol Screening Device (see section 3.3 above). Although almost all stopped motorists provided a breath sample for ASD analysis, the BAC values determined subsequently by the Breathalyzer for those motorists who were interviewed in the trailer were used in preference to the ASD readings in all analyses involving this latter group of motorists. The Breathalyzer determination was used in preference to the ASD determination simply because it was obtained using a widely-tested, well-established method, rather than a newly developed prototype method.

5.1.1 Distribution of Breath Alcohol Concentration

Since two different methods were used for determining breath alcohol concentrations during the present roadside research survey, the two sets of BAC data are presented separately and are arranged by type of interview (long form questionnaire in the trailer versus short form questionnaire at carside) and accordingly by the type of alcohol test (Breathalyzer versus Alcohol Screening Device, respectively) (see Table 2).

The class intervals for analyzing and presenting the distribution of BAC were selected on the basis of the following assumptions and reasons: (1) .000 to .009 is the first class interval and is taken to mean "no detectable alcohol present" since it conservatively includes the probable limits of instrumentation error; (2) .010 to .049 is taken to mean "low detectable alcohol present," but not sufficient to be legally admissible in court and thus not deemed to be dangerous under normal circumstances; (3) .050 to .079 begins with the BAC which is the lower limit for admissibility in court and terminates just below the BAC which is taken to be legally impairing in Utah, as well as in Canada, Great Britain, and many other countries; (4) .080 to .099 begins at the lower limit of legal impairment in the aforementioned jurisdictions, terminates with the BAC just below legal impairment in almost all of the United States, and includes the upper range of BACs which are legally admissible in court for alcohol-aggravated driving incidents; (5) .100 to .149 begins with the BAC which is legally impairing (regardless of whether presumptive or per se) according to federal standard and to almost all state statutes; and (6) .150 and above is the uppermost class interval and begins with the BAC that is taken by some to be one symptom of problem drinking and that was formerly the lower limit of legal impairment in many states.

To minimize the use of numbers in some of the following text, the following conventions are used to label the different regions of the BAC scale: "no alcohol" or "zero BAC" refers to the first class interval (.000 to .009); "low BAC" or "low alcohol" refers to the second class interval (.010 to .049); "medium BAC" or "medium alcohol" refers to the third and fourth class intervals, that is, to the mid-portion of the scale from .050 to .099; and "high BAC" or "high alcohol" refers to the last two class intervals, that is, to the legally impairing portion of the scale from .100 and up.

BAC data were available for 95% (1,663) of 1,757 motorists stopped. The 94 missing cases include 85 motorists (4.8%) who refused the Alcohol Screening Device test at carside, 39 motorists (2.2%) who refused to participate in the interview at carside, and 5 motorists (0.3%) who refused the Breathalyzer test in the trailer (Table 2). It should be

Table 2

All Motorists Stopped Arranged by Type of Interview and Alcohol Test According to Breath Alcohol Concentration

BAC	Long Form + Breathalyzer		Short Form + Alcohol Screening Device		Total	
	N	%	N	%	N	%
.000 to .009	378	51.4	312	33.6	690	41.5
.010 to .049	175	23.8	571	61.5	746	44.8
.050 to .079	82	11.2	31	3.3	113	6.8
.080 to .099	29	3.9	9	1.0	38	2.3
.100 to .149	55	7.5	3	0.3	58	3.5
.150 and above	16	2.2	2	0.2	18	1.1
Missing	9[a]	-	85[b]	-	94[c]	-
Total	744	(42.3)	1,013	(57.6)	1,757	99.9

[a] These missing cases represent 1.2% of the group total (744) and include 5 motorists (0.6%) who refused the Breathalyzer test in the trailer.

[b] These missing cases representing 8.4% of the group total (1,013) are comprised of the 85 motorists (8.4% who refused the Alcohol Screening Device test at carside) and include 39 motorists (2.2%) who refused to participate in the interview.

[c] The total missing cases represent 5.4% of the grand total of motorists stopped (1,757).

noted again that special efforts were made by the "greeter" at carside to encourage any motorist with a substantial BAC (determined by the ASD) to participate in the survey by going to the trailer for the long form interview and Breathalyzer test. As a result, proportionately few motorists with high BACs are found in the column headed "Short Form + Alcohol Screening Device." Thus, despite possible differences between the results obtained from the two determination methods (see next subsection, 5.1.2), the best estimate of the distribution of breath alcohol concentrations among 95% of a 100% sample of late night, weekend drivers is found in the total column of Table 2.

Although 58% of the 1,663 motorists tested had detectable alcohol, the vast majority of these (45% of the total number) had BACs at the low "non-dangerous" end of the scale (.010 to .049). A total of 14% had BACs of .05 or higher, again with the vast majority of these (9% of the total number) falling in the potentially dangerous but not legally impaired mid-region of the scale (.050 to .099). Legally impairing BACs of .10 or higher were found in 5% of these motorists, with 1% being at .15 or higher. It is interesting to note that the proportion of motorists in this highest region of the BAC scale in the present study is identical to the proportion found among 1,125 motorists tested in an earlier roadside research survey conducted on similar roads but at times and places of previous fatal and serious injury crashes (Perrine et al., 1971, p. 75). The highest BAC recorded in the present survey was .260 (Breathalyzer).

5.1.2 Comparison of the Two Breath Alcohol Determination Methods

A regression analysis was performed on the BACs obtained from the Alcohol Screening Device and from the Breathalyzer to determine the relationship between the two alcohol determination methods. It can be seen from Table 3 that there was a very strong linear relationship between them. The Pearson correlation coefficient was .874, and this coefficient squared indicates that over 76% of the variance in the BAC measurements is accounted for by ASD measurements. This correlation coefficient was significant at $p < .001$. Thus, the ASD readings can be considered good predictors of the Breathalyzer readings.

Table 3

Regression of Alcohol Screening Device BAC on Breathalyzer BAC

Parameter	Value
r	.874
r^2	.764
Regression equation	
b (weight)	1.144
a (constant)	-13.607.

The parameters for plotting a regression line are also found in Table 3, where "a" indicates the y-axis intercept and "b" indicates the slope. These parameters indicate one additional aspect of the relationship beyond the fact that the two measurements are highly related. The intercept parameter "a" shows that the ASD readings tend to be higher than the Breathalyzer readings which indicates a consistent trend for the ASD to overestimate the BAC as indicated by the Breathalyzer for the range of most BACs.

An example of the use of this regression equation can be illustrated through the prediction of the best estimate of a Breathalyzer BAC when given only an ASD reading. The given value of the ASD/BAC for this example is 100 mg% (.100), and the best estimate of a Breathalyzer BAC is determined from the parameters in Table 3:

$$\begin{aligned} \text{BAC/Breathalyzer} &= 1.144 \times (\text{BAC/ASD}) - 13.607 \\ &= 1.144 \times 100 - 13.607 \\ &= 100.793 \text{ mg\% (or .10079)} \end{aligned}$$

The predictions generated by this equation are optimal in a least-squares sense and are subject to the limitations of the linear regression statistics themselves. For example, predictions at the very high or very low limits of ASD/BAC will not have the same confidence bounds as those closer to the middle of the distribution (Marascuilo, 1971, pp. 488-490). This shift can readily be illustrated using the above values to determine estimated Breathalyzer BACs from ASD readings (presented in mg% and in reverse order: ASD then estimated BAC, respectively): 10 = > -2.17; 20 = > 9.27; 30 = > 20.71; 40 = > 32.15; 50 = > 43.59; 75 = > 72.19; 100 = > 100.79; 125 = > 129.39; 150 = > 157.99; etc. Based on the correlation coefficient and the regression parameters, it can be concluded that statistically, these two devices are virtually identical in their determinations of BAC in the critical mid-region of the scale.

It should be noted that the ASDs were used under adverse conditions during data collection (e.g., constant external use requiring battery power at temperatures as low as 10^0 Fahrenheit and very rapid purge requirements when traffic flow was heavy). Therefore, they should perform even better under more controlled conditions. However, we did experience frequent mechanical problems which required the attention of technicians at the Transportation Systems Center, and these difficulties should be solved before the ASDs are considered ready for broader application.

5.2 INTERVIEW DATA

The data presented in this subsection were compiled from responses obtained from the group of motorists who received the long form questionnaire and the Breathalyzer test. A large number of variables are compiled in table format here and in Appendix D. The table headings indicate whether the data represent responses from male motorists, female motorists, all motorists, or any other subpopulation designated. Most of the tables presented will be for either male or female motorists or both. In general, the selected variables have been cross-tabulated by BAC and some variables have been cross-tabulated by age as well. Further subdivisions include drinking variables, knowledge concerning alcohol use and driving, and certain driving variables.

5.2.1 Cross-tabulations by Breath Alcohol Concentration

The variables presented below show the most important relations between measured BAC and self-reported biographical, drinking, and driving data.

5.2.1.1 Biographical Variables and BAC

Data from on-road surveys, such as that reported here, are frequently analyzed first to determine the "type" of respondents participating in the survey. These cross-tabulations also serve as a starting point for analyses of the present data.

5.2.1.1.1 Sex (Table 4). Males were significantly over-represented in the same proportion (79%) as they had been in the previous Vermont roadside research survey (Perrine et al., 1971, p. 109). However, an even higher proportion of males (90%) was found among legally impaired drivers. Regarding within-sex comparisons, approximately the same proportion of males (16%) as females (13%) was found with medium BACs. However, proportionately more than twice as many males (11%) as females (5%) were found at the high BACs of .10 or above. It is noteworthy and consistent with other studies that few if any female drivers are found in the highest BAC category; in the present case, there were none, compared with 3% of male drivers at .15 or higher. Thus, driving at elevated BACs continues to be more a male than a female practice.

Table 4

Sex of All Respondents According to BAC

BAC	Male		Female		Total	
	N	%	N	%	N	%
.000 to .009	275	47.2	101	66.4	376	51.2
.010 to .049	152	26.1	25	16.4	177	24.0
.050 to .079	71	12.2	11	7.2	82	11.2
.080 to .099	21	3.6	8	5.3	29	3.9
.100 to .149	48	8.2	7	4.6	55	7.5
.150 and above	16	2.7	0	0.0	16	2.2
Total	583	(79.3)	152	(20.7)	735	100.0

$\chi^2(5) = 23.7, p < .001$

5.2.1.1.2 Age (Tables 5 and 6). The basic distribution of age among nocturnal male motorists is an important consideration. Approximately 20% were age 20 or younger, 40% were 24 or younger, and 60% were 29 or younger. The age distribution among female motorists was essentially the same.

Among drivers of both sexes, persons age 20 or under and age 60 or older were much less likely to have alcohol than were individuals in the intervening years. Among male drivers (Table 5), approximately the same proportion of each class interval from 18 to 20 through 40 to 49 years of age was found with medium BACs (.05 to .099), namely, 16%. However, the majority (57%) of those in the upper portion of this BAC region (.08 to .099) were between the ages of 18 and 24 inclusive. The vast majority (80%) of legally impaired male drivers were in their 20's and 30's (21 to 39 years of age), whereas males in these two decades comprised only 60% of the sample. As a general observation, it can be said that among male drivers with potentially dangerous BACs (.08 or higher), the peak shifts gradually upward to higher BACs as age increases from 18 to 20 on up through 30 to 39.

Among female motorists (Table 6), proportionately more in their 20's and 30's are found in the middle BAC region, whereas the vast majority (71%) of the legally impaired women were between 30 and 59 years of age. This apparent upward shift in age range of impaired females as compared with the ages of impaired males may merely indicate that 30+ age females are more likely to be driving after drinking than younger females.

5.2.1.1.3 Marital Status (Tables 7 and 8). Most male drivers were either married (46%) or single (45%), but 5% were divorced, 3% were separated, and 1% were widowed. The proportion of these drivers with no alcohol was approximately the same in each category of marital status as their representation in the total sample, with the exception of the divorced and separated drivers who were under-represented at no alcohol. At the other end of the BAC scale among those legally impaired (11%), only the married males were proportionately represented (46%), with the single males being under-represented (33%) and both the divorced and separated categories being over-represented (respectively 11% and 10% at .10 or

Table 5

Age of Male Respondents According to BAC

BAC	14 - 17		18 - 20		21 - 24		25 - 29		30 - 39		40 - 49		50 - 59		60 and over		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	16	59.3	42	48.8	56	45.2	51	44.3	45	41.3	32	49.2	23	57.5	10	58.8	275	47.2
.010 to .049	9	33.3	22	25.6	33	26.6	30	26.1	27	24.7	17	26.2	9	22.5	5	29.4	2	26.1
.050 to .079	1	3.7	12	14.0	14	11.3	15	13.0	16	14.7	9	13.8	3	7.5	1	5.9	71	12.2
.080 to .099	0	0.0	6	7.0	6	4.8	2	1.7	2	1.8	2	3.1	2	5.0	1	5.9	21	3.6
.100 to .149	1	3.7	4	4.6	14	11.2	10	8.7	11	10.1	5	7.7	3	7.5	0	0.0	48	8.2
.150 and above	0	0.0	0	0.0	1	0.8	7	6.1	8	7.3	0	0.0	0	0.0	0	0.0	16	2.7
Total	27	(4.6)	86	(14.7)	124	(21.3)	115	(19.7)	109	(18.7)	65	(11.1)	40	(6.9)	17	(2.9)	583	100.0

$\chi^2(35) = 41.65$, $p = .204$

Table 6

Age of Female Respondents According to BAC

BAC	14 - 17		18 - 20		21 - 24		25 - 29		30 - 39		40 - 49		50 - 59		60 and over		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	5	100.0	14	60.9	22	62.9	14	56.0	21	72.4	14	73.7	9	75.0	2	50.0	101	66.5
.010 to .049	0	0.0	5	21.7	8	22.9	6	24.0	5	17.2	0	0.0	0	0.0	1	25.0	25	16.5
.050 to .079	0	0.0	0	0.0	3	8.6	3	12.0	2	6.9	1	5.3	1	8.3	1	25.0	11	7.2
.080 to .099	0	0.0	4	17.4	0	0.0	2	8.0	0	0.0	2	10.5	0	0.0	0	0.0	8	5.3
.100 to .149	0	0.0	0	0.0	2	5.7	0	0.0	1	3.4	2	10.5	2	16.7	0	0.0	7	4.6
.150 and above	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	5	(3.3)	23	(15.1)	35	(23.0)	25	(16.5)	29	(19.1)	19	(12.5)	12	(7.9)	4	(2.6)	152	100.1

$\chi^2(28) = 35.34$, p = .160

Table 7

Marital Status of Male Respondents According to BAC

BAC	Married		Single		Divorced		Separated		Widowed		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	133	49.3	128	49.0	9	30.0	4	25.0	0	0.0	274	47.2
.010 to .049	71	26.4	66	25.3	8	26.7	4	25.0	3	60.0	152	26.2
.050 to .079	29	10.8	33	12.6	6	20.0	2	12.5	1	20.0	71	12.2
.080 to .099	7	2.6	13	5.0	0	0.0	0	0.0	1	20.0	21	3.6
.100 to .149	22	8.2	18	6.9	4	13.3	4	25.0	0	0.0	48	8.3
.150 and above	7	2.6	3	1.1	3	10.0	2	12.5	0	0.0	15	2.6
Total	269	(46.3)	261	(44.9)	30	(5.2)	16	(2.8)	5	(0.9)	581	100.1

$\chi^2(20) = 40.45$, $p = .004$

Table 8

Marital Status of Female Respondents According to BAC

BAC	Married		Single		Divorced		Separated		Widowed		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	47	75.8	38	64.4	11	55.0	3	60.0	2	33.3	101	66.0
.010 to .049	9	14.5	11	18.6	2	10.0	1	20.0	2	33.3	25	16.4
.050 to .079	3	4.8	3	5.1	4	20.0	0	0.0	1	16.7	11	7.2
.080 to .099	1	1.6	5	8.5	2	10.0	0	0.0	0	0.0	8	5.2
.100 to .149	2	3.2	2	3.4	1	5.0	1	20.00	1	16.7	7	4.6
Total	62	(40.7)	59	(38.8)	20	(13.1)	5	(3.2)	6	(3.9)	152	100.0

$\chi^2(16) = 19.72$, $p = .233$

higher). Regarding within-group comparisons, 11% of married males and 8% of single males were legally impaired, whereas 23% of divorced and 38% of separated male drivers were legally impaired. These findings are generally consistent with those of other studies, although the proportion of divorced and separated male drivers is appreciably higher in the present study.

For female drivers, it can be seen in Table 8 that a somewhat smaller proportion were married and single compared to male drivers, but a slightly higher proportion of female drivers were either divorced or widowed. Regarding female respondents who were legally impaired, it can be seen in Table 8 that approximately 11.9% of single females were in this category while 10% of all females were legally impaired. As indicated by the non-significant chi-square for this table, these figures are not disproportionate to the total female population sample. However, it should be noted that nearly 50% of the legally impaired female respondents were single.

5.2.1.1.4 Occupational Level (Table 9). Although the responses to Question 3 were originally coded for analysis by using the standard Hollingshead categories, these were collapsed to the following four categories: (1) upper occupational level (professional; semi-professional; manager, proprietor or executive; farm owner; or sales), (2) middle occupational level (farm manager; craftsman or foreman; clerical worker; vehicle operator; service or protection), (3) lower occupational level (farm laborer or farm foreman; non-farm laborer), and (4) other (student, retired, or other). A large proportion of these male motorists were in the upper occupational level (35%) relative to the earlier Vermont study (Perrine et al., 1971) (25%). Proportionally more male motorists in the upper occupational level (15%) were legally impaired than in the middle (10%), lower (9%), or other (7%) occupational level. Furthermore, of those male motorists who were impaired, 47% were in the "upper" occupations.

Table 9

Occupational Level of Male Respondents According to BAC

BAC	Upper		Middle		Lower		Other		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	100	51.8	73	44.5	56	44.4	34	48.6	263	47.6
.010 to .049	94	22.8	41	25.0	33	26.2	24	34.3	142	25.7
.050 to .079	17	8.8	26	15.9	21	16.7	6	8.6	70	12.6
.080 to .099	4	2.1	8	4.9	5	4.0	1	1.4	18	3.3
.100 to .144	21	10.9	12	7.3	8	6.3	4	5.7	45	8.1
.150 and above	7	3.6	4	2.4	3	2.4	1	1.4	15	2.7
Total	193	(34.9)	164	(29.7)	126	(22.8)	70	(12.7)	553	100.1

$\chi^2(15) = 56.45, p < .001$

5.2.1.1.5 Education (Tables 10 and 11). The educational level obtained by the respondents to our survey was analyzed to determine whether this factor was related to measured BACs. No significant relationship was found between education and BAC for male respondents (Table 10). However, a barely significant difference was obtained when the education of female respondents was cross-tabulated by BAC. Table 11 shows this distribution. Although the total N is relatively small for a table of this size (152 cases) and leads one to question the significance of the data, interesting dichotomies appear at either end of the education scale. Specifically, females with 0 to 8 grades of education or with graduate school work were found to have either very low or very high BACs. The authors place no particular significance on this finding considering the number of cases in this sample, but the apparent differences are intriguing and suggest attention to education level of females for future surveys.

5.2.1.2 Drinking Variables and BAC

Three categories of drinking variables are considered here: (1) the typical patterns of alcohol use, (2) the most recent alcohol use prior to being stopped for the roadside research survey, and (3) knowledge concerning the amount of alcohol considered personally safe to consume prior to driving.

Table 10

Education of Male Respondents According to BAC

BAC	0 - 8		9 - 12		Post High School		College Degree		Graduate Work		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	23	54.7	137	46.4	57	43.1	29	47.5	28	54.9	274	47.1
.010 to .049	8	19.0	80	27.1	35	26.5	17	27.8	11	21.5	151	25.9
.050 to .079	5	11.9	38	12.8	18	13.6	5	8.2	5	9.8	71	12.2
.080 to .099	2	4.7	13	4.4	3	2.2	3	4.9	0	0.0	21	3.6
.100 to .149	3	7.1	22	7.4	13	9.8	5	8.2	5	9.8	48	8.2
.150 and above	1	2.3	5	1.6	6	4.5	2	3.2	2	3.9	16	2.7
Total	42	(7.2)	295	(50.7)	132	(22.7)	61	(10.5)	51	(8.7)	581	100.0

$\chi^2(20) = 11.79$, $p = .923$

Table 11

Education of Female Respondents According to BAC

BAC	0 - 8		9 - 12		Post High School		College Degree		Graduate Work		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	8	80.0	59	73.7	25	56.8	5	41.6	4	66.6	101	66.4
.010 to .049	0	0.0	11	13.7	10	22.7	3	25.0	1	16.6	25	16.4
.050 to .079	0	0.0	5	6.2	3	6.8	3	25.0	0	0.0	11	7.2
.080 to .099	0	0.0	3	3.7	5	11.3	0	0.0	0	0.0	8	5.2
.100 to .149	2	20.0	2	2.5	1	2.2	1	8.3	1	16.6	7	4.6
Total	10	(6.6)	80	(52.6)	44	(28.9)	12	(7.8)	6	(4.0)	152	100.0

$\chi^2(16) = 26.36$, $p = .049$

5.2.1.2.1 Typical Patterns of Alcohol Use (Tables 12 through 25). When given a choice, it is very clear that beer is the preferred beverage among male motorists, with 64% selecting beer, 29% liquor, and 7% wine. Relative to these proportions, beer drinkers with no alcohol at the time of the survey were slightly under-represented, liquor drinkers slightly over-represented, and wine drinkers were proportionally represented. However, at the other end of the BAC scale among those legally impaired, beer drinkers were considerably over-represented (76%), liquor drinkers slightly under-represented (23%), and wine drinkers appreciably under-represented (2%). Regarding comparisons within the beverage-preference groups, no alcohol was found in 42% of beer drinkers, 55% of liquor drinkers, and 51% of wine drinkers. However, legally impairing BACs were found among 13% of beer drinkers, 9% of liquor drinkers, and 3% of wine drinkers. Thus, these data provide further evidence that beer drinking among male motorists is at least as much a menace to highway safety as liquor drinking.

Regarding female motorists, the patterns of beverage preference and their relation to findings of no alcohol and impairing alcohol were essentially just the opposite of those discussed above for the male drivers (Table 13). Thus, liquor is overwhelmingly preferred (64%) to beer (21%) and wine (15%). Nearly all of the legally impaired female drivers preferred liquor (86%) as opposed to beer (14%).

Regarding beer consumption, Tables 14-17 show the quantities and frequencies of consuming both usual amount of beer and more than usual amount of beer for male respondents. The high frequency and high quantity portions of these tables are of particular interest. Regarding usual quantity of beer consumed, 18% of these male drivers report 5 bottles or more, but respondents in this quantity category are substantially over-represented among motorists with a BAC of .08 or higher (30%). Furthermore, there is a tendency for the proportion of legally impaired motorists to increase with increases in the usual number of bottles consumed. More specifically, the proportion of legally impaired among respondents who say they usually have one bottle of beer is 6% and 2 bottles is 11%, whereas it is 19% for those reporting 5 bottles or more. The same general pattern obtains regarding the more than usual quantity of beer (Table 15), except

Table 12

Beverage Preference of Male Respondents According to BAC

BAC	Beer		Wine		Liquor		Total	
	N	%	N	%	N	%	N	%
.000 to .009	147	41.5	19	51.4	89	55.0	255	46.1
.010 to .049	97	27.4	14	37.8	36	22.2	147	26.6
.050 to .079	51	14.4	0	0.0	18	11.1	69	12.5
.080 to .099	12	3.4	3	8.1	5	3.1	20	3.6
.100 to .149	35	9.9	0	0.0	12	7.4	47	8.5
.150 and above	12	3.4	1	2.7	2	1.2	15	2.7
Total	354	(64.0)	37	(6.7)	162	(29.3)	553	100.00

$\chi^2(10) = 21.82, p < .02$

Table 13

Beverage Preference of Female Respondents According to BAC

BAC	Beer		Wine		Liquor		Total	
	N	%	N	%	N	%	N	%
.000 to .009	19	67.9	16	80.0	48	55.8	83	61.9
.010 to .049	5	17.9	2	10.0	18	20.9	25	18.7
.050 to .079	3	10.7	1	5.0	7	8.1	11	8.2
.080 to .099	0	0.0	1	5.0	7	8.1	8	6.0
.100 to .149	1	3.6	0	0.0	6	7.0	7	5.2
Total	28	(20.9)	20	(14.9)	86	(64.2)	134	100.00

$\chi^2(8) = 7.33, p < .50$

Table 14

Quantity of Beer Usually Consumed by Male Respondents According to BAC

BAC	1 Bottle		2 Bottles		3 Bottles		4 Bottles		5 Bottles or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	61	62.2	66	46.2	39	34.0	23	34.8	38	42.2	227	44.3
.010 to .049	23	23.5	40	28.0	40	34.8	24	36.4	12	13.3	139	27.1
.050 to .079	5	5.1	17	11.9	21	18.3	8	12.1	16	17.8	67	13.1
.080 to .099	3	3.1	4	2.8	4	3.5	2	3.0	7	7.8	20	3.9
.100 to .149	6	6.1	12	8.4	7	6.1	7	10.6	13	14.4	45	8.8
.150 and above	0	0.0	4	2.8	4	3.5	2	3.0	4	4.4	14	2.7
Total	98	(19.1)	143	(27.9)	115	(22.5)	66	(12.9)	90	(17.6)	512	99.9

$\chi^2(20) = 45.13$, $p = .001$

Table 15

Quantity of Beer When More Than Usual Amount Is Consumed by Male Respondents According to BAC

BAC	1 - 2 Bottles		3 - 4 Bottles		5 - 6 Bottles		7 Bottles or More		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	38	62.3	49	47.6	68	41.5	66	37.5	221	43.8
.010 to .049	15	24.6	32	31.1	49	29.9	43	24.4	139	27.6
.050 to .079	3	5.0	6	5.8	29	17.7	28	15.9	66	13.1
.080 to .099	0	0.0	6	5.8	3	1.8	11	6.3	20	4.0
.100 to .149	5	8.2	8	7.8	12	7.3	19	10.8	44	8.7
.150 and above	0	0.0	2	1.9	3	1.8	9	5.1	14	2.8
Total	61	(12.1)	103	(20.4)	164	(32.5)	176	(34.9)	504	100.00

$\chi^2(15) = 34.28$, $p = .003$

Table 16

Frequency of Consuming Usual Amount of Beer by Male Respondents According to BAC

BAC	Frequency									
	Once a Day and More		Once a Week and More		Once a Month and More		Less Than Once a Month		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	42	31.8	114	43.5	43	58.1	27	61.4	226	44.1
.010 to .049	34	25.8	73	27.9	22	29.7	11	25.0	140	27.3
.050 to .079	21	15.9	35	13.3	6	8.1	5	11.4	67	13.1
.080 to .099	9	6.8	11	4.2	0	0.0	0	0.0	20	3.9
.100 to .149	21	15.9	21	8.0	3	4.0	0	0.0	45	8.8
.150 and above	5	3.8	8	3.1	0	0.0	1	2.3	14	2.8
Total	132	(25.8)	262	(51.2)	74	(14.4)	44	(8.6)	512	100.00

$\chi^2(15) = 37.27, p < .01$

Table 17

Frequency of Consuming More Than Usual Amount of Beer by Male Respondents According to BAC

BAC	Once a week or more		Once a month or more		Less than once a month		Never		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	16	27.1	59	36.0	102	50.2	44	55.7	221	43.8
.010 to .049	17	28.8	42	25.6	62	30.5	19	24.0	140	27.7
.050 to .079	11	18.6	31	18.9	20	9.9	5	6.3	67	13.3
.080 to .099	1	1.7	11	6.7	7	3.4	1	1.3	20	4.0
.100 to .149	10	16.9	16	9.8	10	4.9	7	8.9	43	8.5
.150 and above	4	6.8	5	3.0	2	1.0	3	3.8	14	2.8
Total	59	(11.7)	164	(32.5)	203	(40.2)	79	(15.6)	505	100.0

$\chi^2(15) = 41.53, p < .001$

that the quantity scale is a few bottles higher in each case.

Regarding frequency of consuming the usual amount of beer (Table 16), half the respondents report once or several times a week. Furthermore, although those who reported drinking beer at least once a day comprised 26% of the sample, those in this group who were legally impaired comprised 44% of all male motorists in the sample who had a BAC of .10 or higher. Not only were these daily beer drinkers proportionally over-represented among legally impaired drivers, but they also had the highest within-group proportion of legally impaired drivers (20%). A very similar, but even more pronounced pattern was found with the data concerning the frequency of consuming more than the usual amount of beer (Table 17). In general terms, heavy and frequent consumption of beer is highly associated with legally impairing BACs obtained from male motorists tested at roadside late in the evening.

Similar cross-tabulations of frequency and quantity of beer consumption for female respondents are presented in Appendix D. Consistent with the female respondents' preference for liquor rather than beer, Tables LI-1 to LI-4 in Appendix D indicate no striking relationships between beer consumption and BAC. Indeed, the female motorists included in our sample appear to rarely drink large quantities of beer and very infrequently consume more than their usual amounts of this beverage.

Further analyses were conducted on beer consumption data for male motorists who prefer beer to determine if this subpopulation accounts for the high frequency and quantity of consumption portions noted in the preceding tables for all male motorists. Tables LI-5 to LI-8 in Appendix D show these data. Comparisons between all male motorists questioned and those males who reported they prefer beer as their beverage of choice reveals virtually no differences in proportions. Since such a large proportion of the male motorists reported that they preferred beer, these consistencies may be expected.

Regarding liquor consumption for male motorists (Tables 18, 19, 20, and 21), patterns of relations emerged which are generally similar to those described immediately above for beer. Thus, although those who reported usually consuming 5 shots of liquor or more comprised 19% of the total sample of male motorists, they represented 29% of those legally

Table 18

Quantity of Liquor Usually Consumed by Male Respondents According to BAC

BAC	1 Shot		2 Shots		3 Shots		4 Shots		5 Shots or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	57	60.6	66	49.6	32	43.2	21	38.9	32	38.1	208	47.4
.010 to .049	22	23.4	32	24.1	25	33.8	14	25.9	20	23.8	113	25.7
.050 to .079	7	7.4	14	10.5	7	9.5	12	22.2	15	17.9	55	12.5
.080 to .099	4	4.3	8	6.0	0	0.0	2	3.7	4	4.8	18	4.1
.100 to .149	3	3.2	11	8.3	10	13.5	4	7.4	11	13.1	39	8.9
.150 and above	1	1.1	2	1.5	0	0.0	1	1.9	2	2.4	6	1.4
Total	94	(21.4)	133	(30.3)	74	(16.9)	54	(12.3)	84	(19.1)	439	100.0

$\chi^2(20) = 30.68, p = .059$

Table 19

Frequency of Drinking Liquor by Male Respondents According to BAC

BAC	3 Times or More a Day		2 Times a Day		Once a Day		Several Times a Week		Once a Week		Several Times a Month		Once a Month		Less Than Once a Month		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	1	33.3	1	33.3	1	5.9	37	57.8	22	37.9	29	59.2	34	45.9	84	48.6	209	47.4
.010 to .049	1	33.3	1	33.3	4	23.5	14	21.9	20	34.5	11	22.4	17	23.0	45	26.0	113	25.6
.050 to .079	0	0.0	0	0.0	3	17.6	7	10.9	8	13.8	6	12.2	12	16.2	20	11.6	56	12.7
.080 to .099	0	0.0	1	33.3	3	17.6	0	0.0	3	5.2	0	0.0	5	6.8	6	3.5	18	4.1
.100 to .149	1	33.3	0	0.0	5	29.4	5	7.8	5	8.6	2	4.1	4	5.4	17	9.8	39	8.8
.150 and above	0	0.0	0	0.0	1	5.9	1	1.6	0	0.0	1	2.0	2	2.7	1	0.6	6	1.4
Total	3	(0.7)	3	(0.7)	17	(3.8)	64	(14.5)	58	(13.1)	49	(11.1)	74	(16.8)	173	(39.2)	441	100.1

$\chi^2(35) = 54.05, p < .01$

Table 20

Quantity of Liquor When More Than Usual Amount Is Consumed by Male Respondents According to BAC

BAC	1-2 Shots		3-4 Shots		5-6 Shots		7 Shots or More		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	42	52.5	54	51.4	48	46.6	55	40.7	199	47.0
.010 to .049	18	22.5	26	24.8	29	28.2	38	28.1	111	26.2
.050 to .079	10	12.5	12	11.4	14	13.6	19	14.1	55	13.0
.080 to .099	4	5.0	5	4.8	3	2.9	5	3.7	17	4.0
.100 to .149	5	6.3	6	5.7	9	8.7	16	11.8	36	8.5
.150 and above	1	1.3	2	1.9	0	0.0	2	1.5	5	1.2
Total	80	(18.9)	105	(24.8)	103	(24.3)	135	(31.9)	423	100.1

$\chi^2(15) = 8.98$, p = .879

Table 21

Frequency of Consuming More Than Usual Amount of Liquor by Male Respondents According to BAC

BAC	Once a week or More		Several Times a Month		Once a Month		More than twice a Year		Once or Twice a Year		Never		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	5	27.8	5	38.5	24	39.3	42	46.7	75	54.3	53	47.3	204	47.2
.010 to .049	3	16.7	4	30.8	17	27.9	24	26.7	39	28.3	26	23.2	113	26.2
.050 to .079	3	16.7	1	7.7	11	18.0	11	12.2	12	8.7	17	51.2	55	12.7
.080 to .099	0	0.0	2	15.4	4	6.6	5	5.6	3	2.2	3	2.7	17	3.9
.100 to .149	5	27.8	1	7.7	5	8.2	7	7.8	9	6.5	11	9.8	38	8.8
.150 and above	2	11.1	0	0.0	0	0.0	1	1.1	0	0.0	2	1.8	5	1.2
Total	18	(4.1)	13	(3.0)	61	(14.1)	90	(20.8)	138	(31.9)	112	(25.9)	432	99.9

$\chi^2(25) = 44.44$, p = .010

impaired. Similarly, although those reporting that they drink liquor at least once a day comprised 5% of the total sample of male motorists, they represented 16% of those who were legally impaired. Furthermore, BACs of .10 of higher were found among 16% of male motorists reporting they usually have 5 shots of liquor or more and among 30% of those reporting that they usually drink liquor at least once a day. Also as was the case with beer, the more than usual quantity and frequency data were very similar to the usual quantity and frequency, but were even more pronounced (Tables 20 and 21). For example, those who reported drinking more than their usual amount of liquor at least once a week comprised 4% of all male motorists. Those in this category who were legally impaired represented 16% of all males who had a BAC of .10 or higher. Perhaps even more startling, almost 40% of male motorists who reported drinking more than their usual amounts at least once a week were legally impaired while driving at the time of our roadside surveys.

In view of the relatively high BACs actually determined among male motorists who report that they typically have 5 or more drinks and atypically have 7 or more drinks, as well as among those who report drinking these quantities very frequently, it seems reasonable to assume that "the more than usual amount" reported is more likely "the usual amount."

Regarding liquor consumption for female motorists, Table 22 reveals that few female respondents report drinking more than 3 shots of liquor when they are consuming their usual amounts. It is particularly interesting that all female respondents with BACs of .10 or above reported drinking no more than 3 shots as their usual consumption level. These data are somewhat surprising since female respondents generally reported that they preferred liquor to beer. It is noteworthy, however, that the female respondents reported rather frequent drinking of liquor (Table 23). Nearly 33% of the female motorists reported drinking liquor at least once a week.

Additional cross-tabulations of quantity and frequency of liquor when more than the usual amount is consumed by female respondents are presented in Tables LI-9 and LI-10 in Appendix D. These data indicate a slight shift upward in terms of the number of shots of liquor, but very infrequent consumption of more than the usual amounts of liquor by female respondents.

Table 22

Quantity of Liquor Usually Consumed by Female Respondents According to BAC

BAC	1 Shot		2 Shots		3 Shots		4 Shots		5 Shots or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	25	78.1	25	54.3	13	56.5	8	57.1	7	70.0	78	62.4
.010 to .049	3	9.4	12	26.1	3	13.0	4	28.6	0	0.0	22	17.6
.050 to .079	3	9.4	3	6.5	4	17.4	0	0.0	0	0.0	10	8.0
.080 to .099	0	0.0	1	2.2	2	8.7	2	14.3	3	30.0	8	6.4
.100 to .149	1	3.1	5	10.9	1	4.3	0	0.0	0	0.0	7	5.6
Total	32	(25.6)	46	(36.8)	23	(18.4)	14	(11.2)	10	(8.0)	125	100.0

$x^2(16) = 30.41$, $p = .016$

Table 23

Frequency of Drinking Liquor by Female Respondents According to BAC

BAC	Once a Day		Several Times a Week		Once a Week		Several Times a Month		Once a Month		Less Than Once a Month		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	0	0.0	4	33.3	14	58.3	17	65.4	15	71.4	27	77.1	77	63.1
.010 to .049	1	25.0	3	25.0	5	20.8	4	15.4	4	8.6	3	8.6	20	16.4
.050 to .079	1	25.0	2	16.7	3	12.5	2	7.7	1	2.9	1	2.9	10	8.2
.080 to .099	0	0.0	2	16.7	1	4.2	2	7.7	1	5.7	2	5.7	8	6.6
.100 to .149	2	50.0	1	8.3	1	4.2	1	3.8	0	5.7	2	5.7	7	5.7
Total	4	(3.3)	12	(9.8)	24	(19.7)	26	(21.3)	21	(17.2)	35	(28.7)	122	100.0

$x^2(20) = 30.37$, $p < .05$

Regarding wine consumption, Tables 24 and 25 show that quantity of wine consumed by male motorists is not an apparent indicator of the BACs of motorists that were stopped. However, there is some indication that frequent wine drinking (once a week or more) is disproportionately evident for male motorists with .10 or higher BACs. Incidentally, one male motorist above .15 indicated that he preferred wine and one male motorist above .15 indicated that he drinks wine three or more times a day. If these responses were made by the same individual, it is likely he represents the proverbial "wino" population.

Tables for frequency and quantity of wine consumed by female respondents are presented in Table LI-11 and LI-12 in Appendix D.

In concluding this discussion of alcohol consumption data, it should be noted that although the within-group proportions of liquor and of beer drinkers among male respondents in the legally impairing BAC categories were essentially the same, the very frequent drinkers of more than usual quantity of beer greatly outnumbered their liquor-drinking counterparts at the high BACs by a factor of 2 or 3 times, in absolute numbers.

5.2.1.2.2 Most Recent Alcohol Use (Tables 26 through 31). Several questions were asked in an attempt to obtain information concerning aspects of drinking which had occurred most recently in terms of the time of the roadside survey. From the point of view of the chemical test for BAC, the elapsed time since the last drink was an important variable (Table 26). Although just over half of all male motorists had consumed alcohol during the previous 3 hours, those in this category comprised almost all (97%) legally impaired respondents. Similarly, those who had been drinking within the previous hour comprised 35% of the sample, but among those who were legally impaired, they comprised a disproportionately high 72%. Conversely, among male motorists who had been drinking within the previous hour, 24% were legally impaired (i.e., proportionately twice as many of the total sample who were legally impaired -- 12%). These data indicate increasing the time between last drinking and subsequent driving of a motor vehicle could be an effective countermeasure to DWI.

Another of the more important variables concerning most recent alcohol use is the location at which the last drinking had occurred (Table 27).

Table 24

Quantity of Wine Usually Consumed by Male Respondents According to BAC

BAC	1 Glass		2 Glasses		3 Glasses		4 Glasses		5 Glasses or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	60	47.6	48	50.5	12	37.5	9	60.0	18	50.0	147	48.4
.010 to .049	41	32.5	25	26.3	7	21.9	4	26.7	7	19.4	84	27.6
.050 to .079	10	7.9	12	12.6	7	21.9	1	6.7	4	11.1	34	11.2
.080 to .099	6	4.8	2	2.1	1	3.1	0	0.0	2	5.6	11	3.6
.100 to .149	9	7.1	7	7.4	4	12.5	1	6.7	3	8.3	24	7.9
.150 and above	0	0.0	1	1.0	1	3.1	0	0.0	2	5.6	4	1.3
Total	126	(41.4)	95	(31.3)	32	(10.5)	15	(4.9)	36	(11.8)	304	100.0

$\chi^2(20) = 19.29$, $p = .503$

Table 25

Frequency of Drinking Wine by Male Respondents According to BAC

BAC	3 or More Times a Day		Once a Day		Several Times a Week		Once a Week		Several Times a Month		Once a Month		Less Than Once a Month		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	1	50.0	1	9.1	16	50.0	19	57.6	20	45.4	24	51.1	64	47.8	145	47.9
.010 to .049	0	0.0	5	45.4	11	34.4	6	18.2	10	22.7	10	21.2	42	31.3	84	27.7
.050 to .079	0	0.0	1	9.1	0	0.0	3	9.1	8	18.2	8	17.0	14	10.4	34	11.2
.080 to .099	0	0.0	2	18.2	1	3.1	1	3.0	2	4.5	1	2.1	4	3.0	11	3.6
.100 to .149	0	0.0	2	18.2	3	9.4	3	9.1	4	9.1	3	6.4	10	7.5	25	8.3
.150 and above	1	50.0	0	0.0	1	3.1	1	3.0	0	0.0	1	2.1	0	0.0	4	1.3
Total	2	(.7)	11	(3.6)	32	(10.6)	33	(10.9)	44	(14.5)	47	(15.5)	134	(44.2)	303	100.0

$\chi^2(30) = 65.93$, $p < .001$

Although approximately equal proportions of the sample had last been drinking either at home (20%), at the home of a friend or relative (24%), or at a bar (26%), the proportion of those legally impaired drivers in each category was vastly different: 5% at home, 18% at the home of a friend or relative, and 46% at a bar. Furthermore, the proportion within each of these three location categories who were legally impaired also showed considerable differences; BACs of .10 or higher were found among 3% of those drinking at home, 9% of those drinking at the home of a friend or relative, and 21% of those drinking at a bar.

A subsequent question of interest concerns the age of motorists who had been drinking at various locations. Table 28 shows a general trend for male motorists to drink at restaurants or at home (their own or others) as age increases. Drinking at a bar is primarily an activity of 18-39 year old male motorists. It is interesting that 8 of the 21 male motorists under 18 years of age reported they had been drinking at home prior to being stopped. The validity of this self report is unknown of course, and the data may reflect an unwillingness to state last location as an illegal activity. In any case, 3 respondents under 18 years old reported they had been drinking at a restaurant. Examination of the data concerning the type of the last beverage consumed (Table 29) reveals a pattern which is essentially identical to that obtained for beverage preference according to BAC (Table 12), that is, the vast majority of male motorists (68%) had been drinking beer and they comprised a slightly higher proportion (74%) of those who were legally impaired. Regarding those male motorists who reported their last drinking was done in a car, nearly all of these respondents had been drinking beer (Table 30) and over 50% of them were between the ages of 21 and 29 (Table 31).

Another interesting facet of the most recent alcohol use by the nocturnal male motorists consists of origin and destination data. To provide a glimpse of this information in terms of alcohol use, the mean BACs arranged by origin of trip are presented in Table 32 according to beverage preference, and in Table 33 according to destination. As would be expected, the higher mean BACs were found among those motorists coming from an evening out dining and/or dancing, or from drinking at a bar, etc. (Table 32). Although slightly higher for those among the male motorists

Table 26

Time Since Last Alcohol Consumed by Male Respondents According to BAC

BAC	Less than 15 Minutes		15 Minutes - 1 Hour		1 - 3 Hours		3 - 6 Hours		6 - 24 Hours		More than 24 Hours		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	4	8.9	17	12.3	34	29.3	37	66.1	34	77.3	107	84.3	233	44.3
.010 to .049	12	26.7	44	31.8	39	33.6	16	28.6	9	20.5	20	15.7	140	26.6
.050 to .079	15	33.3	31	22.5	23	19.8	1	1.8	1	2.3	0	0.0	71	13.5
.080 to .099	3	6.7	13	9.4	5	4.3	0	0.0	0	0.0	0	0.0	21	4.0
.100 to .149	8	17.8	25	18.1	12	10.3	2	3.6	0	0.0	0	0.0	47	9.0
.150 and above	3	6.7	8	5.8	3	2.6	0	0.0	0	0.0	0	0.0	14	2.7
Total	45	(8.6)	138	(26.2)	116	(22.1)	56	(10.6)	44	(8.4)	127	(24.1)	526	100.0

$\chi^2(25) = 242.91, p < .001$

Table 27

Location of Last Drinking Activity by Male Respondents According to BAC

BAC	Home		Home of a Relative		Home of a Friend		Bar		Restaurant		Car		Private Club or Fraternity		Other		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	78	72.9	12	42.9	48	48.5	32	23.5	30	43.5	5	17.2	6	42.9	21	48.8	232	44.2
.010 to .049	25	23.4	6	21.4	26	26.3	34	25.0	20	29.0	15	51.7	5	35.7	9	20.9	140	26.7
.050 to .079	1	0.9	4	14.3	15	15.2	35	25.7	7	10.1	5	17.2	0	0.0	4	9.3	71	13.5
.080 to .099	0	0.0	1	3.6	4	4.0	7	5.1	3	4.3	1	3.4	1	7.1	4	9.3	21	4.0
.100 to .149	0	0.0	4	14.3	5	5.1	22	16.2	7	10.1	3	10.3	2	14.3	4	9.3	47	8.9
.150 and above	3	2.8	1	3.6	1	1.0	6	4.4	2	2.9	0	0.0	0	0.0	1	2.3	14	2.7
Total	107	(20.4)	28	(5.4)	99	(18.9)	136	(25.9)	69	(13.1)	29	(5.5)	14	(2.7)	43	(8.2)	525	99.9

$\chi^2(35) = 111.09, p < .001$

Table 28

Location of Last Drinking Activity for Male Respondents According to Age

Age	Home		Home of a relative		Home of a friend		Bar		Restaurant		Car		Private club or fraternity		Other		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
14 - 17	8	7.5	0	0.0	4	4.0	1	0.7	3	4.3	1	3.4	1	7.1	3	6.8	21	4.0
18 - 20	11	10.3	3	10.7	20	20.0	30	22.1	3	4.3	5	17.2	0	0.0	11	25.0	83	15.7
21 - 24	29	27.1	3	10.7	23	23.0	36	26.5	8	11.4	9	31.0	2	14.3	6	13.6	116	22.0
25 - 29	18	16.8	6	21.4	15	15.0	33	24.3	18	25.7	8	27.6	3	21.4	5	11.4	106	20.1
30 - 39	18	16.8	9	32.1	17	17.0	23	16.9	12	17.1	5	17.2	4	28.6	10	22.7	98	18.6
40 - 49	16	15.0	4	14.3	12	12.0	9	6.6	13	18.6	0	0.0	0	0.0	3	6.8	57	10.8
50 - 59	7	6.5	1	3.6	5	5.0	3	2.2	9	12.9	1	3.4	3	21.4	5	11.4	34	6.4
60 and over	0	0.0	2	7.1	4	4.0	1	0.7	4	5.7	0	0.0	1	7.1	1	2.3	13	2.5
Total	107	(20.3)	28	(5.3)	100	(18.9)	136	(25.8)	70	(13.3)	29	(5.5)	14	(2.7)	44	(8.3)	528	100.1

$x^2(49) = 90.84$, $p < .001$

Table 29

Last Beverage Consumed by Male Respondents According to BAC

BAC	Beer		Wine		Liquor		Total	
	N	%	N	%	N	%	N	%
.000 to .009	144	40.6	20	46.5	69	53.9	233	44.3
.010 to .049	101	28.4	13	30.2	25	19.5	139	26.4
.050 to .079	53	15.0	2	4.7	16	12.6	71	13.5
.080 to .099	12	3.4	5	11.6	4	3.1	21	4.0
.100 to .149	34	9.6	1	2.3	12	9.4	47	9.0
.150 and above	11	3.1	2	4.7	2	1.6	15	2.9
Total	355	(67.5)	43	(8.2)	128	(24.3)	526	100.0

$\chi^2(10) = 20.51, p = .025$

Table 30

Beverage Last Consumed by Males Who Had Been Drinking in Car According to BAC

BAC	Beer		Wine		Liquor		Total	
	N	%	N	%	N	%	N	%
.000 to .009	5	18.5	0	0.0	0	0.0	5	17.2
.010 to .049	14	51.8	1	100.0	0	0.0	15	51.7
.050 to .079	4	14.8	0	0.0	1	100.0	5	17.2
.080 to .099	1	3.7	0	0.0	0	0.0	1	3.5
.100 to .149	3	11.1	0	0.0	0	0.0	3	10.3
Total	27	(93.1)	1	(3.4)	1	(3.5)	29	100.0

$\chi^2(8) = 5.87, p = .662$

Table 31

Age of Males Who Had Been Drinking in Car According to BAC

BAC	14 - 17		18 - 20		21 - 24		25 - 29		30 - 39		50 - 59		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	0	0.0	3	60.0	1	11.1	1	12.5	0	0.0	0	0.0	5	17.2
.010 to .049	1	100.0	1	20.0	4	44.4	4	50.0	4	80.0	1	100.0	15	51.7
.050 to .079	0	0.0	1	20.0	2	22.2	1	12.5	1	20.0	0	0.0	5	17.2
.080 to .099	0	0.0	0	0.0	1	11.1	0	0.0	0	0.0	0	0.0	1	3.5
.100 to .149	0	0.0	0	0.0	1	11.1	2	25.0	0	0.0	0	0.0	3	10.3
Total	1	(3.4)	5	(17.2)	9	(31.0)	8	(27.6)	5	(17.2)	1	(3.5)	29	100.0

$\chi^2(20) = 15.31, p = .759$

who expressed a preference for beer, these mean BACs are essentially the same in 4 of the 6 cells, the most fascinating exception being the extremely high mean BAC for the 2 wine drinkers coming from a bar (.153). It is probable that these 2 individuals were actually drinking wine since Table 29 shows 2 individuals at .15 or higher who said that wine was the last beverage they had consumed. Perhaps less expected is the finding of detectable alcohol among the average male motorists who are driving from work. Although the number of cases involved is quite small, those who were coming from work and going to some sort of recreation produced a slightly higher mean BAC (.034) (Table 33). As expected, the vast majority of respondents were going home. However, the most striking cases in terms of origin and destination (Table 33) are: (1) the individual coming from a bar and going to work at a BAC of .11, and (2) the two individuals coming from visiting friends or relatives and going out for an evening of dining or dancing with a mean BAC of .135.

5.2.1.2.3 Knowledge Concerning Alcohol Use and Driving (Tables 34 and 35). In order to obtain each individual's estimate of his own prudent cutoff level, we asked how many shots of liquor (or bottles of beer) he felt he could drink and still drive safely within about an hour. The results of these two questions provide further evidence for the double standard by whch beer and liquor are frequently -- and differently -- judged. In this particular case, a higher proportion of respondents reported a higher number of bottles of beer than shots of liquor as their safe limit. Thus, 53% of these male drivers felt they could drive safely after four or more bottles of beer (and 33% felt they could do so after five or more bottles of beer), whereas 30% felt they could drive safely after four or more shots of liquor (and 16% felt they could do so after five or more shots of liquor). Of particular interest was the finding that those who felt they could drive safely after five or more bottles of beer comprised 33% of the sample, but represented 51% of the sample who were legally impaired. This over-representation is clearly consistent with their actual driving behavior at high BACs; and it would be especially important to obtain a response to the same question when they had not had anything to drink, i.e., had a zero BAC as opposed to being asked the

Table 32

Mean BAC of Male Respondents Arranged by Activity Coming From According to Beverage Preference

Activity Coming From	Beer		Wine		Liquor	
	Mean	N	Mean	N	Mean	N
Work	.022	59	.024	8	.012	26
Home	.034	30	.009	6	.016	8
Visiting friends or family	.026	95	.006	7	.019	41
Recreation	.027	19	.010	1	.029	8
Entertainment	.020	41	.010	11	.018	21
Evening out dining and/or dancing	.065	37	.066	3	.040	26
Drinking at bar, lounge, etc.	.070	46	.153	2	.066	19
Other	.035	24	.047	3	.011	12

Table 33

Mean BAC of Male Respondents Arranged by Activity Coming From According to Activity Going To

Activity Coming From	Activity Going To															
	Work		Home		Visiting friends or relatives		Recreation		Entertainment		Evening out dining and/ or dancing		Drinking at a bar		Other	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
Work	.005	4	.017	80	.018	6	.034	5	-	-	-	-	.020	1	-	-
Home	.013	8	.025	4	.031	16	.010	2	.043	3	-	-	-	-	.050	7
Visiting friends or relatives	.002	3	.022	125	.019	10	-	-	-	-	.135	2	.035	2	.018	4
Recreation	.000	1	.029	19	.028	6	.110	1	-	-	-	-	.020	2	.035	1
Entertainment	.000	1	.018	71	.000	1	-	-	.018	2	-	-	-	-	.025	1
Evening out dining and/or dancing	-	-	.053	51	.053	4	.104	3	.000	1	.020	1	.080	2	.083	3
Drinking at a bar	.110	1	.067	55	.087	7	.110	2	-	-	-	-	.083	2	.060	1
Other	.050	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

question at a BAC of .10 or higher. It should also be noted that among individuals who responded five bottles of beer or more, a higher proportion was legally impaired (16%) than was the case for any other response category. Regarding the safe personal limit for liquor, a similar (but lower) pattern was obtained at the high end of the scale, i.e., 16% of the sample said five shots of liquor or more, but those in this response category comprised 26% of all legally impaired male motorists in this sample. However, rather curious results were obtained at the other end of the liquor scale such that among legally impaired male motorists, 18% said they felt that they could not drink any liquor at all and still feel that they could drive safely within about an hour; 14% felt this way concerning one shot, and 16% concerning two shots. Perhaps the vast majority of these individuals were exclusively beer drinkers (since a corresponding respect for small amounts of beer was not reflected in Table 34), or it might be hypothesized that many of these high alcohol drivers were feeling a bit contrite and were reflecting this feeling in their responses (although if this had been the case, one would expect the contriteness also to show in the beer question which actually preceded the liquor question in the interview).

Further analyses of knowledge concerning alcohol use and driving were undertaken to determine whether beverage preference (which presumably might indicate the individuals' experience with that particular beverage) was related to the individuals' knowledge concerning the amount of that beverage which could be consumed and still be considered safe for driving (Tables 36 and 37). For male respondents who prefer beer, Table 36 shows a strong relationship between the usual amount of beer consumed by these individuals and the number of beers they consider safe for driving. It can be seen that 62% of male respondents who prefer beer believe they can drink four bottles or more of beer within an hour and still drive safely. Of particular interest is the relationship between the usual amount of beer these respondents say they drink and the number of beers they consider themselves able to drink and still drive safely. It is noted that of the 70 individuals who said they usually consume five bottles or more of beer, 43 (61%) feel they can drink this amount in one hour and still drive safely. Of those respondents who say they generally drink <u>four</u>

Table 34

Number of Beers Considered Safe for Driving by Male Respondents According to BAC

BAC	None		1 Bottle		2 Bottles		3 Bottles		4 Bottles		5 Bottles or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	11	68.7	25	62.5	49	59.8	68	54.4	51	47.7	56	30.8	260	47.1
.010 to .049	4	25.0	10	25.0	22	26.8	30	24.0	29	27.1	48	26.4	143	25.9
.050 to .079	0	0.0	3	7.5	4	4.9	13	10.4	14	13.1	35	19.2	69	12.5
.080 to .099	0	0.0	0	0.0	2	2.4	5	4.0	1	0.9	13	7.1	21	3.8
.100 to .149	1	6.3	1	2.5	4	4.9	6	4.8	10	9.3	23	12.6	45	8.1
.150 and above	0	0.0	1	2.5	1	1.2	3	2.4	2	1.9	7	3.8	14	2.5
Total	16	(2.9)	40	(7.2)	82	(14.9)	125	(22.6)	107	(19.4)	182	(33.0)	552	99.9

$x^2(25) = 53.80 \quad p < .001$

Table 35

Number of Shots of Liquor Considered Safe for Driving by Male Respondents According to BAC

BAC	None		1 Shot		2 Shots		3 Shots		4 Shots		5 shots or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	28	49.1	40	55.6	76	57.6	50	43.9	31	44.3	29	33.3	254	47.7
.010 to .049	14	24.6	15	20.8	31	23.5	30	26.3	20	28.6	26	29.9	136	25.6
.050 to .079	5	8.8	5	6.9	12	9.1	20	17.5	9	12.9	14	16.1	65	12.2
.080 to .099	0	0.0	4	5.6	4	3.0	6	5.3	3	4.3	3	3.4	20	3.8
.100 to .149	6	10.5	6	8.3	6	4.5	7	6.1	4	5.7	14	16.1	43	8.1
.150 and above	4	7.0	2	2.8	3	2.3	1	0.9	3	4.3	1	1.1	14	2.6
Total	57	(10.7)	72	(13.5)	132	(24.8)	114	(21.4)	70	(13.2)	87	(16.3)	532	100.0

x^2 (25) = 37.83, $p < .05$

bottles or more of beer, 81% feel they can drink four bottles or more and still drive safely. These data show consistently high estimates of the number of beers which can be consumed within one hour and still leave the consumer safe for driving. Furthermore, the evidence suggests that those male motorists accustomed to drinking larger amounts of beer tend to estimate that they are able to hold larger amounts of beer and still drive safely.

A similar but less pronounced trend can be seen in the data regarding male respondents who prefer liquor (Table 37). This table shows that 33% of the males who prefer liquor believe that they can drink four shots or more of liquor within an hour and still drive safely. Also, 53% of those respondents who say they usually drink four or more shots believe that they can drive safely after consuming that amount of liquor. At the other end of the scale, only five respondents who prefer liquor do not feel safe driving after consuming any liquor at all. Furthermore, these five individuals indicate they usually drink only one or two shots. These data support the hypothesis that a large proportion of those individuals who feel they cannot drink any liquor at all and still drive safely are comprised primarily of individuals who prefer (and probably drink exclusively) beer.

Body weight is a particularly important variable regarding BACs obtained after consuming given amounts of alcoholic beverages. Clearly, heavier individuals generally can consume larger amounts of alcohol before reaching equivalent BACs to their lighter weight colleagues. A question of interest is whether the respondents to the survey relate their body weight to the amount of alcohol they can ingest and still drive safely. Considering only those individuals who apparently had consumed rather large amounts of alcohol (those individuals whose BACs were .10 or higher), cross-tabulations were done between weight of male respondents and the number of beers or shots of liquor which they considered they could drink within an hour and still drive safely. Tables 38 and 39 show these data. It can be seen that at least for male individuals with BACs above the legal limit there was no apparent relationship between their body weight and the amount of alcohol they believe they can consume and still drive safely.

Table 36

Number of Beers Considered Safe for Driving by Males Who Prefer Beer According to Usual Amount of Beer Consumed

Usual Amount of Beer	BEERS CONSIDERED SAFE													
	None		1 Bottle		2 Bottles		3 Bottles		4 Bottles		5 Bottles or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1 Bottle	1	50.0	6	40.0	14	34.1	13	17.3	7	8.5	7	5.1	48	13.7
2 Bottles	1	50.0	5	33.3	11	26.8	30	40.0	26	31.7	28	20.6	101	28.8
3 Bottles	0	0.0	2	13.3	8	19.5	18	24.0	17	20.7	31	22.8	76	21.6
4 Bottles	0	0.0	0	0.0	6	14.6	5	6.7	18	21.9	27	19.9	56	16.0
5 Bottles or More	0	0.0	2	13.3	2	4.9	9	12.0	14	17.1	43	31.6	70	19.9
Total	2	(0.6)	15	(4.3)	41	(11.7)	75	(21.4	82	(23.4)	136	(38.7)	351	100.0

$\chi^2(20) = 67.48, p < .001$

Table 37

Number of Shots Considered Safe for Driving by Males Who Prefer Liquor According to Usual Amount of Liquor Consumed

Usual Amount of Liquor	SHOTS CONSIDERED SAFE															
	None		1 Shot		2 Shots		3 Shots		4 Shots		5 Shots		6 Shots or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1 Shot	3	60.0	9	56.2	9	25.0	6	12.5	0	0.0	2	13.3	0	0.0	29	18.5
2 Shots	2	40.0	2	12.5	11	30.6	18	37.5	2	9.5	0	0.0	4	25.0	39	24.8
3 Shots	0	0.0	2	12.5	4	11.1	11	22.9	4	19.0	6	40.0	2	12.5	29	18.5
4 Shots	0	0.0	1	6.3	4	11.1	3	6.3	6	28.6	2	13.3	1	6.2	17	10.8
5 Shots or more	0	0.0	2	12.5	8	22.2	10	20.8	9	42.9	5	33.3	9	56.3	43	27.4
Total	5	(3.2)	16	(10.2)	36	(22.9)	48	(30.6)	21	(13.4)	15	(9.6)	16	(10.1)	157	100.0

$\chi^2(24) = 62.39, p < .001$

Table 38

Number of Beers Considered Safe for Driving by Males with BAC of .10 or Higher According to Weight

Weight	None		1 Bottle		2 Bottles		3 Bottles		4 Bottles		5 Bottles or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Less than 125	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	3.3	1	1.7
125 - 149	1	100.0	0	0.0	1	20.0	2	22.2	2	16.7	4	13.3	10	16.9
150 - 174	0	0.0	0	0.0	2	40.0	5	55.6	6	50.0	12	40.0	25	42.4
175 - 199	0	0.0	1	50.0	1	20.0	1	11.1	3	25.0	11	36.7	17	28.8
200 - 224	0	0.0	1	50.0	1	20.0	1	11.1	0	0.0	2	6.7	5	8.5
225 - 500	0	0.0	0	0.0	0	0.0	0	0.0	1	8.3	0	0.0	1	1.7
Total	1	(1.7)	2	(3.4)	5	(8.5)	9	(15.2)	12	(20.3)	30	(50.8)	59	100.0

$\chi^2(25) = 20.11, p < .80$

Table 39

Number of Shots Considered Safe for Driving by Males With BAC of .10 or Higher According to Weight

Weight	None		1 Shot		2 Shots		3 Shots		4 Shots		5 Shots		6 Shots or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Less than 125	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	8.3	1	1.7
125 - 149	4	40.0	0	0.0	3	33.3	1	12.5	1	14.3	0	0.0	1	8.3	10	17.5
150 - 174	4	40.0	2	25.0	6	66.7	3	37.5	3	42.9	1	33.3	4	33.3	23	40.3
175 - 199	2	20.0	3	37.5	0	0.0	2	25.0	3	42.9	2	66.7	4	33.3	16	28.1
200 - 224	0	0.0	2	25.0	0	0.0	2	25.0	0	0.0	0	0.0	2	16.7	6	10.5
225 - 500	0	0.0	1	12.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	1.8
Total	10	(17.5)	8	(14.0)	9	(15.8)	8	(14.0)	7	(12.3)	3	(5.3)	12	(21.1)	57	100.0

$\chi^2(30) = 30.88, p < .50$

Regarding the amounts of beer and liquor female respondents believe they can drink within an hour and still drive safely (Tables 40 and 41), lower estimates were given than for their male counterparts. Female respondents conservatively estimated the amount of beer they could consume, but the data show a positive relationship between higher estimates and higher BACs. Similar results were obtained for liquor (Table 41). Female motorists appear to have greater respect for the decremental influence of alcohol upon driving performance than do males. Considering the relative numbers of male and female motorists observed in this research, it may be suggested that differences in respect for the drug appear to be manifest also in differences in their willingness to drive at elevated BACs.

5.2.1.3 Driving Variables and BAC

One of the most persistent unanswered questions in this general problem area concerns the continued driving at higher BACs after one has been convicted of DWI. Although it was impossible to conduct the intended validation check using the official DMV records due to legal constraints discussed above, it is nevertheless possible to examine the self-reported number of DWI convictions (Table 42) and DWI crashes (Table 43) in terms of measured BAC on the occasion of the roadside research survey. In the earlier Vermont roadside research study (Perrine et al., 1971), a comparison of self-reported driving record (i.e., crashes, citations, and license suspensions) with official DMV records revealed a high degree of consistency, with a tendency for the self-reported numbers to be slightly larger than those recorded in the official files.

Regarding DWI convictions during the last three years (Table 42), 11% of male motorists reported having had one or more and almost 3% reported having two or more. Nevertheless, despite previous problems and punishment for this very behavior, those male drivers with one or more DWI convictions during the past three years comprised 19% of all those who were legally impaired and those with two or more DWI convictions comprised 5%. Conversely, among those motorists reporting one DWI conviction, 7% were legally impaired, and among those reporting two or more DWI convictions, 20% were legally impaired, whereas among those reporting no such convictions, 10% had BACs of .10 or higher. While these proportions are not

Table 40

Number of Beers Considered Safe for Driving by Female Respondents According to BAC

BAC	None		1 Bottle		2 Bottles		3 Bottles		4 Bottles		5 Bottles or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	15	83.3	28	84.8	22	68.7	20	58.8	6	37.5	1	25.0	92	67.1
.010 to .049	1	5.6	3	9.1	5	15.6	9	26.5	3	18.7	1	25.0	22	16.1
.050 to .079	1	5.6	0	0.0	2	6.2	3	8.8	4	25.0	0	0.0	10	7.3
.080 to .099	1	5.6	1	3.0	0	0.0	1	2.9	3	18.7	2	50.0	8	5.8
.100 to .149	0	0.0	1	3.0	3	9.4	1	2.9	0	0.0	0	0.0	5	3.6
Total	18	(13.1)	33	(24.1)	32	(23.4)	34	(24.8)	16	(11.7)	4	(2.9)	137	100.00

$\chi^2(20) = 45.44, p < .001$

Table 41

Number of Shots of Liquor Considered Safe for Driving by Female Respondents According to BAC

BAC	None		1 Shot		2 Shots		3 Shots		4 Shots		5 Shots or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	20	90.9	30	78.9	24	60.0	15	57.7	4	36.4	1	20.0	94	66.2
.010 to .049	0	0.0	6	15.8	7	17.5	5	19.2	4	36.4	2	40.0	24	16.9
.050 to .079	2	9.1	1	2.6	2	5.0	3	11.5	1	9.1	0	0.0	9	6.3
.080 to .099	0	0.0	0	0.0	1	2.5	3	11.5	2	18.2	2	40.0	8	5.6
.100 to .149	0	0.0	1	2.6	6	15.0	0	0.0	0	0.0	0	0.0	7	4.9
Total	22	(15.5)	38	(26.8)	40	(28.2)	26	(18.3)	11	(7.7)	5	(3.5)	142	100.0

$\chi^2(20) = 48.24, p < .001$

statistically different than expected, the absolute numbers merit concern.

Since a large proportion of DWI convictions result from a crash which is investigated by the police, it is not surprising that the data concerning the number of DWI crashes during the last three years according to BAC (Table 43) are very similar to those reported above for DWI convictions.

The relative effectiveness of legal punishment for a DWI conviction can be evaluated to some extent by examining the persistence of driving at potentially dangerous BACs. Among male motorists reporting no previous DWI convictions during the previous three years, 25% had BACs of .05 or higher, whereas among those reporting one or more DWI conviction during the same period, 40% were found to have BACs of .05 or higher. The overrepresentation of those with previous DWI accidents may be interpreted as an indication of the ineffectiveness of legal countermeasures, as well as the serious persistence of the misuse of alcohol.

5.2.2 Cross-tabulations by Age

Since age is a confounding factor in most of the key biographical variables examined in the present study (e.g., marital status, occupation), none of these cross-tabulations are presented in this subsection. Accordingly, the following material is limited to cross-tabulations of selected drinking variables and driving variables by age.

5.2.2.1 Drinking Variables and Age

Three categories of drinking variables are considered here: (1) the typical patterns of alcohol use, (2) the most recent alcohol use prior to being stopped for the roadside research survey, and (3) knowledge concerning the amount of alcohol considered personally safe to consume prior to driving.

5.2.2.1.1 Typical Patterns of Alcohol Use (Tables 44 through 52). Beer is the preferred beverage of 64% of male motorists in the present study (Table 44). When examined in terms of age, the proportion who prefer beer is extremely high among the younger male drivers (88% of the 14-to-17 year olds and approximately 72% of the 18-to-24 year olds);

Table 42

Number of DWI Convictions for Male Respondents According to BAC

BAC	None		1		2 or More		Total	
	N	%	N	%	N	%	N	%
.000 to .009	232	47.5	17	36.2	5	33.3	254	46.2
.010 to .049	132	27.0	12	25.5	3	20.0	147	26.7
.050 to .079	60	12.3	8	17.0	3	20.0	71	12.9
.080 to .099	16	3.3	2	4.3	1	6.7	19	3.5
.100 to .149	37	7.6	4	8.5	3	20.0	44	8.0
.150 and above	11	2.3	4	8.5	0	0.0	15	2.7
Total	488	(88.7)	47	(8.6)	15	(2.7)	550	100.0

$\chi^2(10) = 13.37$, $p = .204$

Table 43

Number of DWI Accidents for Male Respondents According to BAC

BAC	None		1		2 or More		Total	
	N	%	N	%	N	%	N	%
.000 to .009	233	48.5	17	32.1	3	20.0	253	46.2
.010 to .049	129	26.9	12	22.6	6	40.0	147	26.8
.050 to .079	57	11.9	12	22.6	1	6.7	70	12.8
.080 to .099	15	3.1	3	5.7	1	6.7	19	3.5
.100 to .149	37	7.7	3	5.7	4	26.7	44	8.0
.150 and above	9	1.9	6	11.3	0	0.0	15	2.7
Total	480	(87.6)	53	(9.7)	15	(2.7)	548	100.0

$\chi^2(10) = 35.43$, $p < .001$

however, the proportion who prefer beer gradually decreases with increasing age, especially after age 50 (i.e., 37% of those 50-to-59 years of age, and 21% of those 60 and over). Among the 30% of male drivers who would choose liquor first, a trend just opposite that for beer is found, with only 13% of the 14-to-17 year olds and 24% of the 18-to-24 year olds preferring liquor, as opposed to 50% of those 50-to-59 years of age and 71% of those 60 years and over. Conversely, the under-30 male drivers constitute 67% of those who prefer beer, 55% of those who prefer wine, and only 48% of those who prefer liquor. Since the proportions of male motorists who prefer these three beverage choices varies, a finer analysis of beverage consumption by age by BAC seemed warranted.

Table 44

Beverage Preference for Males According to Age

Age	Beer		Wine		Liquor		Total	
	N	%	N	%	N	%	N	%
14 - 17	21	5.9	0	0.0	3	1.8	24	4.3
18 - 20	61	17.2	2	5.3	23	14.1	86	15.5
21 - 24	86	24.2	7	18.4	25	15.3	118	21.2
25 - 29	71	20.0	12	31.6	27	16.6	110	19.8
30 - 39	68	19.2	8	21.1	28	17.2	104	18.7
40 - 49	31	8.7	3	7.9	28	17.2	62	11.2
50 - 59	14	3.9	5	13.2	19	11.7	38	6.8
60 and over	3	.8	1	2.6	10	6.1	14	2.5
Total	355	(63.8)	38	(6.8)	163	(29.3)	556	99.9

$\chi^2(14) = 49.74,\ p < .001$

Regarding beer consumption, the age differences noted above with respect to beer preference are especially pronounced in terms of the quantity and frequency measures. The relatively heavier and more frequent consumption among the younger male motorists is strikingly illustrated by the 18-to-20-year-old group. Approximately half these young men report that they usually drink four or more bottles of beer at a sitting (and a third of them report five or more bottles) and 84% of them report at least five bottles as their more than usual amount consumed (with 61% reporting at least one six-pack) (Tables 45 and 46). The reported frequency of consumption within this group is also very striking; 77% report drinking their usual amount of beer at least once a week (with 54% reporting at least several times a week and 14% reporting at least daily). Furthermore, slightly over half (57%) report drinking their more than usual amount of beer at least once a month (with 24% consuming this amount at least several times a month and 12% at least once a week) (Tables 47 and 48). The general trend in these four beer tables is for male drivers under 30 to report heavier and more frequent beer consumption than those age 40 and older.

Regarding <u>liquor consumption</u> (Tables 49, 50, 51, and 52), the differences attributable to age are less pronounced than was the case with beer, or was the case with liquor and BAC. Nevertheless, as with beer, the 18-to-20 year old male motorists presented a very striking profile of liquor use, with 28% reporting that they usually drink five or more shots at a sitting (Table 49) and with 51% reporting that they have at least seven shots when they drink more than usual amount (Table 50). Relative to beer however, the young men in this age category report a lower frequency of liquor consumption, with 24% reporting they drink their usual amount once a week or more frequently (Table 51) and 25% reporting that they drink more than their usual amount once a month or more frequently (Table 52). It should also be noted that among male motorists who report consuming at least five shots when they usually drink liquor, 64% are under 30 years of age (which is in approximately the same proportion as they are represented in the sample); however, among those who report having at least seven shots when they drink more than their usual amount, 72% are under 30. By contrast, male motorists age 40 and older are generally under-represented at the very high end of the distributions of usual liquor quantity and more than usual liquor quantity. Thus, a similar, but much less pronounced picture of heavy liquor drinking emerges from the data of the under-30 male motorists

Table 45

Quantity of Beer Usually Consumed by Male Respondents According to Age

Age	1 Bottle		2 Bottles		3 Bottles		4 Bottles		5 Bottles or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
14 - 17	3	3.0	7	4.9	6	5.2	4	6.1	4	4.4	24	4.7
18 - 20	2	2.0	20	13.9	18	15.5	12	18.2	31	34.4	83	16.1
21 - 24	19	19.2	27	18.8	29	25.0	17	25.8	21	23.3	113	21.9
25 - 29	13	13.1	33	22.9	28	24.1	12	18.2	16	17.8	102	19.8
30 - 39	19	19.2	34	23.6	16	13.8	16	24.2	12	13.3	97	18.8
40 - 49	24	24.2	11	7.6	12	10.3	5	7.6	5	5.6	57	11.1
50 - 59	14	14.1	10	6.9	5	4.3	0	0.0	1	1.1	30	5.8
60 and over	5	5.1	2	1.4	2	1.7	0	0.0	0	0.0	9	1.8
Total	99	(19.2)	144	(28.0)	116	(22.5)	66	(12.8)	90	(17.5)	515	100.0

$\chi^2(28) = 93.77$, $p < .001$

Table 46

Quantity of Beer When More Than Usual Amount Is Consumed by Male Respondents According to Age

Age	1 - 2 Bottles		3 - 4 Bottles		5 - 6 Bottles		More than 1 six pack		Total	
	N	%	N	%	N	%	N	%	N	%
14 - 17	2	3.2	2	1.9	13	7.9	7	4.0	24	4.7
18 - 20	3	4.8	10	9.5	19	11.6	50	28.4	82	16.2
21 - 24	8	12.9	18	17.1	39	23.8	46	26.1	111	21.9
25 - 29	7	11.3	18	17.1	44	26.8	32	18.2	101	19.9
30 - 39	12	19.4	26	24.8	26	15.9	31	17.6	95	18.7
40 - 49	13	21.0	16	15.2	18	11.0	9	5.1	56	11.0
50 - 59	15	24.2	10	9.5	3	1.8	1	.6	29	5.7
60 and over	2	3.2	5	4.8	2	1.2	0	0.0	9	1.7
Total	62	(12.2)	105	(20.7)	164	(32.3)	176	(34.7)	507	99.8

$\chi^2(21) = 121.32$, $p < .001$

Table 47

Frequency of Consuming Usual Amount of Beer by Male Respondents According to Age

Age	Once a day or more		Several times a week		Once a week		Several times a month		Once a month		Less than once a month		Never		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
14 - 17	2	1.5	5	2.7	6	7.9	4	11.8	4	9.8	3	6.7	0	0.0	24	4.3
18 - 20	12	9.1	35	18.7	19	25.0	7	20.6	6	14.6	3	6.7	4	8.7	86	15.3
21 - 24	33	25.0	40	21.4	17	22.4	8	23.5	6	14.6	9	20.0	7	15.2	120	21.4
25 - 29	29	22.0	45	24.1	11	14.5	7	20.6	7	17.1	4	8.9	8	17.4	111	19.8
30 - 39	31	23.5	32	17.1	11	14.5	6	17.6	7	17.1	10	22.2	8	17.4	105	18.7
40 - 49	15	11.4	21	11.2	7	9.2	0	0.0	5	12.2	9	20.0	6	13.0	63	11.2
50 - 59	9	6.8	6	3.2	4	5.3	1	2.9	5	12.2	5	11.1	8	17.4	38	6.8
60 and over	1	.8	3	1.6	1	1.3	1	2.9	1	2.4	2	4.4	5	10.9	14	2.5
Total	132	(23.5)	187	(33.3)	76	(13.5)	34	(6.1)	41	(7.3)	45	(8.0)	46	(8.2)	561	99.9

x^2 (42) = 79.80, p < .001

Table 48

Frequency of Consuming More Than Usual Amount of Beer by Male Respondents According to Age

Age	Once a Week or More		Several Times a Month		Once a Month		More than Twice a Year		Once or Twice a Year		Never		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
14 - 17	1	1.7	1	1.9	8	7.1	6	6.1	4	3.8	4	5.0	24	4.7
18 - 20	10	16.9	10	19.2	27	23.9	12	12.1	13	12.4	11	13.8	83	16.3
21 - 24	16	27.1	12	23.1	23	20.4	26	26.3	22	21.0	15	18.8	114	22.4
25 - 29	13	22.0	12	23.1	26	23.0	20	20.2	21	20.0	10	12.5	102	20.1
30 - 39	13	22.0	9	17.3	20	17.7	17	17.2	21	20.0	13	16.3	93	18.3
40 - 49	3	5.1	5	9.6	7	6.2	11	11.1	14	13.3	16	20.0	56	11.0
50 - 59	2	3.4	1	1.9	2	1.8	6	6.1	9	8.6	7	8.8	27	5.3
60 and over	1	1.7	2	3.8	0	0.0	1	1.0	1	1.0	4	5.0	9	1.8
Total	59	(11.6)	52	(10.2)	113	(22.2)	99	(19.5)	105	(20.7)	80	(15.7)	508	99.9

x^2(35) = 44.23, p = .136

Table 49

Quantity of Liquor Usually Consumed by Male Respondents According to Age

Age	1 Shot		2 Shots		3 Shots		4 Shots		5 Shots or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
14 - 17	4	4.3	2	1.5	5	6.8	0	0.0	2	2.3	13	3.0
18 - 20	8	8.5	19	14.3	11	14.9	8	14.8	18	20.9	64	14.5
21 - 24	22	23.4	34	25.6	13	17.6	13	24.1	18	20.9	100	22.7
25 - 29	12	12.8	26	19.5	19	25.7	14	25.9	17	19.8	88	20.0
30 - 39	14	14.9	21	15.8	13	17.6	8	14.8	21	24.4	77	17.5
40 - 49	19	20.2	16	12.0	5	6.8	4	7.4	9	10.5	53	12.0
50 - 59	13	13.8	9	6.8	7	9.5	5	9.3	0	0.0	34	7.7
60 and over	2	2.1	6	4.5	1	1.4	2	3.7	1	1.2	12	2.7
Total	94	(21.3)	133	(30.2)	74	(16.8)	54	(12.2)	86	(19.5)	441	100.1

$\chi^2(28) = 44.00$, $p = .028$

Table 50

Quantity of Liquor When More Than Usual Amount Is Consumed by Male Respondents According to Age

Age	1-2 shots		3-4 shots		5-6 shots		7 shots or more		Total	
	N	%	N	%	N	%	N	%	N	%
14 - 17	2	2.5	3	2.9	1	1.0	4	2.9	10	2.4
18 - 20	6	7.5	12	11.4	12	11.5	31	22.8	61	14.3
21 - 24	16	20.2	20	19.0	31	29.8	30	22.1	97	22.8
25 - 29	13	16.3	17	16.2	22	21.2	34	25.0	86	20.2
30 - 39	11	13.8	24	22.9	15	14.4	25	18.4	75	17.6
40 - 49	17	21.3	11	10.5	16	15.4	8	5.9	52	12.2
50 - 59	11	13.8	14	13.3	6	5.8	3	2.2	34	8.0
60 and over	4	5.0	4	3.8	1	1.0	1	.7	10	2.4
Total	80	(18.8)	105	(24.7)	104	(24.5)	136	(32.0)	425	99.9

$\chi^2(21) = 50.94$, $p < .001$

Table 51

Frequency of Consuming Usual Amount of Liquor by Male Respondents According to Age

Age	Once a day or more		Several times a week		Once a week		Several times a month		Once a month		Less than once a month		Never		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
14 - 17	0	0.0	0	0.0	0	0.0	1	2.0	3	4.1	9	5.2	11	9.6	24	4.3
18 - 20	1	4.3	8	12.3	12	20.7	6	12.2	11	14.9	27	15.5	21	18.3	86	15.4
21 - 24	4	17.4	9	13.8	12	20.7	15	30.6	19	25.7	41	23.6	20	17.4	120	21.5
25 - 29	1	4.3	17	26.2	11	19.0	8	16.3	18	24.3	33	19.0	21	18.3	109	19.5
30 - 39	5	21.7	12	18.5	6	10.3	11	22.4	13	17.6	31	17.8	26	22.6	104	18.6
40 - 49	8	34.8	10	15.4	6	10.3	3	6.1	5	6.8	20	11.5	11	9.6	63	11.3
50 - 59	2	8.7	6	9.2	10	17.2	4	8.2	4	5.4	9	5.2	3	2.6	38	6.8
60 and over	2	8.7	3	4.6	1	1.7	1	2.0	1	1.4	4	2.3	2	1.7	14	2.5
Total	23	(4.1)	65	(11.6)	58	(10.4)	49	(8.8)	74	(13.3)	174	(31.2)	115	(20.6)	558	99.9

χ^2 (42) = 68.25, p < .02

Table 52

Frequency of Consuming More Than Usual Amount of Liquor by Male Respondents According to Age

Age	Once a week or more		Several times a month		Once a month		More than twice a year		Once or twice a year		Never		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
14 - 17	0	0.0	0	0.0	0	0.0	1	1.1	7	5.1	5	4.4	13	3.0
18 - 20	2	11.1	2	15.4	12	19.7	18	19.8	15	10.9	14	12.4	63	14.5
21 - 24	2	11.1	5	38.5	15	24.6	19	20.9	39	28.3	19	16.8	99	22.8
25 - 29	0	0.0	3	23.1	9	14.8	20	22.0	32	23.2	20	17.7	84	19.3
30 - 39	8	44.4	2	15.4	9	14.8	18	19.8	17	12.3	22	19.5	76	17.5
40 - 49	4	22.2	0	0.0	9	14.8	6	6.6	17	12.3	17	15.0	53	12.2
50 - 59	1	5.6	1	7.7	6	9.8	7	7.7	9	6.5	10	8.8	34	7.8
60 and over	1	5.6	0	0.0	1	1.6	2	2.2	2	1.4	6	5.3	12	2.8
Total	18	(4.1)	13	(3.0)	61	(14.0)	91	(21.0)	138	(31.8)	113	(26.0)	434	99.9

$\chi^2(35) = 45.82$, $p = .104$

and their over-40 counterparts.

5.2.2.1.2 Most Recent Alcohol Use (Tables LI-13, Appendix D). Although the amount of elapsed time since the last drink was an important variable when analyzed in terms of BAC (Table 26), a less clearcut pattern emerges when analyzed in terms of age (Table LI-13, Appendix D). The only age categories which may be over-represented among those male motorists who reported drinking less than an hour prior to being stopped at the roadside survey (35%) were the 30-to-39 year olds (45%) and the 21-to-24 year olds (39%).

As noted earlier, one drinking variable on which age differences might be reasonably expected is the location at which the last drinking had occurred (Table 28). One finding which is not surprising is that the highest proportion of younger male drivers age 18 to 29 reported having been drinking in a bar; and conversely, although these men comprised 58% of the sample, they represented 73% of all those who stated that they had been drinking at a bar most recently.

Somewhat unexpected, however, was the proportion of male motorists who reported they had last been drinking at home (20%) since data collection occurred after 10:00 P.M. These data suggest a fairly large population of motorists who should be educated about the merits of staying home once they have begun drinking.

5.2.2.1.3 Knowledge Concerning Alcohol Use and Driving (Tables 53 and 54). In discussing these variables above in terms of BAC (see 5.2.1.2.3), the double standard with which beer and liquor are judged was noted, especially for those individuals at higher BACs. When these variables are examined in terms of age, it becomes apparent that the strongest believers in the double standard are the younger drivers from age 18 to 29 (Table 53). More specifically, almost 40% of drivers in this age category felt they could drive safely after five or more bottles of beer. By contrast, only about 18% of these young men age 18 to 29 felt they could drive safely after five or more shots of liquor -- which generally contain about the same amount of ethanol as the five or more bottles of beer.

Another striking indication of lack of knowledge was found at the opposite end of the liquor continuum, namely, a surprisingly large proportion of these young men felt that they could not drive safely after one or two shots, or even after any liquor (Table 54). Thus, analysis of these questions concerning a motorist's understanding of his own safe limits for drinking and then driving clearly indicate a very strong need for more effective information and education countermeasures.

5.2.2.2 Driving Variables and Age

The notion that younger drivers have a high degree of crash involvement is clearly substantiated by the present data. Although 28% of all male motorists in this survey reported having had one or more crashes during the previous three years (Table 55), 38% of 18-to-20 year olds, 37% of 21-to-24 year olds and 33% of 25-to-29 year olds reported having had one or more crash during the period. Conversely, among male motorists reporting one crash in the previous three years, 66% were between age 18 and 29; whereas among those reporting two or more crashes, 92% were age 18 to 29.

Regarding the number of DWI crashes during the previous three-year period (Table 56), it should be noted that the higher proportion of involvement relative to all crashes (regardless of alcohol involvement) shifts slightly upwards in the age range. More specifically, 23% of male motorists age 21 to 39 (especially those in their 30's) report having had one or more DWI crash and 7% report having had two or more. The same pattern appears in the case of the number of DWI convictions during the previous three-year period according to age (Table 57) although in this case the trend is not statistically significant.

Table 53

Number of Beers Considered Safe for Driving by Male Respondents According to Age

Age	None		1 bottle		2 bottles		3 bottles		4 bottles		5 bottles		6 bottles or more		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
14 - 17	0	0.0	0	0.0	3	3.7	8	6.3	8	7.5	1	2.0	6	4.5	26	4.7
18 - 20	3	18.8	1	2.5	8	9.8	15	11.7	23	21.5	5	10.2	32	24.1	87	15.7
21 - 24	2	12.5	9	22.5	14	17.1	24	18.8	26	24.3	11	22.4	35	26.3	121	21.9
25 - 29	3	18.8	6	15.0	16	19.5	26	20.3	17	15.9	15	30.6	25	18.8	108	19.5
30 - 39	5	31.3	5	12.5	17	20.7	27	21.1	19	17.8	10	20.4	21	15.8	104	18.7
40 - 49	0	0.0	11	27.5	13	15.9	14	10.9	9	8.4	4	8.2	9	6.8	60	10.8
50 - 59	1	6.3	5	12.5	8	9.8	11	8.6	4	3.7	2	4.1	5	3.8	36	6.4
60 and over	2	12.5	3	7.5	3	3.7	3	2.3	1	0.9	1	2.0	0	0.0	13	2.3
Total	16	(2.9)	40	(7.2)	82	(14.8)	128	(23.1)	107	(19.3)	49	(8.8)	133	(24.0)	555	100.1

$X^2(42) = 75.00, p <.05$

Table 54

Number of Shots of Liquor Considered Safe for Driving by Male Respondents According to Age

Age	None		1 shot		2 shots		3 shots		4 shots		5 shots		6 shots or more		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
14 - 17	3	5.2	4	5.6	7	5.3	2	1.8	4	5.7	1	2.6	2	4.1	23	4.3
18 - 20	6	10.3	8	11.1	19	14.3	22	19.3	12	17.1	6	15.4	11	22.4	84	15.7
21 - 24	9	15.5	17	23.6	32	24.1	19	16.7	16	22.9	9	23.1	14	28.6	116	21.7
25 - 29	14	24.1	15	20.8	28	21.1	15	13.2	17	24.3	6	15.4	10	20.4	105	19.6
30 - 39	13	22.4	9	12.5	21	15.8	25	22.0	13	18.6	9	23.1	8	16.3	98	18.3
40 - 49	8	13.8	12	16.7	12	9.0	16	14.0	4	5.7	3	7.7	3	6.1	58	10.8
50 - 59	3	7.0	5	6.8	9	10.5	12	5.7	4	10.3	4	0.0	0	6.9	37	6.9
60 and over	2	2.8	2	3.8	5	2.6	3	0.0	0	2.6	1	2.0	1	2.6	14	2.6
Total	58	(10.8)	72	(13.5)	133	(24.9)	114	(21.3)	70	(13.1)	39	(7.3)	49	(9.2)	535	100.1

$X^2(42) = 36.24$, p = .99

Table 55

Number of Auto Accidents in the Last 3 Years for Male Respondents According to Age

Age	None		1		2 or more		Total	
	N	%	N	%	N	%	N	%
14 - 17	21	5.0	6	4.8	0	0.0	27	4.6
18 - 20	54	12.8	22	17.7	11	29.7	87	14.9
21 - 24	78	18.4	34	27.4	12	32.4	124	21.2
25 - 29	76	18.0	26	21.0	11	29.7	113	19.3
30 - 39	91	21.5	17	13.7	2	5.4	110	18.8
40 - 49	54	12.8	11	8.9	1	2.7	66	11.3
50 - 59	35	8.3	5	4.0	0	0.0	40	6.8
60 and over	14	3.3	3	2.4	0	0.0	17	2.9
Total	423	(72.4)	124	(21.2)	37	(6.3)	584	99.8

$\chi^2(14) = 35.27$, $p = .001$

Table 56

Number of DWI Accidents in the Last 3 Years for Male Respondents According to Age

Age	None		1		2 or more		Total	
	N	%	N	%	N	%	N	%
14 - 17	23	4.8	0	0.0	1	6.7	24	4.4
18 - 20	80	16.6	3	5.7	0	0.0	83	15.1
21 - 24	100	20.7	15	28.3	2	13.3	117	21.2
25 - 29	93	19.3	13	24.5	2	13.3	108	19.6
30 - 39	79	16.4	17	32.1	7	46.7	103	18.7
40 - 49	58	12.0	4	7.5	2	13.3	64	11.6
50 -59	36	7.5	0	0.0	1	6.7	37	6.7
60 and over	14	2.9	1	1.9	0	0.0	15	2.7
Total	483	(87.7)	53	(9.6)	15	(2.7)	551	100.0

$\chi^2(14) = 29.68$, $p < .01$

Table 57

Number of DWI Convictions in the Last 3 Years for Male Respondents According to Age

Age	None		1		2 or more		Total	
	N	%	N	%	N	%	N	%
14 - 17	23	4.7	0	0.0	1	6.3	24	4.3
18 - 20	76	15.5	6	12.8	1	6.3	83	15.0
21 - 24	103	21.0	11	23.4	4	25.0	118	21.3
25 - 29	96	19.6	10	21.3	4	25.0	110	19.9
30 - 39	85	17.3	12	25.5	6	37.5	103	18.6
40 - 49	57	11.6	7	14.9	0	0.0	64	11.6
50 - 59	35	7.1	1	2.1	0	0.0	36	6.5
60 and over	15	3.1	0	0.0	0	0.0	15	2.7
Total	490	(88.6)	47	(8.5)	16	(2.9)	553	99.9

$\chi^2(14) = 11.78, p < .60$

5.3 PERFORMANCE MEASURES

As noted in Section 4.4, retrieval and analysis of the performance measures proved to be a time-consuming process which required considerable filtering of the electronic records and coordination of the speed and lateral movement data. While the performance data were being digitized, transmitted to the analytical computer, archived, and rearranged for subsequent analyses, a number of graphic representations of the performance measures were generated for drivers in different BAC categories in order to compare driving patterns. This effort was undertaken with the hope that recurring behavioral patterns might become apparent which could be subjected to analytical procedures.

5.3.1 Graphic Representation

The computer-generated graphics which were prepared for drivers across the full range of BACs are exemplified by three representative plots (Figures 10, 11, and 12). These plots represent a single motorist's lateral position in the primary site and his speed in the primary and secondary sites. Figure 10 is the record of lateral position in the primary site data window. The data represented in Figure 10 become meaningful when compared to the calibration run for this roadblock since the calibration record represents the track signature. Thus, although little meaning can be attributed to this plot per se, subsequent analyses attempted to create a measure of tracking error by comparing these data to the track signature.

A major difficulty encountered in the project can be seen in Figure 11. This figure represents the speed of vehicle No. 87370 through the primary site window and shows that the doppler radar signal contains many dropout points which make analyses extremely difficult. However, it can be seen in this figure that the vehicle entered the primary site window at approximately 44 mph and apparently increased speed slightly to perhaps 46 mph at roughly 12 seconds after the beginning of data collection. These data suggest a number of analyses which were eventually incorporated: entering speed, mean speed, acceleration and deceleration, and the time after data acquisition at which maximum acceleration and

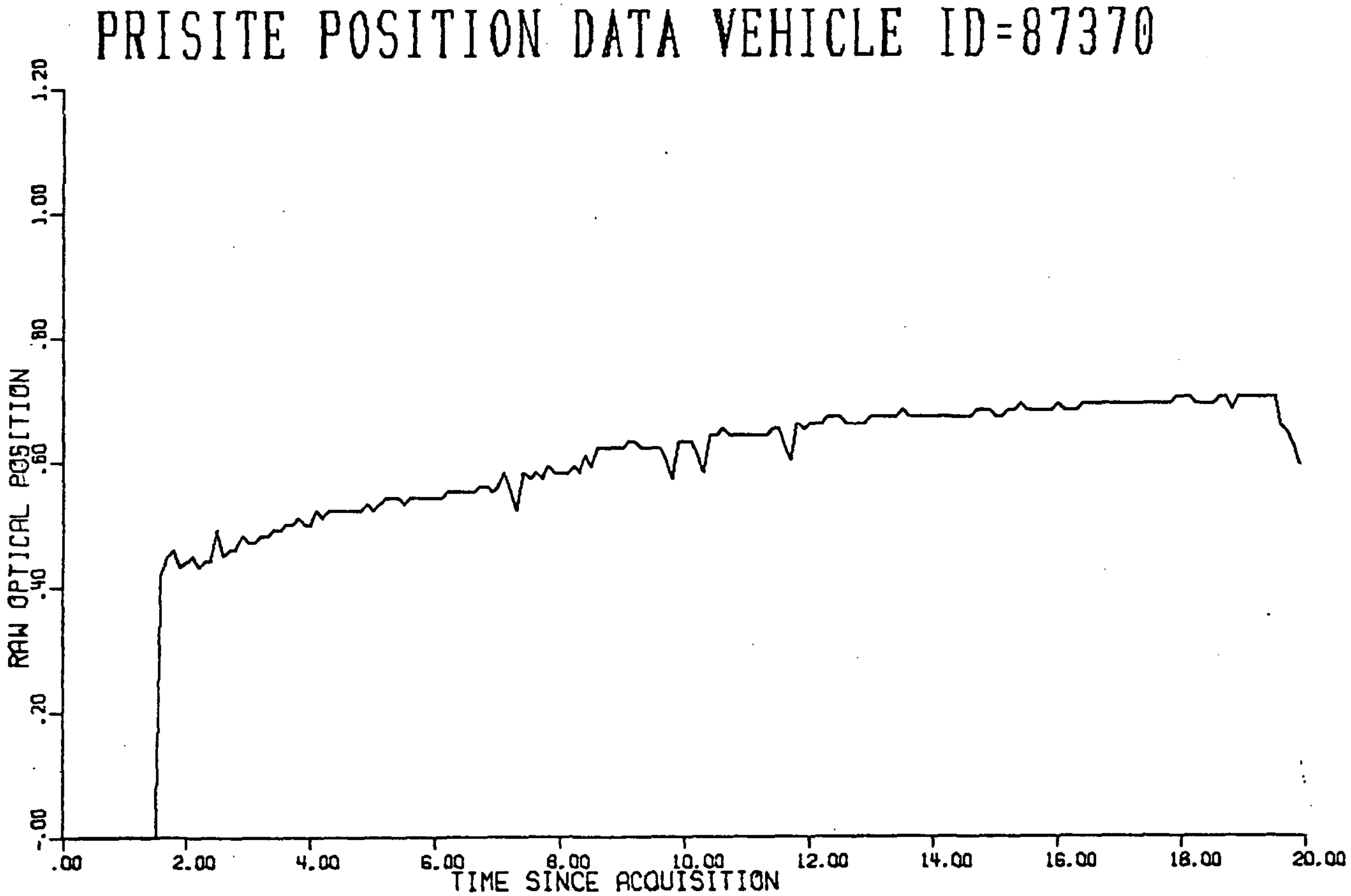

Figure 10: Analog Record of Lateral Position

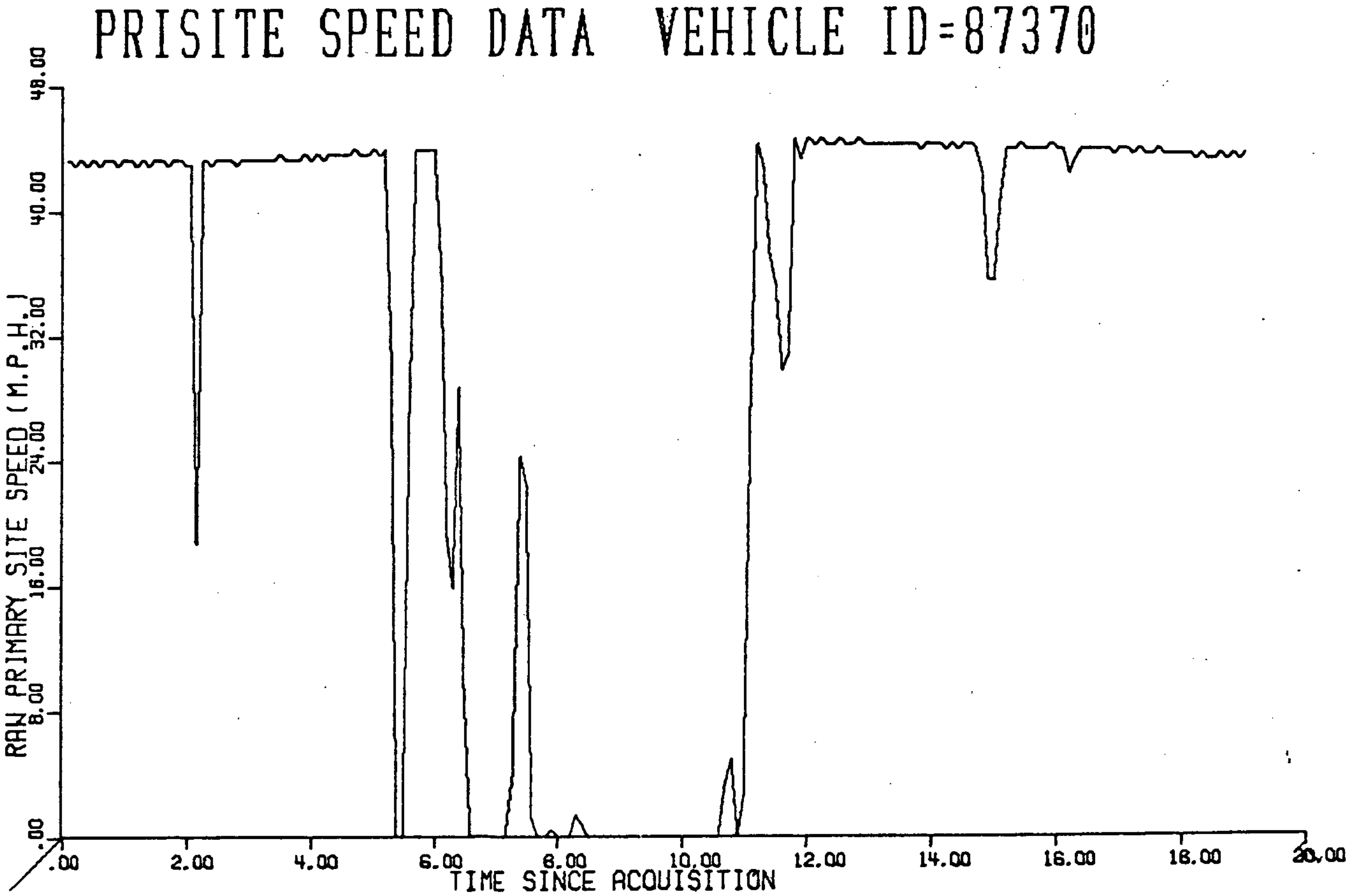

Figure 11: Analog Record of Primary Site Speed

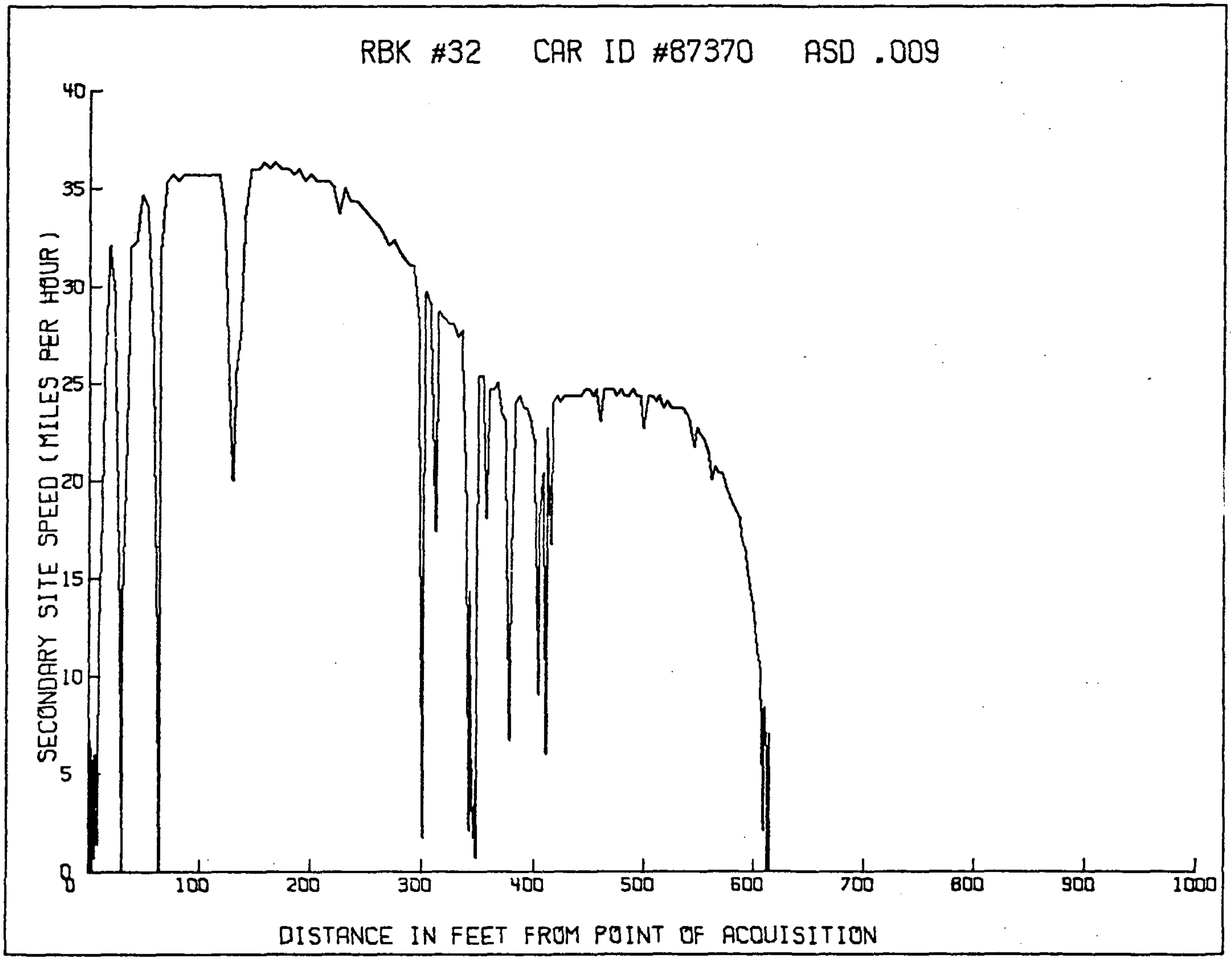

Figure 12: Analog Record of Secondary Site Speed

deceleration occurred. While these types of analyses seem logical and simplistic, the effort required to deal with inherently unstable data and develop algorithms to produce the desired performance parameters was extremely time-consuming and difficult.

Additional examples of the doppler signal dropout problem can be seen in Figure 12. This figure exemplifies a typical driving pattern noted at the secondary site as motorists came to a stop near the police cruiser. The plots of speed at the secondary site were particularly intriguing, because they exhibited what seemed to be different patterns of stopping behavior. While drivers with very low BACs seemed to stop in a relatively smooth and consistent manner, drivers with medium to high BACs appeared to adopt less consistent behaviors. For example, three stopping patterns seemed to emerge from plots similar to the one shown in Figure 12: (1) very sharp braking and rapid deceleration; (2) moderate deceleration until close to the stop point, followed by very sharp deceleration; or (3) moderate deceleration followed by a plateau indicating braking modulation, and very sharp deceleration immediately before the stopping point. This figure is an example of the observed patterns which led to the third hypothesis noted above.

Although the graphic representations and subsequent hypotheses were intriguing, it was clear that automated, analytical procedures were necessary to quantify these data records. As noted in Section 4.4.3, computer programming efforts were undertaken to develop performance parameters including entering speed and mean speed, maximum acceleration and deceleration, and the time at which maximum acceleration and deceleration occurred for both the primary site and secondary site data. In addition, the mean and standard deviation of lateral position were generated for the primary site data.

5.3.2 BAC and Performance Measures

A first step in the analytical process was to prepare correlation matrices for BAC and each of the performance measures. The correlations of BAC with the primary site performance measures are shown in Table 58. It can be seen that the correlations among BAC and these performance measures are distressingly low. Significant correlations were obtained

Table 58

Correlations of BAC and Primary Site Performance Measures

	ENTERING SPEED	MEAN SPEED	STD. DEV. OF SPEED	MAXIMUM SPEED	TIME OF MAX. SPEED
BAC	-.0905	.0929	-.0439	.0152	.0124
	s = .038	s = .034	s = .195	s = .383	s = .404

	MINIMUM SPEED	TIME OF MIN. SPEED	MEAN ACCELERATION	STD. DEV. OF ACCELERATION
BAC	.0579	-.0030	.0556	.0135
	s = .128	s = .476	s = .138	s = .395

	MAXIMUM ACCELERATION	TIME OF MAX. ACCELERATION	MAXIMUM DECELERATION	TIME OF MAX. DECELERATION
BAC	.0315	.0549	.0371	.0572
	s = .269	s = .141	s = .234	s = .131

	MEAN POSITION	STD. DEV. POSITION
BAC	.0030 .0030	.0353
	s = .476	s = .245

only for BAC and two measures: entering speed and mean speed. However, even these correlations are so low that it is difficult to attribute any practical significance to these figures.

Although the obtained correlations are extremely discouraging, it is recognized that correlations depend upon linearity of the data and may not represent differences which might exist for specific categories of BAC ranges. Therefore, all performance parameters were subjected to analysis of variance to determine whether categorical differences might emerge.

5.3.2.1 Primary Site Performance Measures

The parameters of interest in the primary site include entering speed, mean speed, standard deviation of speed, mean acceleration characteristics, standard deviation of acceleration, and the mean and standard deviation of the position measures. Means of the primary site entering speed according to BAC category are presented in Table 59. Analysis of variance for this parameter indicated that the mean speeds for each BAC category were not significantly different. It can be seen that the average entering speeds were quite similar for the entire BAC range. However, the Ns associated with each BAC category are quite disparate and it is possible that the slower speeds indicated at the higher BACs (.10 and above) may indicate that motorists at higher BACs tend to drive somewhat slower in the normal driving environment than their counterparts at lower BACs. This comment is a suggestion only, of course, and should be interpreted accordingly since the statistical analysis indicates a fairly high probability that any differences are due to chance.

Table 59

Primary Site Entering Speed

BAC	Entering Speed (mph)	
	Mean mph	N
.000 to .009	49.85	201
.010 to .049	48.76	127
.050 to .079	45.73	22
.080 to .099	50.97	12
.100 to .149	45.22	17
.150 and above	45.30	7

F(5,385) = 1.29, p = .266

Regarding primary site mean speed, statistical analysis revealed no significant differences. Table 60 shows these data. However, Table 60 again shows an intriguing trend in that the higher mean speeds seem to be associated with the higher BACs. This trend might account for the significant correlation obtained between BAC and mean speed.

Table 60

Primary Site Mean Speed

BAC	Mean Speed	
	Mean mph	N
.000 to .009	46.19	201
.010 to .049	46.14	127
.050 to .079	47.00	22
.080 to .099	47.96	12
.100 to .149	48.61	17
.150 and above	49.33	7

F(5,385) = .513, p = .766

Speed variation seemed to be a potential indicator of alcohol influenced driving behavior so the standard deviation of speed was investigated. Table 61 shows the mean standard deviation of speed according to BAC category. Significant differences were not obtained.

Table 61

Primary Site Standard Deviation of Speed

BAC	Std. Dev. of Speed	
	Mean	N
.000 to .009	5.88	201
.010 to .049	6.22	127
.050 to .079	6.26	22
.080 to .099	6.25	12
.100 to .149	4.12	17
.150 and above	3.41	7

F(5,385) = .804, p = .547

The speed data obtained for cars in the primary observation window were used to generate acceleration characteristics. Tables 62 and 63 present the mean and standard deviation of acceleration according to BAC for the primary site data. It can be seen that mean acceleration was similar for all BAC categories. It appears that there may have been a slight tendency for motorists between .01 and .079 BAC to decelerate slightly throughout the primary window while motorists in other categories may have exhibited a very slight tendency to accelerate. However, it must be noted that these differences were again statistically nonsignificant.

Table 62

Primary Site Mean Acceleration

BAC	Mean Acceleration	
	Mean G's	N
.000 to .009	.00102	201
.010 to .049	-.00399	127
.050 to .079	-.01084	22
.080 to .099	.03564	12
.100 to .149	.02552	17
.150 and above	.01046	7

F(5,385) = 1.29, p = .266

Table 63

Primary Site Standard Deviation of Acceleration

BAC	Std. Dev. of Accel.	
	Mean	N
.000 to .009	.167	201
.010 to .049	.164	127
.050 to .079	.172	22
.080 to .099	.209	12
.100 to .149	.163	17
.150 and above	.134	7

F(5,385) = .804, p = .548

Regarding lateral position of vehicles on the road in the primary site window, Table 64 presents the means in each BAC category for the average position of vehicles while they were being recorded in the primary site window. Again, no statistically significant differences were obtained. Although we would like to suggest that motorists with BACs above .15 and between .05 and .079 appear to have driven somewhat closer to the center line than did other motorists, we will refrain from that inference because of the variance associated with the lateral position data. Table 65 shows the means of the standard deviation of position for the BAC categories.

Table 64

Primary Site Mean Position

BAC	Position from Centerline	
	Mean ft.	N
.000 to .009	3.29	201
.010 to .049	4.10	127
.050 to .079	2.61	22
.080 to .099	6.74	12
.100 to .149	3.30	17
.150 and above	1.59	7

F(5,385) = 1.33, p = .250

Table 65

Primary Site Standard Deviation of Position

BAC	Std. Dev. of Position	
	Mean	N
.000 to .009	5.42	200
.010 to .049	5.29	126
.050 to .079	5.90	21
.080 to .099	4.66	12
.100 to .149	5.47	17
.150 and above	6.08	7

F(5,382) = 1.21, p = .304

In summary, the primary site performance measures are discouraging. Our first reaction was that the obtained parameters contained more noise than signal, and it is possible that that is the situation. However, it is at least as likely that measurement of normal driving behavior over a maximum 1200-ft. observation window is simply inadequate to detect driving anomalies due to BAC (if such anomalies exist). It should be noted that we attempted to obtain subjective evaluations of erratic driving behavior by positioning one observer in the equipment truck to record only those data. We obtained evaluation forms on only 44 of the 1,757 motorists observed. Furthermore, the ratings of erratic behaviors represented the entire range of obtained BACs with virtually no relationship between the observed erratic behavior and the measured alcohol levels. Given that we were unable to either observe or measure behaviors which represented probable alcohol influences, it seems clear that either those behaviors were not manifest or the situational constraints (fixed roadside site, no intervention stimulus) were too confining.

5.3.2.2 Secondary Site Performance Measures

The secondary site performance measures consist of parameters generated from the doppler radar speed record obtained as drivers were directed to a halt by a law enforcement officer. These data were reduced to measures of entering speed, mean acceleration and standard deviation of acceleration, maximum acceleration, time of maximum acceleration, maximum deceleration, and time of maximum deceleration. The correlations of BAC and secondary site performance measures are presented in Table 66. These correlations are lower than we had hoped. If one accepts the philosophy that exploratory research such as the present project justifies setting significance levels as high as .10, then it can be seen that mean acceleration, standard deviation of acceleration, and time of maximum acceleration for the secondary site performance measures reached significant levels. It must again be noted that the obtained correlations were small and do not necessarily reflect practically important linear relationships between BAC and the performance parameters.

The secondary site performance measures were also analyzed for significant differences among BAC categories which might not be apparent in

Table 66

Correlations of BAC and Secondary Site Performance Measures

	ENTERING SPEED	MEAN ACCELERATION	STD. DEV. OF ACCELERATION	MAXIMUM ACCELERATION
BAC	-.0177	-.0593	-.0577	-.0414
	s = .340	s = .084	s = .090	s = .168

	TIME OF MAX. ACCELERATION	MAXIMUM DECELERATION	TIME OF MAX. DECELERATION
BAC	.0752	.0443	-.0236
	s = .040	s = .152	s = .292

a correlation test for significant linear relationships. Secondary site entering speed is that speed first obtained by the doppler radar as a vehicle enters the secondary site observation window. Since the doppler radar signal operates on a line-of-sight principle, this measure represents vehicle speed at a point where the driver could have first seen the secondary site law enforcement officer and vehicle. The data for secondary site entering speed are presented in Table 67. Analysis of variance on these data revealed no significant differences among the BAC categories.

Table 67

Secondary Site Entering Speed

BAC	Mean Entering Speed	
	Mean mph	N
.000 to .009	23.43	223
.010 to .049	23.99	234
.050 to .079	26.46	33
.080 to .099	24.75	20
.100 to .149	20.21	27
.150 and above	26.92	4

F(5,540) = 1.072, p = .375

Table 68 presents the secondary site average acceleration characteristics according to BAC categories. These data were calculated by obtaining the average speed change over each 0.1-second interval for each vehicle and then computing the mean of those means for each BAC category. It can be seen in this table that there was very little difference in mean acceleration among BAC categories and the analysis of variance indicated no statistically significant differences.

Table 68

Secondary Site Mean Velocity Change

BAC	Mean Velocity Change	
	Mean G's	N
.000 to .009	-.0699	223
.010 to .049	-.0751	234
.050 to .079	-.0797	33
.080 to .099	-.0794	20
.100 to .149	-.0809	27
.150 and above	-.0724	4

F(5,540) = .893, p = .485

A further test for fluctuations in speed change was computed by obtaining the standard deviation of acceleration for each motorist and determining the mean of those standard deviations for each BAC category. Table 69 presents data showing the <u>standard deviation of acceleration</u> according to BAC. The analysis of variance for these data indicated statistically significant differences among BACs. It can be seen that motorists with BACs of .05 to .079 or .150 and above exhibited less variation in their acceleration characteristics at the secondary site. It is also noteworthy that motorists between .10 and .149 BAC had a higher mean standard deviation of acceleration than motorists in all other BAC categories. These data can be compared to the entering speeds shown previously in Table 67. It may be noted that motorists with the higher mean standard deviations of acceleration were also those motorists who exhibited lower entering speeds. It can be seen that motorists with smaller standard deviations of acceleration also had higher secondary site entering speeds. This relationship is expected since higher entering speeds would necessitate somewhat stronger braking action and quite probably less fluctuation in that braking response.

Table 69

Secondary Site Standard Deviation of Velocity Change

BAC	Mean Std. Dev. of Velocity Change	
	Mean	N
.000 to .009	.2140	223
.010 to .049	.2135	234
.050 to .079	.1790	33
.080 to .099	.2138	20
.100 to .149	.2257	27
.150 and above	.1335	4

F(5,540) = 2.802, p = .016

Mean speed change (shown in Table 67) is an average of both positive and negative accelerations (or decelerations) at each of the 0.1-second intervals sampled. A more direct means of testing for peak braking activity is to measure the peak deceleration achieved at any point in the secondary site measurement window. Table 70 presents data representing the BAC category averages for the maximum deceleration obtained for each motorist. Analysis of variance revealed that the differences among BAC categories obtained for this parameter were significant at a .059 level. Again, it can be seen that motorists with BACs of .050 to .079 or .150 and above showed lower maximum deceleration forces than other motorists. These data also suggest that motorists who entered the secondary site at higher rates of speed generated lower maximum deceleration peaks than those motorists who entered at lower speeds. These data appear to be contrary to expectations except for the fact that the obtained standard deviations of acceleration were also lower for motorists with higher entering speeds and lower maximum deceleration peaks. Thus, it is indicated that motorists with higher initial speed at the secondary site came to a halt with less point to point variation in speed change and consequently lower momentary peak deceleration.

Table 70

Secondary Site Maximum Deceleration

BAC	Mean of Maximum Deceleration	
	Mean G's	N
.000 to .009	-.6329	223
.010 to .049	-.6458	234
.050 to .079	-.5879	33
.080 to .099	-.6569	20
.100 to .149	-.6421	27
.150 and above	-.4579	4

F(5,540) = 2.138, p = .059

An additional item of interest which cuts across entering speed, standard deviation of mean acceleration, and maximum deceleration peaks is that motorists with BACs of .10 to .15 seem to have rather high maximum deceleration peaks, higher standard deviation of mean acceleration, and lower entering speeds. It should be recalled that a significant positive correlation between BAC and primary site mean speed was obtained and that the primary site mean speed data shown in Table 60 revealed that motorists in this BAC category had a relatively high primary site mean speed. These data may indicate that motorists in the critical .100 to .149 BAC range appropriately modified their driving behavior by slowing down as they approached the secondary site, but had some difficulty in smoothly decelerating to a stop near the law enforcement officer by careful, even brake modulation.

One additional comment is in order regarding the secondary site maximem deceleration data. Although the G forces indicated for maximum deceleration appear exceedingly high, it must be noted that these figures represent peak forces rather than a moving average. In other words, these data represent differences between two 0.1-second intervals. Thus, they are indeed peak, momentary decelerations and may contain minor anomalies due to the inherent radar doppler dropout problem.

If it is assumed that the doppler signal dropouts are randomly distributed, then it would be expected that each mean of the maximum deceleration data contains the same amount of this signal carrier noise or error. Thus, although the absolute figures for maximum deceleration are somewhat high, the relationship between the BAC category means is accurate.

The stopping behavior of motorists at different BACs can also be considered in terms of the time at which peak deceleration occurred. Table 71 presents the mean time of maximum deceleration peaks according to BAC category. This parameter reflects the time after first data acquisition at which the peak deceleration occurred. In other words, this measure is the time after the law enforcement officer could have been seen by the motorist that peak deceleration was measured. It can be seen that there were little differences between BAC categories for this performance parameter. Table 71 also shows that analysis of variance confirmed any apparent differences among BAC categories were not statistically significant for this performance parameter.

Table 71

Secondary Site Time of
Maximum Deceleration

BAC	Mean Time of Max. Deceleration	
	Mean Secs.	N
.000 to .009	10.59	223
.010 to .049	11.58	234
.050 to .079	11.16	33
.080 to .099	10.82	20
.100 to .149	9.30	27
.150 and above	10.87	4

F(5,540) = .913, p = .472

It was noted earlier that velocity changes from time point to time point (0.1-second interval) can be either positive, negative, or no change. Thus, motorists may exhibit both acceleration and deceleration while coming to a halt. In order to test for this behavior, maximum acceleration peaks and time of maximum acceleration were computed. Specifically, maximum acceleration peaks and time at which those maximum acceleration peaks occurred were generated from the speed data for each vehicle and means of these measures were obtained by BAC category. Table 72 shows the categorical means of maximum acceleration. It can be seen that the analysis of variance test revealed the differences between BAC categories were statistically significant. Here again it appears that motorists with BACs of .050 to .079 or .150 and above had significantly lower maximum acceleration peaks than did other motorists. These differences coincide with the maximum deceleration peaks and the standard deviation of acceleration presented earlier and appear to be directly related to the secondary site entering speed. In other words, smaller maximum deceleration and acceleration peaks as well as smaller standard deviations of acceleration are evident for those motorists with higher secondary site entering speeds.

Table 72

Secondary Site
Maximum Acceleration

BAC	Mean of Max. Acceleration	
	Mean G's	N
.000 to .009	.5709	223
.010 to .049	.5881	234
.050 to .079	.4936	33
.080 to .099	.6226	20
.100 to .149	.5867	27
.150 and above	.3057	4

F(5,540) = 3.053, p = .010

Table 73 presents data regarding the time after data acquisition at which maximum acceleration occurred. No significant differences between BAC categories were found for this performance parameter.

Table 73

Secondary Site Time of
Maximum Acceleration

BAC	Mean Time of Max. Acceleration	
	Mean Secs.	N
.000 to .009	9.82	223
.010 to .049	10.15	234
.050 to .079	12.04	33
.080 to .099	9.54	20
.100 to .149	10.15	27
.150 and above	16.43	4

F(5,540) = 1.312, p = .257

Another generated performance parameter which could indicate differences in the caution or care with which motorists at various BACs operate their vehicle may be evident in the difference between primary site mean speed and secondary site entering speed. Drivers may be expected to react with some caution to passing a vehicle (rusty milk truck) parked off the roadway, and/or negotiating a curve or cresting a hill, and/or noting a law enforcement officer near a cruiser with flashing signals as a function of BAC. Consequently, we calculated the speed difference between primary site mean speed and secondary site entering speed of each motorist for which we had valid speed data at both sites and a measure of BAC. The resulting N was small, but the distribution across the BAC range was reasonable.

Table 74 shows the speed difference data according to BAC along with the analysis of variance results. It can be seen that differences among BAC categories were significant at p = .10. The data in Table 74 are noteworthy in one important respect: motorists with critical BACs of

.08 to .149 exhibited a substantial reduction in speed between the primary and secondary sites which sets these drivers apart from other motorists. It is unknown whether this difference can be attributed to one or more of the situational variables present, but the difference very likely represents some sort of precautionary response to the factors noted above. If this is the appropriate interpretation of these data, then it appears that motorists whose BACs are at or near the .10 level are modifying their driving to some extent. However, a cautionary response by these motorists is not followed by appropriate fine modulation of stopping behavior at the secondary site. Instead, their stopping behavior may be less smooth than other motorists' responses. Drivers with BACs at or near .10 may exhibit little change in their normal driving behavior (note primary site data), be more cautious of unusual circumstances (greater speed reduction between primary and secondary sites), and are somewhat less able to make the specific control manipulations to smoothly and efficiently stop when necessary (secondary site data) than motorists with lower BACs.

Table 74

Mean Primary Speed Minus
Secondary Site Entering Speed
According to BAC

BAC	Speed Difference	
	Mean mph	N
.000 to .009	26.1	22
.010 to .049	19.5	13
.050 to .079	11.8	5
.080 to .099	40.1	2
.100 to .149	30.9	10
.150 and above	25.1	2

F(5,53) = 1.946, p = .104

Although these observations are made with less clear evidence than we would like, the data at least suggest the possibility of these circumstances. Perhaps the elusive nature of behavioral clues indicating DWI motorists are to be expected and attempts to objectively quantify relevant performance parameters should be encouraged based upon the clues suggested by the present project. It is recalled that Borkenstein (1968) estimated the frequency of DWI violations is roughly 2000 for each arrest. Waller (1971) estimated that even specially trained ASAP law enforcement officers were arresting only one out of 200 impaired drivers who went by them. Compared to these estimates of hit rates for observant law enforcement officers, it is not particularly surprising that the present project did not find striking differences in driving performance which could be directly related to motorists' BACs.

5.3.3 Secondary Site Entering Speed and Selected Interview Variables

The relationships between driving performance and some data from the long interview forms also were of interest because it seemed likely that variables other than BAC could influence driving behavior. In order to minimize possible signal noise biases, the secondary site entering speed was chosen for these post hoc comparisons. Long form interview data regarding quantity and frequency of alcohol use and certain driving variables were of particular interest.

The following list of variables was chosen for these comparisons. With the exception of the first variable (sex), all analyses were accomplished for male motorists. The parenthetical note following each variable indicates the question number on the long interview from which the data were obtained. An asterisk before the variable number indicates that differences among entering speeds were significant at $p < .10$ for that particular variable.

1. Sex (Q. 49)
2. Age (Q. 2)
3. Frequency of Drinking Usual Amount of Beer (Q. 29)
4. Quantity of Usual Amount of Beer (Q. 30)
5. Frequency of Drinking Usual Amount of Liquor (Q. 33)

*6. Quantity of Usual Amount of Liquor (Q. 34)
7. Frequency of More Than Usual Beer (Q. 32)
8. Quantity of More Than Usual Beer (Q. 31)
9. Frequency of More Than Usual Liquor (Q. 36)
10. Quantity of More Than Usual Liquor (Q. 35)
11. Number of Beers Considered Safe (Q. 47)
12. Number of Shots Considered Safe (Q. 48)
13. Length of Time Driving (Q. 12)
14. Frequency of Driving (Q. 11)
*15. Location of Last Drinking (Q. 39)
16. Speeding Convictions (Q. 15d)
17. Elapsed Time Since Last Drink (Q. 38)
18. Number of Traffic Violations (Q. 14)
*19. Activity Coming From (Q. 21)
20. Activity Going To (Q. 22)
21. BAC for Males Who Drank Within 3 Hours
22. Number of Accidents (Q. 18)
23. Beverage Preference (Q. 37)

It can be seen from this list of variables that the entering speed was apparently different for motorists who reported drinking varied quantities of their usual amount of liquor, different locations of last drinking, and different activities from which they were coming.

Table 75 shows the mean entering speed according to amount of liquor usually consumed. A relatively linear trend is evident. These data show that increases in motorists' self-reported usual amounts of liquor consumed were related to higher secondary site entering speeds. While it might be assumed that individuals who drink larger amounts of liquor might also be older and have driven for a longer period of time, this supposed relationship apparently does not hold since significant differences were not obtained either for length of time driving or for age.

Table 75

Secondary Site Entering Speed
According to Usual Amount
of Liquor Consumed

Usual Amount of Liquor	Secondary Site Entering Speed	
	Mean mph	N
1 shot	18.8	24
2 shots	22.6	34
3 shots	25.3	23
4 shots	28.2	17
5 shots or more	29.5	4

F(4,101) = 2.27, p = .067

Table 76 shows an interesting relationship between secondary site entering speed and the location of last drinking. These differences were highly significant (p = .002). It can be seen that the motorists who had been drinking at bars or in their car entered the secondary site at faster speeds than did other motorists. Those motorists who had been drinking at the home of a friend were also driving at a high speed relative to the other motorists in the sample. Since this question does not discriminate between those who had been drinking the same evening they were stopped from those who had been drinking a day or more earlier, these data are not necessarily revealing with regard to the activity each motorist had been participating in prior to being stopped.

Table 76

Secondary Site Entering Speed
According to Location
of Last Drinking

Location	Secondary Site Entering Speed	
	Mean mph	N
Home	20.4	29
Relative's Home	20.9	7
Friend's Home	25.1	30
Bars	27.8	49
Restaurants	18.8	11
Car	32.3	7
Club or Fraternity	11.4	3
Other	19.0	16

F(7,151) = 3.40, p = .002

Secondary site entering speed was also different for motorists coming from various activities (Table 77). In particular, motorists who reported they had just come from an evening of entertainment (movies, races, ball games) entered the secondary site at a significantly higher speed than motorists who were coming from other activities. The secondary site entering speed for those motorists who reported they were coming from drinking at a bar or lounge is of particular interest in Table 77. It can be seen that these motorists were driving slower than motorists coming from some form of entertainment, but were driving significantly faster than individuals coming from other types of activities. The data may reflect less cautious driving for individuals coming from entertainment or drinking rather than generally higher speed of driving. It should be recalled that although a statistically significant positive correlation was obtained between primary site mean speed and BAC, that correlation was very low. Furthermore, when the primary site mean speed data were subjected to analysis of variance for BAC categories no statistically significant differences were found.

Table 77

Secondary Site Entering Speed
According to Activity Coming From

Activity Coming From	Secondary Site Entering Speed	
	Mean mph	N
Work	24.2	43
Home	22.7	10
Visiting	21.8	35
Recreation	17.1	7
Entertainment	29.1	22
Dining/Dancing	21.0	10
Drinking	26.9	31
Other	19.3	14

$F(7,164) = 2.01, p = .057$

The results of the analyses noted in this sub-section were disappointing, but significant differences among secondary site entering speed were obtained for both types of participatory activity engaged in by respondents and the location of last drinking. For both of these variables, social activities in which drinking is probably a focal point are related to faster secondary site entering speeds. Relatively non-active "entertainment" and "drinking" as activity coming from as well as bars and cars as location of last drinking were particularly related to the fastest secondary site entering speeds. This performance parameter was also related to the reported amount of liquor usually consumed by respondents.

CONCLUSIONS

The three categories of data obtained in the present roadside research project were: (1) breath alcohol concentration; (2) interview data; and (3) driving performance measures. The interview data and BAC categories are similar to data found in previous roadside surveys. Thus, the information obtained in the present research is probably generalizable to a larger population. Since the data were obtained from all motorists rather than a sampling, the information contained in the present report reflects population characteristics of nocturnal motorists driving on rural Vermont roads between the hours of 10:00 P.M. and 3:00 A.M. on Thursday, Friday, and Saturday nights. Results and conclusions summarized below were limited by decisions made concerning which variables and code categories should be analyzed and reported. It should be noted that: (1) interview information is reported for motorists who received the long form questionnaire; (2) cross-tabulations and analyses of interview data were done for male motorists since this subpopulation is of particular concern, but a number of additional tables were prepared for female motorists where sex differences might be expected; (3) analyses of the driving performance measures were accomplished for all motorists regardless of sex; and (4) analyses of the driving performance data according to BAC used the Breathalyzer estimate where available and the ASD reading if the Breathalyzer test was not taken by the motorist (cases in which the short form interview was used).

6.1 BREATH ALCOHOL CONCENTRATION

BAC data were available for 95% of 1,757 motorists stopped. The 94 missing cases include 4.8% who refused the Alcohol Screening Device test at carside, 2.2% who refused to participate in the interview at carside, and 0.3% who refused the Breathalyzer test in the trailer.

Although 58% of the 1,663 motorists tested had detectable alcohol, the vast majority of these (45% of the total number) had BACs at the low "non-dangerous" end of the scale (.010 to .049). A total of 14% had BACs of .05 or higher, again with the vast majority of these (9% of the total number) falling in the potentially dangerous but not legally impaired mid-region of the scale (.050 to .099). Legally impairing BACs of .10 or higher were found in 5% of these motorists, with 1% being at .15 or higher.

The two breath alcohol determination methods were compared by means of regression analysis performed on the obtained BAC values. There was a very strong linear relationship between the data obtained from the Alcohol Screening Device and from the Breathalyzer, with a significant correlation coefficient of .87. From these analyses, it was determined that the ASD readings tend to be higher than the Breathalyzer readings which indicate a consistent trend for the ASD to overestimate the BAC as indicated by the Breathalyzer for the range of most BACs. It was concluded that statistically, these two devices are virtually identical in their determinations of BAC in the critical mid-region of the scale, i.e., around .10. However, certain limitations were noted regarding broader application of the prototype ASDs.

6.2 INTERVIEW DATA

Considering the length of the present report, it was decided that very brief summaries of the relevant results should be presented in this section along with the conclusions. The section is organized in terms of biographical variables, drinking variables, and driving variables.

6.2.1 Biographical Variables

Regarding sex, 79% of the nocturnal motorists contacted were male, whereas 90% of those who were legally impaired were male. Proportionately more than twice as many males (11%) as females (5%) were found at the higher BACs of .10 and above. Thus, male motorists are an important population at risk both with regard to their exposure, but also with regard to their greater willingness to drive after drinking.

Regarding age, approximately 20% of these male motorists were aged 20 or younger, 40% were aged 24 or younger, and 60% were aged 29 or younger. The vast majority (80%) of legally impaired male drivers were in their 20's and 30's (29 to 39 years of age), whereas males in these two decades comprise only 60% of the sample. Although there were relatively few female motorists driving at night in our sample, it is noted that impaired (.10 and above) female drivers were generally older (31-59 years) than their male counterparts. These data agree with many previous research conclusions which identify younger male motorists, especially those who drink, as an important population at risk. It is also suggested that female motorists who drink and drive are somewhat older and may be a separate subpopulation with increased risk.

Regarding marital status, most male drivers were either married (46%) or single (45%), but 5% were divorced, 3% were separated and 1% were widowed. Among those legally impaired male motorists (11%), both the divorced and separated categories were proportionately over-represented, with respectively 11% and 10% at .10 or higher. Similar trends in marital status were evident for female drivers, but differences for this group were generally not statistically significant.

Regarding occupational level, the data indicated a somewhat larger representation of "upper" occupation at higher BACs than have been found in previous research. No particular conclusions were reached in this regard, but continued attention to occupational groups may be warranted in future research.

Regarding education, no differences among BAC categories were found for male motorists as a function of educational level attained, but a rather interesting dichotomy appeared for female motorists. Females with relatively little education (0-8 years) and those who completed some college or graduate work registered either very low amounts of alcohol (below .049) or relatively high amounts of alcohol (above .10) in our breath tests. This dichotomy may suggest need for a more careful examination of variables which influence drinking habits of females with education being one of the variables which should be considered.

6.2.2 Drinking Variables

Three categories of drinking variables were of particular interest: (1) typical patterns of alcohol use; (2) most recent alcohol use prior to being stopped at the roadside research survey; and (3) amount of alcohol considered personally safe to consume prior to driving.

6.2.2.1 Typical Patterns of Alcohol Use

When given a choice, beer is the preferred beverage among male motorists, with 64% selecting it, 29% selecting liquor, and 7% choosing wine. Among legally impaired male motorists, beer drinkers were proportionately over-represented (76%), liquor drinkers slightly under-represented (23%), and wine drinkers appreciably under-represented (2%). Furthermore, legally impairing BACs were found among 13% of beer drinkers, 9% of liquor drinkers, and 3% of wine drinkers. These data provide evidence that beer drinking among male motorists is at least as much a menace to highway safety as liquor drinking.

When examined in terms of age, the proportion who prefer beer is extremely high among the younger male drivers (88% of the 14-17 year olds and approximately 72% of the 18-24 year olds); however, the proportion who prefer beer gradually decreases with increasing age, especially after age 50.

On the other hand, female motorists generally prefer liquor to beer or wine. Concomitantly, nearly all (86%) of the legally impaired female drivers indicated they preferred liquor. These stated beverage preferences were corroborated by responses concerning the quantity and frequency of consumption of these beverages by the respondents.

Regarding beer consumption, there was a tendency for the proportion of legally impaired male motorists to increase with increases in the self-reported usual number of bottles consumed (e.g., among those reporting that they usually drink at least five bottles at a sitting, 19% were legally impaired). In terms of age, the relatively heavier and more frequent consumption of beer among the younger male motorists is strikingly illustrated by the 18-20 year old group. Approximately half of these young men report that they usually drink at least four bottles of beer at a sitting (and a third of them report at least five bottles), and 84% of them report that their more than usual amount is at least five bottles, with 61% reporting at least one six-pack. Similar relationships regarding beer consumption by female motorists were not obtained.

Regarding frequency of consuming the usual amount of beer, daily beer drinkers were proportionately over-represented among legally impaired male drivers (44%), and they also had the highest within-group proportion of legally impaired drivers (20%). In terms of age, the 18-20 year olds were again quite outstanding, with 77% reporting that they drink their usual amount of beer at least once a week, 54% reporting at least several times a week, and 14% reporting at least daily. In general terms, heavy and frequent consumption of beer is highly associated with legally impairing BACs obtained from male motorists tested at roadside late in the evening. Furthermore, the general trend is for these drivers under 30 to report heavier and more frequent beer consumption than those aged 40 and older.

Regarding liquor consumption, patterns of relations emerged which are generally similar to those described above for beer. One particularly striking result was that almost 40% of male motorists who reported drinking more than their usual amounts of liquor at least once a week were legally impaired while driving at the time of our roadside surveys. It should be noted that although the within-group proportions of liquor and of beer drinkers with legally impairing BACs were essentially the same, the very frequent drinkers of more than usual quantity of beer greatly outnumbered their liquor-drinking counterparts at the high BACs by a factor of two or three times, in absolute numbers.

Coinciding with their stated preference for liquor rather than beer, female motorists did not exhibit similar relationships between frequency and quantity of beer consumption and BACs. Female motorists also reported drinking lower quantities of liquor and with less frequency than did male respondents. However, there was some indication that female motorists who consumed liquor relatively frequently tended to have higher BACs when tested. Although few female motorists report drinking more than three shots of liquor on a regular basis, 33% do so at least once a week. Thus, it appears that the frequency of liquor consumption by female respondents is of particular concern while more general alcohol abuse appears prevalent for male motorists. This observation is exemplified in the fact that relatively few male motorists report that they prefer drinking wine, but half of those male motorists who were over .10 reported drinking wine at least once per week.

6.2.2.2 Most Recent Alcohol Use

Regarding the elapsed time since the last drink, almost all (97%) legally impaired male respondents reported having consumed alcohol during the previous three hours, and 72% reported drinking within the previous hour. Conversely, among those who had been drinking within the previous hour, 24% were legally impaired--proportionately twice as many of the total sample who were legally impaired (12%). These data clearly point out the importance of establishing educational programs to convince individuals who drink and then drive to increase the time period between their last drink and taking the wheel. Success in such a campaign might have a significant influence on both DWI and alcohol-related accidents.

Regarding the location at which the last drinking had occurred, 46% of legally impaired drivers said at a bar, 10% said at the home of a friend, and 5% said at home. Conversely, 21% of those who said at a bar were legally impaired. In terms of age, the highest proportion of young male drivers age 18-29 reported that their last drinking had occurred at a bar. Another somewhat surprising finding was that the highest proportion of the under-age male drinkers (i.e., less than age 18) report that their last drinking location was at home (38%). Regarding drinking at home, it was noted that a fairly large proportion of all motorists with moderate BACs reported that they had been drinking at home and it should be recalled that data were collected after 10:00 P.M. Informational campaigns to convince motorists to remain at home once they have begun drinking at that location may be advised.

6.2.2.3 Knowledge Concerning Alcohol Use and Driving

In order to obtain each individual's estimate of his own prudent cutoff level, we asked how many shots of liquor (or bottles of beer) he felt he could drink and still drive safely within about an hour. The results of these two questions provide further evidence for the double standard by which beer and liquor are frequently--and differently--judged. In particular, a higher proportion of male respondents reported a higher number of bottles of beer than shots of liquor as their safe limit. Furthermore, those who felt they could drive safely within an hour after consuming five or more bottles of beer comprised about half of those who were legally impaired. When examined in terms of age, the strongest believers in the double standard are the younger drivers from age 18 to 29. More specifically, almost 40% of male drivers in this age category felt they could drive safely after five or more bottles of beer; by contrast only about 18% felt they could drive safely after five or more shots of liquor. However, a surprisingly large proportion of these young men felt that they could <u>not</u> drive safely after one or two shots, or even after <u>any</u> liquor. Thus, analysis of these questions concerning a motorist's understanding of his own safe limits for drinking and then driving clearly indicate a very strong need for more effective information and education countermeasures--especially among the younger male drivers.

6.2.3 Driving Variables

One of the most persistent unanswered questions in this general problem area concerns the continued driving at higher BACs after one has been previously convicted of DWI. Regarding self-reported DWI conviction during the previous three years, 11% of male motorists reported having had one or more, and almost 3% reported having two or more. Nevertheless, despite previous punishment and inconvenience for this very behavior, those male drivers with one or more DWI convictions during the previous three years comprised 19% of all those who were legally impaired, and those with two or more DWI convictions comprised 5%. Conversely, among those motorists reporting one or more DWI conviction, 18% were legally impaired, and among those reporting two or more DWI convictions, 20% were legally impaired. In comparison, among those reporting no previous DWI convictions, 10% were legally impaired. Thus, proportionally twice as many male motorists already convicted of at least one DWI violation during the previous three years were actually driving again at BACs of .10 or higher--in violation of the very same DWI law. This striking disproportion is especially discouraging since an intensive alcohol countermeasure program had already been operating in Vermont for approximately three years--the same period of driving history being sampled among these motorists in the present study. The proportional over-representation of those with previous DWI experience may be interpreted as an indication of the ineffectiveness of legal countermeasures, as well as the serious persistence of the misuse of alcohol.

6.3 PERFORMANCE MEASURES

The results of analyses of the driving performance measures were generally disappointing and the conclusions which can be drawn from these data are more tenuous than those which could be made on the basis of the interview data. Nevertheless, a few interesting clues to differences in the driving performance of motorists at different BACs can be found. Considering the uniqueness of this attempt to obtain actual on-road measures of driving performance and BAC, the "conclusions" can better be thought of as hypotheses for further work.

6.3.1 Primary Site Performance

The correlations between the primary site performance parameters of entering speed, mean speed, mean acceleration, and standard deviation of acceleration with BAC were small, although the correlations for entering speed and the mean speed were statistically significant. A significant negative correlation was obtained for BAC and the primary site entering speed. This relationship would suggest that as BAC increases there is some tendency for motorists to drive somewhat slower, at least in this particular test situation (i.e., driving by a vehicle parked on the right shoulder of the roadway). A small significant positive correlation was obtained between BAC and primary site mean speed. These data may suggest that as BACs increase so does caution in driving behavior. If this relationship in fact exists, then one might expect motorists with higher BACs to drive past a vehicle parked on the side of the road at a relatively cautious slower speed and increase their speed somewhat when the situation has been passed. This type of behavior seems reasonable in an anecdotal sense and could be reflected by the obtained speed measures.

Although we obviously hoped to find differences in the lateral position and movement of vehicles as a function of BAC, these measures did not indicate any apparent influences of alcohol. Similarly, observations for and check ratings of deviant driving behavior in terms of aberrant lateral movement or speed was completely unsuccessful. It seems clear that further efforts to measure on-road driving behavior from a stationary roadside site are contraindicated by our efforts and results.

Further research involving unobtrusive measurement of on-road driving should not necessarily be abandoned based upon the results of the present project. It is conceivable that a mobile data collection method which could be employed over longer distances and for longer periods of data collection may be useful. In this regard, it is suggested that a vehicle mounted radar system which can lock onto a specific vehicle once it acquires the radar signal could be employed for this effort. Such a system could obtain speed data from a single vehicle for any time period desired. Commercially available radar units of this type could be used to obtain digital speed information from the readout box available and would circumvent many of the problems we experienced with the analog data. These digital data could, of course, be analyzed in terms of acceleration characteristics as well as speed since appropriate timing pulses could also be recorded.

6.3.2 Secondary Site Driving Performance

The driving performance of motorists as they were directed to a halt by a law enforcement officer afforded data which were more interesting than those obtained at the primary observation site. For this particular "intervention" situation, small but significant ($p < .10$) were obtained between BAC and mean acceleration or velocity change, standard deviation of acceleration, and the time at which positive acceleration occurred within the data acquisition window. The linear trends suggested by these correlations were not robust enough to also be evident in subsequent analyses of variance on these data. Generally, the correlations indicated that as BAC increases mean acceleration decreases, standard deviation of acceleration decreases and the time at which maximum acceleration occurs is longer after initial data acquisition. In other words, these data suggest that the average mean change from time point to time point as motorists are coming to an easy controlled stop become smaller as BAC increases, that the variation of that acceleration is smaller as BAC increases, and that momentary increases in velocity change occur nearer the final stopping point as BAC increases. These small correlations are expected since it is unrealistic to expect strong linear trends between BAC and these types of performance measures. Based upon induced intoxication experiments, it seems much more likely that changes in driving performance would occur at relatively high BAC levels rather than in linear fashion.

Analyses of variance on the secondary site driving performance measures were conducted with the BAC categories of .00-.009, .01-.049, .05-.079, .08-.099, .10-.149, and .15 and above. These analyses revealed significant differences among BAC categories for the standard deviation of acceleration, the maximum deceleration forces generated, and the maximum acceleration forces generated. These performance parameters seem to be related to the speed of vehicles as they approached the secondary site and were initially picked up by the radar. In general, the data indicate that motorists who were probably slightly influenced by alcohol (BACs between .05 and .079) or who were at very high BACs (.15 and above) brought their cars to a halt somewhat more smoothly than motorists with other BACs. Since the trends suggested motorists with these BACs entered the secondary site at slightly higher speeds (differences were not statistically significant), larger and more consistent acceleration might be expected.

A more intriguing observation can be made on the basis of these performance measures regarding the driving behavior at or near the critical .10 BAC. It appeared that motorists with BACs between .08 and .149 may have modified their driving behavior in a manner consistent with increased caution as they drove in our research area. For example, the difference in speed between primary site and secondary site were much greater for these motorists which indicated significant speed reduction as they approached the secondary site observation window. Furthermore, the acceleration data showed that these motorists had difficulty in smoothly decelerating to a stop near the law enforcement officer despite their seemingly more cautious behavior as they approached the secondary site. In other words, these motorists did not exhibit differences in primary site entering speed (perhaps the best measure of "normal" driving), decreased speed significantly before entering the secondary site (a cautionary response to an unusual situation), and had less smooth stopping behavior than other drivers. <u>If these observations are real, then these</u>

performance characteristics may be important clues which could improve detection of those motorists who are legally impaired but rarely arrested by law enforcement officers. Efforts to corroborate these data and "conclusions" seem warranted.

Secondary site entering speed was significantly different for respondents reporting different quantities of usual liquor consumed, locations of last drinking, and activity coming from. Entering speeds increased in a linear fashion with increased quantities of liquor normally consumed. Entering speeds were also higher for motorists who last drank in a bar or car and who were coming for activities characterized as primarily drinking or entertainment (such as ball games, races, etc.). These data suggest a possibly important population of motorists whose driving performance may be considered potentially more dangerous based upon their drinking characteristics and type of social activities preferred.

The objective of using these data as a first step in relating on-road driving behavior with instrumented car and laboratory research results were effectively obviated by the necessity to abandon use of controlled stimulus intervention procedures in order to collect these data. This development essentially negated comparing the results from the present project with the substantial literature on the influences of alcohol upon divided attention. However, this laboratory recently initiated research using an instrumented car which includes measurement of speed and speed change as motorists perform controlled stops over relatively long distances. These data will be relevant to the secondary site performance parameters in the present report.

Finally, a serendipitous finding should be noted. The law enforcement officers assisting our research crew counted the number of passengers in each vehicle and reported these data to us. We found that slightly more than 63% of motorists with BACs above .05 were accompanied by passengers and 41% of drivers above .10 had at least one passenger. Data on passengers' BAC are desirable, but were not collected in the present research. Attempts should be made to involve this substantial population as a viable social force with responsibility of help minimize the coincidence of drinking and driving.

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APPENDIX A

TECHNICAL FEASIBILITY OF NOCTURNAL OBSERVATION OF IN-CAR BEHAVIOR

APPENDIX A

Measuring performance by covertly filming or videotaping driver behavior at night presented a three-fold problem: (1) Developing a lens system which would provide a large enough depth of field to record at least six seconds of behavior. This would require a record of at least 350 feet of road for vehicles moving 40 mph; (2) finding a device sensitive enough to film in darkness ranging from full moon to completely overcast situations. None of the standard films available would allow this degree of sensitivity; and (3) finding a device which could suppress the brightness of the lights of an oncoming car and still have enough remaining resolution in low-light conditions to capture the driver's behavior.

A.1 Infrared Techniques

Since low-light filming techniques have used IR film with some success for a number of years, it seemed reasonable that this technique might be useful for the present research project. However, consultation with Barnes Engineering (a Stamford, Connecticut firm which specializes in IR devices) revealed that IR film was not the answer. Since IR film is highly heat sensitive, the heat given off by the vehicle and especially by the engine would interfere with observation within the vehicle compartment. It was also noted that IR film cannot readily "see" through safety glass and would be unsuitable for any sort of in-car filming when the windows are rolled up. The Barnes engineers recommended staying within the visible spectrum.

Consideration was also given to the use of regular film in conjunction with an IR light source, but evaluation of this approach revealed that IR light sources do not have adequate range. At least six light sources would have been needed to film vehicles for a minimum of 350 feet. The light sources would also have required extensive cable and power supplies, which would exacerbate problems of mobility and unobtrusiveness. Furthermore, since many IR light emitters are not entirely invisible to the human eye, fairly expensive sources would be required to eliminate detection by the drivers as they passed the light source.

A.2 Light Intensification Units

Another possible solution was a so-called "low-level light intensification unit." These devices were developed primarily for armed forces use, but are also being used now by police agencies for nocturnal surveillance. They are capable of greatly intensifying very low ambient light and producing visible images in conditions of extreme darkness.

The first unit evaluated was a Singer Corporation product called the Librascope. This first-generation type of light amplification unit collects available light and electronically intensifies it up to 125,000 times. It can be used in conjunction with 8mm, 16mm, or video cameras, as well as with an optical piece for direct viewing by an observer. The Librascope is available with 300mm and 500mm lenses and therefore seemed to fulfill the requirements both for a large focal-length and for very high intensification capabilities in low-light conditions.

In actual field testing, however, the Singer Librascope was found to have a number of physical drawbacks. For example, it is over two feet long and weighs approximately 19 pounds without a camera and attachments. Thus, the unit is awkward to handle and requires a rather large and expensive tripod mounting for any stability. With a unit of this size, it is extremely difficult to pan fast enough to keep a moving target within the field of view. Extensive work with the unit made it clear that it would have to be positioned some 150 to 200 feet off the road in order to be able to film vehicles for the necessary minimum of 350 feet. While panning, it was also necessary to adjust the depth of field control constantly to keep the vehicle and driver in focus. This was an impossible task for targets traveling faster than 35 mph.

Finally, although the Librascope provided excellent passive viewing results in relatively uniform darkness, it was less useful when light sources were present. Since the Librascope is extremely sensitive to light, large "blooming" occurred around headlights, taillights, brake lights, and even the side lights of vehicles. This bloom caused the area of the light source to seem several times its original size (depending on the intensity of the source) and actually obscured any view of the driver of the vehicle. In addition, if the lights were very intense and the bloom effect was very large, the Librascope would lower its own gain automatically as part of a built-in, self-limiting system designed to prevent destruction of the image screen. This decrease in the intensification level was such that it was impossible to see into the vehicle compartment.

Attempts to overcome the bloom around the light sources were only partially successful. At the manufacturer's suggestion, a sheild was inserted in the lower half of the screen at a point behind the light collection lens but ahead of the light intensifying tube. While this shield effectively screened off the bottom half of the tube, it did not affect the bloom which continued to cover the full diameter of the viewing screen. Obviously, first-generation light intensifiers were not very useful for observing in-car behavior.

At that point, an article was discovered (Needham, 1973) which discussed image intensifier tubes that were much smaller than the first-generation equipment exemplified by the Librascope and were also less expensive. These second-generation devices intensified available light by means of numerous microchannel tubes which could specifically suppress bright lights without decreasing the brightness of the remaining surface of the intensifying tube. This seemed to be the answer to blooming problems caused by headlights, side lights, and brake lights.

The second-generation device which was tested and evaluated is manufactured by the Smith and Wesson Corporation and is available in a number of different models. The Star-tron model functioned with moderate success in retaining field-of-view brightness while nullifying light-source problems. However, dome decrement in the brightness of the surrounding field was experienced whenever bright light sources impinged upon the field of view. Although this was not a problem for direct viewing, it sufficiently reduced image brightness to preclude filming or videotaping. The results of these fairly extensive evaluations of light intensification units, as well as the legal concerns which were beginning to surface, dictated abaondonment of further attempts to obtain measures of in-car behavior.

A.3 Camera Systems

The cameras tested in conjunction with the light intensification units also deserve brief comment. Initial efforts to obtain a film record of the light intensification unit image included both a super-8 and a 16mm movie camera using sensitive black-and-white film. It was found that 8mm film resulted in unsatisfactorially small picture size and too much granularity for visual analysis. On the other hand, 16mm film afforded larger frame size and much better granularity characteristics, but it cost about twice as much as 8mm film. In addition, a 16mm movie camera is considerably more expensive than an 8mm.

In terms of relative costs, the best recording system seemed to be a videotaping device. The cost of half-inch videotape is much less than 8mm film, and since no processing is required analysis could begin on any tape shortly after recording.

Two types of video cameras were investigated. A standard vidicon tube video camera was coupled with the Librascope and the Star-tron with equally unacceptable results. Although the image produced by the light intensifiers was bright enough for retinal transduction, it was insufficient for video recording. This was true even when the scene was flooded with IR light.

Video cameras are also available with a silicon diode detector rather than the standard vidicons. These units are much more light sensitive, fairly insensitive to damage by bright light sources, and minimize image ghosting. Two silicon diode cameras were tested: a two-thirds inch and a one-inch. When coupled with the light intensifier, the one-inch system was clearly more sensitive, but neither camera proved adequate for videotaping the available image.

Thus, it was clear that nocturnal surveillance of in-car behavior was not feasible for this study and may even be technically impossible with currently available equipment. A decision was made to ignore recording in-car behaviors and concentrate on obtaining objective data on vehicle performance such as speed, speed change, lateral position, and lateral movement.

APPENDIX B

LONG INTERVIEW FORM
WITH RESPONSE FREQUENCIES

Respondent Number ____________

RESEARCH - CONFIDENTIAL

VERMONT ROADSIDE RESEARCH SURVEY

Psychological Research Foundation of Vermont

1. What city or town do you presently live in?

[write in] ____________ city or town ________ state [ ] [ ] [ ] [ ]

2. What is your birth date?

[write in] ______ Month ______ Day ______ Year [ ] [ ]

3. What is your principal occupation (for example: farmer, laborer, truck driver, factory worker, housewife, carpenter, teacher, high school student, grocery store clerk.) (If working on more than one job, indicate the most important one. If retired or unemployed, list the job you had when you were working.)

[write in] ____________________ [ ] [ ]

4. What is the highest grade of education you have completed? (If currently a student, what grade are you in?)

				N	%
a.	0 - 8	a.	[ ] 1	54	7.3
b.	9 - 12	b.	[ ] 2	377	50.9
c.	some college or technical training after high school	c.	[ ] 3	176	23.8
d.	completed 4-year college	d.	[ ] 4	73	9.9
e.	graduate work	e.	[ ] 5	58	7.8
		R	[ ] 0	3	.4

5. What is the highest grade of education that your mother completed?

				N	%
a.	0 - 8	a.	[ ] 1	127	17.1
b.	9 - 12	b.	[ ] 2	351	47.4
c.	some college or technical training after high school	c.	[ ] 3	68	9.2
d.	completed 4-year college	d.	[ ] 4	69	9.3
e.	graduate work	e.	[ ] 5	18	2.4
		DK	[ ] 9	103	13.9
		R	[ ]	5	.7

6. What is your present marital status?

				N	%
a.	single (never married)	a.	[ ] 1	323	43.6
b.	married	b.	[ ] 2	331	44.7
c.	divorced or annulled	c.	[ ] 3	52	7.0
d.	separated	d.	[ ] 4	21	2.8
e.	widowed	e.	[ ] 5	11	1.5
		R	[ ] 0	3	.4

7. About how many miles have you personally driven the car (vehicle) you are driving tonight?

		N	%
a. less than 50	a. ☐ 1	26	3.5
b. 50 - 99	b. ☐ 2	11	1.5
c. 100 - 499	c. ☐ 3	47	6.3
d. 500 - 999	d. ☐ 4	29	3.9
e. 1000 - 2999	e. ☐ 5	90	12.1
f. 3000 - 4999	f. ☐ 6	63	8.5
g. 5000 - 9999	g. ☐ 7	89	12.0
h. 10,000 or more	h. ☐ 8	382	51.6
	R ☐ 0	4	.5

8. How often do you drive after dark on each night of the week? Let's start with Monday.

Q. 8 matrix follow this questionnaire

Monday	M ☐
Tuesday	T ☐
Wednesday	W ☐
Thursday	T ☐
Friday	F ☐
Saturday	S ☐
Sunday	S ☐

Response categories	Code numbers
a. Almost always	a. 1
b. Sometimes	b. 2
c. Almost never	c. 3
	R 0

9. How often after dark do you drive by this point going in this direction?

		N	%
a. This is the first time	a. ☐ 1	69	9.3
b. More than this time, but less than once a week	b. ☐ 2	281	37.9
c. About once a week	c. ☐ 3	101	13.6
d. Several times a week or more	d. ☐ 4	285	38.5
	R ☐ 0	5	.7

10. How often during the day do you drive by this point going in this direction?

		N	%
a. Never	a. ☐ 1	129	17.4
b. This is the first time	b. ☐ 2	12	1.6
c. More than this time, but less than once a week	c. ☐ 3	238	32.1
d. About once a week	d. ☐ 4	82	11.1
e. Several times a week or more	e. ☐ 5	275	37.1
	R ☐ 0	5	.7

11. How often do you drive a car?

		N	%
a. Several times a day	a. [ ] 1	567	76.5
b. About once a day	b. [ ] 2	93	12.6
c. Several times a week	c. [ ] 3	60	8.1
d. About once a week	d. [ ] 4	11	1.5
e. Several times a month	e. [ ] 5	4	.5
f. About once a month	f. [ ] 6	0	.0
g. Less than once a month	g. [ ] 7	1	.1
	R [ ] 0	5	.7

12. How long have you been driving?

		N	%
a. Less than 1 month	a. [ ] 1	2	.3
b. 1 - 2 months	b. [ ] 2	7	.9
c. 3 - 5 months	c. [ ] 3	10	1.3
d. 6 - 11 months	d. [ ] 4	13	1.8
e. 1 - 2 years	e. [ ] 5	61	8.2
f. 3 - 4 years	f. [ ] 6	79	10.7
g. 5 - 9 years	g. [ ] 7	191	25.8
h. 10 years or more	h. [ ] 8	375	50.6
	R [ ] 0	3	.4

13. Who was wearing seat belts just now in your vehicle?

		N	%
a. no one was	a. [ ] 1	561	75.7
b. only the driver	b. [ ] 2	61	8.2
c. only passengers	c. [ ] 3	16	2.2
d. everyone was wearing seatbelts	d. [ ] 4	99	13.4
	R [ ] 0	4	.5

14. Other than parking tickets, how many traffic violations have you had during the last 3 years?

		N	%
a. none [SKIP TO Q. 17]	a. [ ] 1	518	69.9
b. 1	b. [ ] 2	129	17.4
c. 2	c. [ ] 3	88	11.9
d. 3	d. [ ] 4	0	.0
e. 4	e. [ ] 5	0	.0
f. 5 - 6	f. [ ] 6	0	.0
g. 7 - 8	g. [ ] 7	0	.0
h. 9 or more	h. [ ] 8	0	.0
	R [ ] 0	6	.8

15. If any of these actually resulted in convictions, what were they? [write in number]

Q. 15 matrix follows this questionnaire

Response categories

a. Careless and negligent driving, leaving the scene of an accident, violation of law of the road	a. [ ] 1
b. Driving while intoxicated, refusing chemical test	b. [ ] 2
c. Driving while license suspended/revoked, driving without license	c. [ ] 3
d. Exceeding speed limit	d. [ ] 4
e. Other (Please specify: ______________________)	e. [ ] 5
R [If applicable, write in 1; if not, 0]	R [ ]

[IF NONE, SKIP TO Q. 17]

16. Which convictions occurred in Vermont? [write in number]

a. Careless and negligent driving, leaving the scene of an accident, violation of law of the road . . . . a. [ ] 1
b. Driving while intoxicated, refusing chemical test. . . . . . b. [ ] 2
c. Driving while license suspended/revoked, driving without license. . . . . c. [ ] 3
d. Exceeding speed limit. . . . . d. [ ] 4
e. Other (Please specify: ______________________________) e. [ ] 5
R [If applicable, write in 1; if not, 0]. . . . . R [ ]

Q. 16 matrix
follows this
questionnair

17. How many times has your driver's license been suspended (or revoked) in your lifetime?

			N	%
a.	never	a. [ ] 1	554	74.8
b.	1	b. [ ] 2	138	18.6
c.	2	c. [ ] 3	44	5.9
d.	3	d. [ ] 4	0	.0
e.	4	e. [ ] 5	0	.0
f.	5	f. [ ] 6	0	.0
g.	6	g. [ ] 7	0	.0
h.	7 or more times	h. [ ] 8	0	.0
		R [ ] 0	5	.7

18. How many auto accidents have you had as a driver during the last 3 years which were necessary to report to the police or Department of Motor Vehicles?

			N	%
a.	none [SKIP TO Q. 21]	a. [ ] 1	537	72.5
b.	1	b. [ ] 2	161	21.7
c.	2	c. [ ] 3	40	5.4
d.	3	d. [ ] 4	0	.0
e.	4	e. [ ] 5	0	.0
f.	5	f. [ ] 6	0	.0
g.	6	g. [ ] 7	0	.0
h.	7 or more	h. [ ] 8	0	.0
		R [ ] 0	3	.4

19. Of these, how many were in Vermont?

			N	%
a.	none	a. [ ] 1	54	7.3
b.	1	b. [ ] 2	134	18.1
c.	2	c. [ ] 3	26	3.5
d.	3	d. [ ] 4	0	.0
e.	4	e. [ ] 5	0	.0
f.	5	f. [ ] 6	0	.0
g.	6	g. [ ] 7	0	.0
h.	7 or more	h. [ ] 8	0	.0
		NA [ ] 9	517	69.8
		R [ ] 0	10	1.3

20. What was the outcome of each accident (starting with the most recent one)?

		N	%
Most recent accident	☐	Q. 20 matri follows thi questionnai	
Accident before that	☐		
Accident before that	☐		
Accident before that	☐		

Response categories	Code numbers
a. I was convicted of driving while intoxicated.	a. 1
b. I was convicted of careless and negligent driving.	b. 2
c. I was convicted of some other traffic violation.	c. 3
d. I was not convicted of a traffic violation.	d. 4
	NA 9
	R 0

21. What activity are you coming from?

		N	%
a. work	a. ☐ 1	140	18.9
b. being at home	b. ☐ 2	56	7.6
c. visiting friends or family	c. ☐ 3	193	26.0
d. recreation (fishing, softball, snowmobiling)	d. ☐ 4	34	4.6
e. entertainment (movies, races, ball game)	e. ☐ 5	94	12.7
f. evening out dining and/or dancing	f. ☐ 6	80	10.8
g. having a few drinks at a bar, lounge, etc.	g. ☐ 7	84	11.3
h. other (Please specify: ______)	h. ☐ 8	53	7.2
	R ☐ 0	7	.9

22. What activity are you going to?

		N	%
a. work	a. ☐ 1	23	3.1
b. being at home	b. ☐ 2	572	77.2
c. visiting friends or family	c. ☐ 3	65	8.8
d. recreation (fishing, softball, snowmobiling)	d. ☐ 4	15	2.0
e. entertainment (movies, races, ball game)	e. ☐ 5	8	1.1
f. evening out dining and/or dancing	f. ☐ 6	8	1.1
g. having a few drinks at a bar, lounge, etc.	g. ☐ 7	13	1.8
h. other (Please specify: ______)	h. ☐ 8	29	3.9
	R ☐ 0	8	1.1

23. Tonight, you say that you have just come from ______, and are going to ______. How often do you do this?

		N	%
a. daily	a. ☐ 1	78	10.5
b. several times a week	b. ☐ 2	190	25.6
c. once a week	c. ☐ 3	142	19.2
d. several times a month	d. ☐ 4	94	12.7
e. once a month	e. ☐ 5	85	11.5
f. more than twice a year, but less than once a month	f. ☐ 6	61	8.2
g. about once or twice a year	g. ☐ 7	84	11.3
	R ☐ 0	7	.9

24. Do you currently drink any alcohol beverages?

		N	%
a. yes [SKIP TO Q. 27]	a. [ ] 1	644	86.9
b. no	b. [ ] 2	93	12.6
	R [ ] 0	4	.5

25. Was there ever a time when you did drink at least occasionally?

a. yes.	a. [ ] 1	58	7.8
b. no [SKIP TO Q. 47].	b. [ ] 2	36	4.9
	NA [ ] 9	624	84.2
	R [ ] 0	23	3.1

26. How long has it been since you were drinking at least occasionally?

a. within the past month.	a. [ ] 1	4	.5
b. 1 - 5 months ago	b. [ ] 2	10	1.3
c. 6 - 11 months ago.	c. [ ] 3	9	1.2
d. 1 - 4 years ago.	d. [ ] 4	22	3.0
e. 5 - 9 years ago.	e. [ ] 5	3	.4
f. 10 - or over	f. [ ] 6	10	1.3
	NA [ ] 9	661	89.2
	R [ ] 0	22	3.0

27. How often do (did) you generally drink <u>wine</u> (or hard cider, sherry, port)?

a. three or more times a day.	a. [ ] 01	3	.4
b. twice a day.	b. [ ] 02	0	.0
c. once a day	c. [ ] 03	16	2.2
d. several times a week	d. [ ] 04	39	5.3
e. once a week.	e. [ ] 05	45	6.1
f. several times a month.	f. [ ] 06	50	6.7
g. once a month	g. [ ] 07	64	8.6
h. less than once a month	h. [ ] 08	155	20.9
i. never [SKIP TO Q. 29]	i. [ ] 09	324	43.7
	NA [ ] 99	41	5.5
	R [ ] 00	4	.5

28. How much <u>wine</u> (or cider, sherry, port) do you generally drink <u>at one time</u>? (at one sitting or session)

a. 1 wine glass (4 ounces).	a. [ ] 01	157	21.2
b. 2 wine glasses	b. [ ] 02	117	15.8
c. 3 wine glasses	c. [ ] 03	43	5.8
d. 4 wine glasses	d. [ ] 04	20	2.7
e. 5 wine glasses	e. [ ] 05	38	5.1
f. 1 fifth.	f. [ ] 06		
g. 1/2 gallon	g. [ ] 07		
h. 1 gallon	h. [ ] 08		
i. 1 1/2 gallon	i. [ ] 09		
j. 2 gallons.	j. [ ] 10		
k. 3 gallons or more.	k. [ ] 11		
	NA [ ] 99	354	47.8
	R [ ] 00	12	1.6

29. How often do you generally drink beer?

		N	%
a. three or more times a day	a. [ ] 01	15	2.0
b. twice a day	b. [ ] 02	20	2.7
c. once a day	c. [ ] 03	101	13.6
d. several times a week	d. [ ] 04	207	27.9
e. once a week	e. [ ] 05	92	12.4
f. several times a month	f. [ ] 06	52	7.0
g. once a month	g. [ ] 07	53	7.2
h. less than once a month	h. [ ] 08	64	8.6
i. never [SKIP TO Q. 33]	i. [ ] 09	92	12.4
	NA [ ] 99	41	5.5
	R [ ] 00	4	.5

30. How much beer do you generally drink at one time (at one sitting or session)?

		N	%
a. 1 bottle (typical 12-ounce bottle)	a. [ ] 01	136	18.4
b. 2 bottles	b. [ ] 02	166	22.4
c. 3 bottles	c. [ ] 03	133	17.9
d. 4 bottles	d. [ ] 04	73	9.9
e. 5 bottles	e. [ ] 05	96	13.0
f. 1 six-pack	f. [ ] 06		
g. more than 1, but less than 2 six-packs	g. [ ] 07		
h. 2 six-packs	h. [ ] 08		
i. 3 six-packs	i. [ ] 09		
j. 4 six-packs	j. [ ] 10		
k. 5 or more six-packs	k. [ ] 11		
	NA [ ] 99	131	17.7
	R [ ] 00	6	.8

31. How much beer do you drink on those occasions when you drink more than your usual amount (of beer)?

		N	%
a. 1 bottle (typical 12-ounce bottle)	a. [ ] 01	88	11.9
b. 2 bottles	b. [ ] 02		
c. 3 bottles	c. [ ] 03	136	18.4
d. 4 bottles	d. [ ] 04		
e. 5 bottles	e. [ ] 05	185	25.0
f. 1 six-pack	f. [ ] 06		
g. more than 1, but less than 2 six-packs	g. [ ] 07	183	24.7
h. 2 six-packs	h. [ ] 08		
i. 3 six-packs	i. [ ] 09		
j. 4 six-packs	j. [ ] 10		
k. 5 or more six-packs	k. [ ] 11		
	NA [ ] 99	140	18.9
	R [ ] 00	9	1.2

32. How often do you drink more than your usual amount of beer?

		N	%
a. every day	a. ☐ 1	61	8.2
b. several times a week	b. ☐ 2	↓	
c. once a week	c. ☐ 3	↓	
d. several times a month	d. ☐ 4	54	7.3
e. once a month	e. ☐ 5	131	17.7
f. more than twice a year, but less than once a month	f. ☐ 6	111	15.0
g. about once or twice a year	g. ☐ 7	132	17.8
h. never	h. ☐ 8	105	14.2
	NA ☐ 9	141	19.0
	R ☐ 0	6	.8

33. How often do you generally drink liquor?

		N	%
a. three or more times a day	a. ☐ 01	3	.4
b. twice a day	b. ☐ 02	3	.4
c. once a day	c. ☐ 03	21	2.8
d. several times a week	d. ☐ 04	77	10.4
e. once a week	e. ☐ 05	82	11.1
f. several times a month	f. ☐ 06	75	10.1
g. once a month	g. ☐ 07	96	13.0
h. less than once a month	h. ☐ 08	209	28.2
i. never [SKIP TO Q. 37]	i. ☐ 09	126	17.0
	NA ☐ 99	43	5.8
	R ☐ 00	6	.8

34. How much liquor do you generally drink at one time? (at one sitting or session)

		N	%
a. 1 shot (1 shot is about 1 1/2 ounces)	a. ☐ 01	127	17.1
b. 2 shots	b. ☐ 02	179	24.2
c. 3 shots	c. ☐ 03	97	13.1
d. 4 shots	d. ☐ 04	68	9.2
e. 5 shots	e. ☐ 05	96	13.0
f. 6 shots	f. ☐ 06	↓	
g. 7 - 8 shots	g. ☐ 07	↓	
h. 1 pint	h. ☐ 08	↓	
i. 1 fifth	i. ☐ 09	↓	
j. 2 fifths	j. ☐ 10	↓	
k. 3 fifths	k. ☐ 11	↓	
	NA ☐ 99	165	22.3
	R ☐ 00	9	1.2

35. How much liquor do you drink on those occasions when you drink more than your usual amount (of liquor)?

		N	%
a. 1 shot	a. [ ] 01	111	15.0
b. 2 shots	b. [ ] 02		
c. 3 shots	c. [ ] 03	160	21.6
d. 4 shots	d. [ ] 04		
e. 5 shots	e. [ ] 05	132	17.8
f. 6 shots	f. [ ] 06		
g. 7 - 8 shots	g. [ ] 07	145	19.6
h. 1 pint	h. [ ] 08		
i. 1 fifth	i. [ ] 09		
j. 2 fifths	j. [ ] 10		
k. 3 fifths	k. [ ] 11		
	NA [ ] 99	185	25.0
	R [ ] 00	8	1.1

36. How often do you drink more than your usual amount of liquor?

		N	%
a. every day	a. [ ] 1	0	.0
b. several times a week	b. [ ] 2	0	.0
c. once a week	c. [ ] 3	21	2.8
d. several times a month	d. [ ] 4	20	2.7
e. once a month	e. [ ] 5	73	9.9
f. more than twice a year, but less than once a month	f. [ ] 6	112	15.1
g. about once or twice a year	g. [ ] 7	178	24.0
h. never	h. [ ] 8	152	20.5
	NA [ ] 9	174	23.5
	R [ ] 0	11	1.5

37. When you have your choice, what alcoholic beverage do you generally drink?

		N	%
a. beer	a. [ ] 1	383	51.7
b. wine	b. [ ] 2	59	8.0
c. liquor	c. [ ] 3	249	33.6
d. other (Please specify: ____________________)	d. [ ] 4	6	.8
	NA [ ] 9	38	5.1
	R [ ] 0	6	.8

[FORMER DRINKERS: SKIP TO Q. 45]

……

38. How long ago did you last consume alcohol?

		N	%
a. was drinking when stopped	a. [ ] 01	0	.0
b. less than 15 minutes ago	b. [ ] 02	49	6.6
c. 15 minutes to 1 hour ago	c. [ ] 03	166	22.4
d. 1 - 3 hours ago	d. [ ] 04	139	18.8
e. 3 - 6 hours ago	e. [ ] 05	64	8.6
f. 6 - 12 hours ago	f. [ ] 06	58	7.8
g. 12 - 24 hours ago	g. [ ] 07		
h. 24 - 48 hours ago	h. [ ] 08	171	23.1
i. 2 - 7 days ago	i. [ ] 09		
j. more than 1 week ago	j. [ ] 10		
	NA [ ] 99	85	11.5
	R [ ] 00	9	1.2

39. Where were you drinking then?

			N	%
a.	home	a. [ ] 1	130	17.5
b.	relative's home	b. [ ] 2	34	4.6
c.	friend's home	c. [ ] 3	127	17.1
d.	bars	d. [ ] 4	167	22.5
e.	restaurants	e. [ ] 5	84	11.3
f.	car	f. [ ] 6	32	4.3
g.	private club or fraternity	g. [ ] 7	21	2.8
h.	other (Please specify: ______________________)	h. [ ] 8	50	6.7
		NA [ ] 9	10	1.3
		R [ ] 0	86	11.6

40. What were you drinking?

a.	beer	a. [ ] 1	395	53.3
b.	wine [SKIP TO Q. 42]	b. [ ] 2	61	8.2
c.	liquor [SKIP TO Q. 43]	c. [ ] 3	190	25.6
		NA [ ] 9	10	1.3
		R [ ] 0	85	11.5

41. How much beer did you have then?

a.	none	a. [ ] 01	3	.4
b.	1 bottle (typical 12-ounce bottle)	b. [ ] 02	115	15.5
c.	2 bottles	c. [ ] 03	96	13.0
d.	3 bottles	d. [ ] 04	73	9.9
e.	4 bottles	e. [ ] 05	29	3.9
f.	5 bottles	f. [ ] 06	24	3.2
g.	1 six-pack	g. [ ] 07	26	3.5
h.	more than 1, but less than 2 six-packs	h. [ ] 08	17	2.3
i.	2 six-packs	i. [ ] 09	8	1.1
j.	3 six-packs	j. [ ] 10	1	.1
k.	4 six-packs	k. [ ] 11	2	.3
l.	5 or more six-packs	l. [ ] 12	0	.0
		NA [ ] 99	20	2.7
		R [ ] 00	327	44.1

[SKIP TO Q. 44]

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42. How much wine did you have then?

a.	none	a. [ ] 01	1	.1
b.	1 wine glass (4 ounces)	b. [ ] 02	25	3.4
c.	2 wine glasses	c. [ ] 03	13	1.8
d.	3 wine glasses	d. [ ] 04	11	1.5
e.	4 wine glasses	e. [ ] 05	3	.4
f.	5 wine glasses	f. [ ] 06	3	.4
g.	1 fifth	g. [ ] 07	2	.3
h.	1/2 gallon	h. [ ] 08	1	.1
i.	1 gallon	i. [ ] 09	0	.0
j.	1 1/2 gallon	j. [ ] 10	0	.0
k.	2 gallons	k. [ ] 11	0	.0
l.	3 gallons or more	l. [ ] 12	0	.0
		NA [ ] 99	20	2.7
		R [ ] 00	662	89.3

[SKIP TO Q. 44

43. How much liquor did you have then?

		N	%
a. none	a. [ ] 01	3	.4
b. 1 shot (one shot is about 1 1/2 ounces)	b. [ ] 02	56	7.6
c. 2 shots	c. [ ] 03	55	7.4
d. 3 shots	d. [ ] 04	32	4.3
e. 4 shots	e. [ ] 05	21	2.8
f. 5 shots	f. [ ] 06	11	1.5
g. 6 shots	g. [ ] 07	5	.7
h. 7 - 8 shots	h. [ ] 08	5	.7
i. 1 pint	i. [ ] 09	4	.5
j. 1 fifth	j. [ ] 10	2	.3
k. 2 fifths	k. [ ] 11	0	.0
l. 3 fifths	l. [ ] 12	0	.0
	NA [ ] 99	17	2.3
	R [ ] 00	530	71.5

44. Compared with your friends, do you find that you drink:

a. much more than they do	a. [ ] 1	7	.9
b. somewhat more than they do	b. [ ] 2	18	2.4
c. about the same as they do	c. [ ] 3	252	34.0
d. somewhat less than they do	d. [ ] 4	184	24.8
e. much less than they do	e. [ ] 5	182	24.6
f. not at all	f. [ ] 6	2	.3
	NA [ ] 9	15	2.0
	R [ ] 0	81	10.9

45. During your lifetime, how often have you been in an automobile accident as a driver after you had been drinking?

a. none	a. [ ] 1	617	83.3
b. 1	b. [ ] 2	53	7.2
c. 2	c. [ ] 3	9	1.2
d. 3	d. [ ] 4	2	.3
e. 4	e. [ ] 5	2	.3
f. 5	f. [ ] 6	0	.0
g. 6	g. [ ] 7	1	.1
h. 7 or more	h. [ ] 8	1	.1
	NA [ ] 9	10	1.3
	R [ ] 0	46	6.2

46. During your lifetime, how many traffic violations have you had after you had been drinking?

a. none	a. [ ] 1	626	84.5
b. 1	b. [ ] 2	48	6.5
c. 2	c. [ ] 3	7	.9
d. 3	d. [ ] 4	4	.5
e. 4	e. [ ] 5	1	.1
f. 5	f. [ ] 6	1	.1
g. 6	g. [ ] 7	0	.0
h. 7 or more	h. [ ] 8	3	.4
	NA [ ] 9	9	1.2
	R [ ] 0	42	5.7

47. How many beers do you feel that you can drink and still drive safely within about an hour?

		N	%
a. none	a. [ ] 01	34	4.6
b. 1 bottle (typical 12-ounce bottle)	b. [ ] 02	73	9.9
c. 2 bottles	c. [ ] 03	114	15.4
d. 3 bottles	d. [ ] 04	162	21.9
e. 4 bottles	e. [ ] 05	123	16.6
f. 5 bottles	f. [ ] 06	51	6.9
g. 1 six-pack	g. [ ] 07	84	12.1
h. more than 1, but less than 2 six-packs	h. [ ] 08	28	3.8
i. 2 six-packs	i. [ ] 09	17	2.3
j. 3 six-packs	j. [ ] 10	6	.8
	NA [ ] 99	32	4.3
	R [ ] 00	17	2.3

48. How many shots of liquor do you feel that you can drink and still drive safely within about an hour?

a. none	a. [ ] 01	80	10.8
b. 1 shot (one shot is about 1 1/2 ounces)	b. [ ] 02	110	14.8
c. 2 shots	c. [ ] 03	173	23.3
d. 3 shots	d. [ ] 04	140	18.9
e. 4 shots	e. [ ] 05	81	10.9
f. 5 shots	f. [ ] 06	43	5.8
g. 6 shots	g. [ ] 07	24	3.2
h. 7 - 8 shots	h. [ ] 08	12	1.6
i. 1 pint	i. [ ] 09	14	1.9
j. 1 fifth or more	j. [ ] 10	0	.0
	NA [ ] 99	42	5.7
	R [ ] 00	22	3.0

49. Sex

Male	[ ] 1	587	79.2
Female	[ ] 2	152	20.5

50. Weight (approximate) . . . . [ ] [ ] [ ]

51. BAC (Breathalyzer) . . . . [ ] [ ] [ ]

52. BAC (estimated) . . . . [ ] [ ] [ ]

INTERVIEWER RATING OF RESPONDENT

53. Comprehension rating:

a. poor . . . . a. ☐ 1
b. fair . . . . b. ☐ 2
c. good . . . . c. ☐ 3
d. very good. . . . . d. ☐ 4
e. excellent. . . . . e. ☐ 5

54. Credibility rating:

a. poor . . . . a. ☐ 1
b. fair . . . . b. ☐ 2
c. good . . . . c. ☐ 3
d. very good. . . . . d. ☐ 4
e. excellent. . . . . e. ☐ 5

Interviewer
Signature ______________________________ Date ______________ Time ________

Q. 8: How Often do you Drive after Dark Each Night of the Week?

NIGHTS OF THE WEEK

LABEL	MONDAY		TUES.		WEDNESDAY		THURS.		FRIDAY		SAT.		SUNDAY	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Almost always	365	49.3	355	47.9	360	48.6	367	49.5	463	62.5	424	57.2	347	46.8
Sometimes	174	23.5	194	26.2	184	24.8	194	26.2	181	24.4	203	27.4	204	27.5
Almost never	196	26.5	186	25.1	191	25.8	174	23.5	92	12.4	109	14.7	184	24.8
Missing	6	.8	6	.8	6	.8	6	.8	5	.7	5	.7	6	.8

Q. 15: Number of Traffic Violations Resulting in Convictions in Last 3 Years

NUMBER OF CONVICTIONS	CARELESS CONVICTIONS		DWI CONVICTIONS		NO LICENSE		SPEEDING		OTHER		CONVICTION REFUSE TO ANSWER	
	N	%	N	%	N	%	N	%	N	%	N	%
0	679	91.6	733	98.9	737	99.5	621	83.8	723	97.6	723	97.6
1	54	7.3	7	.9	3	.4	93	12.6	16	2.2	18	2.4
2	7	.9	1	.1	1	.1	15	2.0	1	.1	0	.0
3	1	.1	0	.0	0	.0	9	1.2	1	.1	0	.0
4	0	.0	0	.0	0	.0	2	.3	0	.0	0	.0

Q. 16: Which Traffic Violations for Which You Have Received Convictions Occurred in Vermont?

NUMBER OF CONVICTIONS	CARELESS CONVICTIONS		DWI CONVICTIONS		NO LICENSE		SPEEDING		OTHER		CONVICTION REFUSE TO ANSWER	
	N	%	N	%	N	%	N	%	N	%	N	%
0	696	93.9	734	99.1	734	99.1	643	86.8	721	97.3	719	97.0
1	35	4.7	5	.7	3	.4	75	10.1	15	2.0	19	2.6
2	6	.8	0	.0	1	.1	11	1.5	1	.1	0	.0
3	1	.1	0	.0	0	.0	9	1.2	1	.1	0	.0
Missing	3	.4	2	.3	3	.4	3	.4	3	.4	3	.4

Q. 20: Outcome of Accidents in Last 3 Years

OUTCOME OF ACCIDENT	MOST RECENT ACCIDENT		ACCIDENT BEFORE THAT		ACCIDENT BEFORE THAT		ACCIDENT BEFORE THAT	
	N	%	N	%	N	%	N	%
DWI conviction	4	.5	1	.1	0	.0	0	.0
Careless & negligent conviction	17	2.3	3	.4	0	.0	0	.0
Other	17	2.3	2	.3	2	.3	0	.0
No conviction	154	20.8	31	4.2	8	1.1	1	.1
Refuse to answer	14	1.9	29	3.9	31	4.2	31	4.2
Not applicable	535	72.2	675	91.1	700	94.5	709	95.7

APPENDIX C

SHORT INTERVIEW FORM
WITH RESPONSE FREQUENCIES

[RESEARCH - CONFIDENTIAL]   Respondent Number ____________

1. About how many miles have you personally driven the car (vehicle) you are driving tonight?

			N	%
a.	less than 50	a. [ ] 1	30	3.0
b.	50 - 99	b. [ ] 2	19	1.9
c.	100 - 499	c. [ ] 3	75	7.4
d.	500 - 999	d. [ ] 4	24	2.4
e.	1000 - 2999	e. [ ] 5	104	10.3
f.	3000 - 4999	f. [ ] 6	64	6.3
g.	5000 - 9999	g. [ ] 7	117	11.5
h.	10,000 or more	h. [ ] 8	517	51.0
		R [ ] 0	63	6.2

2. How often after dark do you drive by this point going in this direction?

a.	This is the first time	a. [ ] 1	89	8.8
b.	More than this time, but less than once a week	b. [ ] 2	332	32.8
c.	About once a week	c. [ ] 3	113	11.8
d.	Several times a week or more	d. [ ] 4	424	41.9
		R [ ] 0	55	5.5

3. How long have you been driving?

a.	Less than 1 month	a. [ ] 1	2	.2
b.	1 - 2 months	b. [ ] 2	9	.9
c.	3 - 5 months	c. [ ] 3	13	1.3
d.	6 - 11 months	d. [ ] 4	17	1.7
e.	1 - 2 years	e. [ ] 5	85	8.4
f.	3 - 4 years	f. [ ] 6	94	9.3
g.	5 - 9 years	g. [ ] 7	194	19.2
h.	10 years or more	h. [ ] 8	544	53.7
		R [ ] 0	55	5.4

4. Other than parking tickets, how many traffic violations have you had during the last 3 years?

a.	none	a. [ ] 1	714	70.5
b.	1	b. [ ] 2	164	16.2
c.	2	c. [ ] 3	42	4.1
d.	3	d. [ ] 4	22	2.2
e.	4	e. [ ] 5	5	.5
f.	5 - 6	f. [ ] 6	4	.4
g.	7 - 8	g. [ ] 7	1	.1
h.	9 or more	h. [ ] 8	0	.0
		R [ ] 0	61	6.0

5. How many auto accidents have you had as a driver during the last 3 years which were necessary to report to the police or Department of Motor Vehicles?

a.	none	a. [ ] 1	717	70.8
b.	1	b. [ ] 2	202	19.9
c.	2	c. [ ] 3	27	2.7
d.	3	d. [ ] 4	6	.6
e.	4	e. [ ] 5	4	.4
f.	5	f. [ ] 6	1	.1
g.	6	g. [ ] 7	0	.0
h.	7 or more	h. [ ] 8	1	.1
		R [ ] 0	55	5.4

6. BAC estimate . . . . [ ] [ ] [ ]

Birth date (______________) . . . . [ ] [ ]

Interviewer ______________________

APPENDIX D

SUPPLEMENTARY TABLES FOR INTERVIEW DATA

Table LI-1

Quantity of Beer Usually Consumed by Female Respondents According to BAC

BAC	1 bottle		2 bottles		3 bottles		4 bottles		5 bottles or more		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	25	69.4	11	50.0	8	47.1	4	57.1	4	66.7	52	59.1
.010 to .049	2	5.6	6	27.3	5	29.4	1	14.3	1	16.7	15	17.0
.050 to .079	5	13.9	2	9.1	1	5.9	0	0.0	0	0.0	8	9.1
.080 to .099	0	0.0	2	9.1	2	11.8	1	14.3	1	16.7	6	6.8
.100 to .149	4	11.1	1	4.5	1	5.9	1	14.3	0	0.0	7	7.9
Total	36	(41.0)	22	(25.0)	17	(19.3)	7	(7.9)	6	(6.8)	88	100.0

$x^2(16) = 15.77$, $p = .469$

Table LI-2

Quantity of Beer When More Than the Usual Amount Is Consumed by Female Respondents According to BAC

BAC	1-2 Bottles		3-4 Bottles		5-6 Bottles		7 Bottles or more		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	17	65.4	16	51.6	10	47.6	6	85.7	49	57.6
.010 to .049	1	3.8	8	25.8	5	23.8	1	14.3	15	17.6
.050 to .079	3	11.5	3	9.7	2	9.5	0	0.0	8	9.4
.080 to .099	1	3.8	2	6.4	3	14.3	0	0.0	6	7.1
.100 to .149	4	15.4	2	6.4	1	4.8	0	0.0	7	8.2
Total	26	(30.6)	31	(36.5)	21	(24.7)	7	(8.2)	85	100.0

$x^2(12) = 12.11$, $p = .437$

Table LI-3

Frequency of Consuming Usual Amount of Beer by Female Respondents According to BAC

BAC	Frequency									
	Once a Day or More		Once a week or More		Once a Month or More		Less than Once a Month		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	3	75.0	17	48.6	20	66.7	12	63.1	52	59.1
.010 to .049	1	25.0	9	25.7	4	13.3	1	5.3	15	17.0
.050 to .079	0	0.0	4	11.4	1	3.3	3	15.8	8	9.1
.080 to .099	0	0.0	3	8.6	3	10.0	0	0.0	6	6.8
.100 to .149	0	0.0	2	5.7	2	6.7	3	15.8	7	7.9
Total	4	(4.5)	35	(39.8)	30	(34.1)	19	(21.6)	88	100.00

$x^2(12) = 11.50, p < .50$

Table LI-4

Frequency of Consuming More Than Usual Amount of Beer by Female Respondents According to BAC

BAC	FREQUENCY									
	Once a week or more		Once a month or more		Less Than Once a month		Never		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	1	50.0	10	50.0	24	61.5	16	64.0	51	59.3
.010 to .049	1	50.0	4	20.0	7	17.9	3	12.0	15	17.4
.050 to .079	0	0.0	3	15.0	3	7.7	2	8.0	8	9.3
.080 to .099	0	0.0	2	10.0	2	5.1	2	8.0	6	7.0
.100 to .149	0	0.0	1	5.0	3	7.7	2	8.0	6	7.0
Total	2	(2.3)	20	(23.2)	39	(45.3)	25	(29.1)	86	100.0

$x^2(12) = 3.99, p = .985$

Table LI-5

Quantity of Beer Usually Consumed by Males Who Prefer Beer According to BAC

BAC	1 Bottle		2 Bottles		3 Bottles		4 Bottles		5 Bottles or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	29	60.4	44	43.6	26	33.8	19	33.9	29	40.8	147	41.6
.010 to .049	11	22.9	29	28.7	26	33.8	22	39.3	8	11.3	96	27.2
.050 to .079	2	4.2	13	12.9	16	20.8	6	10.7	14	19.7	51	14.5
.080 to .099	1	2.1	3	3.0	2	2.6	1	1.8	5	7.0	12	3.4
.100 to .149	5	10.4	9	8.9	4	5.2	6	10.7	11	15.5	35	9.9
.150 and above	0	0.0	3	3.0	3	3.9	2	3.6	4	5.6	12	3.4
Total	48	(13.6)	101	(28.6)	77	(21.8)	56	(15.9)	71	(20.1)	353	100.1

$\chi^2(20) = 35.65$, $p = .017$

Table LI-6

Quantity of Beer When More Than the Usual Amount Is Consumed by Males Who Prefer Beer According to BAC

BAC	1-2 Bottles		3-4 Bottles		5-6 Bottles		7 Bottles or More		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	12	54.5	25	41.7	50	41.3	57	39.0	144	41.3
.010 to .049	6	27.3	21	35.0	34	38.1	35	24.0	96	27.5
.050 to .079	1	4.5	5	8.3	22	18.2	23	15.7	51	14.6
.080 to .099	0	0.0	3	5.0	2	1.6	7	4.8	12	3.4
.100 to .149	3	13.6	5	8.3	10	8.3	16	11.0	34	9.7
.150 and above	0	0.0	1	1.7	3	2.5	8	5.5	12	3.4
Total	22	(6.3)	60	(17.2)	121	(34.7)	146	(41.8)	349	100.0

$\chi^2(15) = 14.79$, $p = .467$

Table LI-7

Frequency of Consuming Usual Amount of Beer by Males Who Prefer Beer According to BAC

BAC	Once a Day or More		Once a Week or More		Once a Month or More		Less Than Once a Month		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	37	32.7	82	43.6	20	50.0	8	61.5	147	41.5
.010 to .049	29	25.7	49	26.1	15	37.5	4	30.8	97	27.4
.050 to .079	19	16.8	27	14.4	4	10.0	1	7.7	51	14.4
.080 to .099	5	4.4	7	3.7	0	0.0	0	0.0	12	3.4
.100 to .149	18	15.9	16	8.5	1	2.5	0	0.0	35	9.9
.150 and above	5	4.4	7	3.7	0	0.0	0	0.0	12	3.4
Total	113	(31.9)	188	(53.1)	40	(11.3)	13	(3.7)	354	100.0

$x^2(15) = 19.89, p < .20$

Table LI-8

Frequency of Consuming More Than Usual Amount of Beer by Males Who Prefer Beer According to BAC

BAC	Once a Week or More		Several Times a Month		Once a Month		More Than Twice a Year		Once or Twice a Year		Never		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	13	27.7	15	34.9	31	37.8	31	44.3	35	53.8	18	42.9	143	41.0
.010 to .049	14	29.8	10	23.3	20	24.4	21	30.0	20	30.8	12	28.6	97	27.8
.050 to .079	8	17.0	10	23.3	15	10.3	11	15.7	4	6.2	3	7.1	51	14.6
.080 to .099	0	0.0	2	4.6	5	6.1	2	2.9	2	3.1	1	2.4	12	3.4
.100 to .149	8	17.0	3	7.0	10	12.2	4	5.7	4	6.1	5	11.9	34	9.7
.150 and above	4	8.5	3	7.0	1	1.2	1	1.4	0	0.0	3	7.1	12	3.4
Total	47	(13.5)	43	(12.3)	82	(23.5)	70	(20.1)	65	(18.6)	42	(12.0)	349	100.0

$x^2(25) = 34.86, p = .091$

Table LI-9

Quantity of Liquor When More Than Usual Amount Is Consumed by Female Respondents According to BAC

BAC	1-2 Shots		3-4 Shots		5-6 Shots		7 Shots or More		Total	
	N	%	N	%	N	%	N	%	N	%
.000 to .009	25	83.3	27	49.1	17	60.7	6	66.7	75	61.5
.010 to .049	2	6.7	14	25.4	6	21.4	1	11.1	23	18.8
.050 to .079	1	3.3	6	10.9	1	3.6	1	11.1	9	7.4
.080 to .099	0	0.0	4	7.3	3	10.7	1	11.1	8	6.6
.100 to .149	2	6.7	4	7.3	1	3.6	0	0.0	7	5.7
Total	30	(24.6)	55	(45.1)	28	(22.9)	9	(7.4)	122	100.0

$\chi^2(12) = 14.13$, $p = .293$

Table LI-10

Frequency of Consuming More Than Usual Amount of Liquor by Female Respondents According to BAC

BAC	Once a Week or More		Several Times a Month		Once a Month		More than Twice a Year		Once or Twice a Year		Never		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	1	33.3	2	28.6	8	66.7	11	52.4	28	71.8	25	64.1	75	62.0
.010 to .049	1	33.3	3	42.9	1	8.3	4	19.0	8	20.5	6	15.4	23	19.0
.050 to .079	0	0.0	1	14.3	1	8.3	4	19.0	1	2.6	2	5.1	9	7.4
.080 to .099	0	0.0	0	0.0	2	16.7	1	4.8	0	0.0	4	10.3	7	5.8
.100 to .149	1	33.3	1	14.3	0	0.0	1	4.8	2	5.1	2	5.1	7	5.8
Total	3	(2.5)	7	(5.8)	12	(9.9)	21	(17.4)	39	(32.2)	39	(32.2)	121	100.0

$\chi^2(20) = 24.39$, $p = .226$

Table LI-11

Frequency of Drinking Wine by Female Respondents According to BAC

BAC	Once a Day		Several Times a Week		Once a Week		Several Times a Month		Once a Month		Less Than Once a Month		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	3	75.0	4	57.1	10	83.3	3	50.0	13	76.5	9	42.9	42	62.7
.010 to .049	0	0.0	0	0.0	1	8.3	2	33.3	3	17.6	5	23.8	11	16.4
.050 to .079	1	25.0	1	14.3	1	8.3	0	0.0	0	0.0	3	14.3	6	9.0
.080 to .099	0	0.0	1	14.3	0	0.0	0	0.0	1	5.9	2	9.5	4	6.0
.100 to .149	0	0.0	1	14.3	0	0.0	1	16.7	0	0.0	2	9.5	4	6.0
Total	4	(6.0)	7	(10.4)	12	(17.9)	6	(9.0)	17	(25.4)	21	(31.3)	67	100.0

$\chi^2(20) = 18.02$, $p = .586$

Table LI-12

Quantity of Wine Usually Consumed By Female Respondents According to BAC

BAC	1 Glass		2 Glasses		3 Glasses		4 Glasses		5 Glasses or More		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
.000 to .009	23	76.7	13	59.1	4	36.4	4	80.0	0	0.0	44	63.8
.010 to .049	3	10.0	5	22.7	1	9.1	1	20.0	1	100.0	11	15.9
.050 to .079	2	6.7	2	9.1	2	18.2	0	0.0	0	0.0	6	8.7
.080 to .099	1	3.3	2	9.1	1	9.1	0	0.0	0	0.0	4	5.8
.100 to .149	1	3.3	0	0.0	3	27.3	0	0.0	0	0.0	4	5.8
Total	30	(43.5)	22	(31.9)	11	(15.9)	5	(7.2)	1	(1.4)	69	100.0

$\chi^2(16) = 22.88$, $p = .117$

Table LI-13

Time Since Last Alcohol Consumption by Male Respondents According to Age

Age	Less than 1 hr ago		1 - 3 hrs ago		3 - 6 hrs ago		6 - 24 hrs ago		More than 24 hrs ago		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
14 - 17	2	1.1	4	3.4	0	0.0	3	6.7	12	9.4	21	4.0
18 - 20	24	13.0	19	16.2	8	14.3	9	20.0	23	18.1	83	15.7
21 - 24	45	24.5	20	17.1	14	25.0	8	17.8	29	22.8	116	21.9
25 - 29	39	21.2	26	22.2	8	14.3	9	20.0	24	18.9	106	20.0
30 - 39	44	23.9	19	16.2	10	17.9	7	15.6	18	14.2	98	18.5
40 - 49	17	9.2	15	12.8	9	16.1	4	8.9	13	10.2	58	11.0
50 - 59	10	5.4	9	7.7	7	12.5	3	6.7	5	3.9	34	6.4
60 and over	3	1.6	5	4.3	0	0.0	2	4.4	3	2.4	13	2.4
Total	184	(34.8)	117	(22.1)	56	(10.6)	45	(8.5)	127	(24.0)	529	99.9

$\chi^2(28) = 38.73$, $p < .10$