U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

DOT HS 807 748
Final Report

May 1991

Analysis of VASCAR

This document is available to the public from the National Technical Information Service, Springfield, Virginia 22161.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Analysis of VASCAR		5. Report Date May 1991 6. Performing Organization Code NRD-23
7. Author(s) J. Gavin Howe Transportation Research Center of Ohio, Inc.		8. Performing Organization Report No. VRTC-70-167
9. Performing Organization Name and Address National Highway Traffic Safety Administration Vehicle Research and Test Center P.O. Box 37 East Liberty, Ohio 43319		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration 400 Seventh Street, S.W. Washington, D.C. 20590		13. Type of Report and Period Covered FINAL -- 6/90-5/91 14. Sponsoring Agency Code

15. Supplementary Notes

The discussion and conclusions in this paper represent the opinions of the author and not necessarily those of the NHTSA or the Transportation Research Center of Ohio. I would like to acknowledge the support of the following Police Departments: Columbus Police Department, Columbus, Ohio; Zanesville Police Department, Zanesville, Ohio; Arizona Department of Public Safety - Highway Patrol Bureau; Indiana State Police Department, and the Wisconsin State Patrol. We would also like to acknowledge R & R Research and the Ohio State University Statistics Department for their technical support. I would also like to thank the following people for their help in completing this project: Mary Wagner, Linda Middleton, Rick Mills, Doyle McPherson, Don Phipps, Chuck Arehart, Gerda England, Sonya Shuler, and Susie Weiser.

16. Abstract

This study is part of an effort by the National Highway Traffic Safety Administration (NHTSA) to determine the accuracy of the VASCAR-plus speed measurement device. VASCAR-plus is used extensively for speed law enforcement by state and local police. VASCAR-plus calculates average speed using the basic formula: Speed = Distance/Time.

The VASCAR-plus manual claims an overall speed measurement accuracy of ± 1%. This accuracy was recently challenged. This study determined the accuracy of VASCAR-plus time, distance, and speed measurements. Two VASCAR-plus units were electronically tripped (no human operator) to determine the timing accuracy. Six VASCAR certified officers participated in a study to determine VASCAR-plus distance measurement accuracy. Eight VASCAR certified officers participated in a series of studies to determine VASCAR-plus speed measurement accuracy. The results of these studies show that VASCAR-plus does not have an overall speed measurement accuracy of ± 1%, but that a + 2 mph upper 90th percentile tolerance limit (95% of the speed errors are less than + 2 mph) is achievable when the speed measurement is 4 seconds in duration for stationary methods (angular and parking), and is 5 seconds in duration for moving methods (following and approaching from the rear).

17. Key Words	18. Distribution Statement
VASCAR-plus Speed Enforcement	Document is available to the public from the National Technical Information Service, Springfield, VA 22161

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

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Department of Transportation
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TECHNICAL SUMMARY

Report Title: Evaluation of the VASCAR-plus Speed Measurement Device	
Report Author(s): J. Gavin Howe, Transportation Research Center of Ohio, Inc.	

The National Highway Traffic Safety Administration (NHTSA) conducted tests at the Vehicle Research and Test Center (VRTC) to determine the accuracy of the VASCAR-plus speed measurement device. This device is used extensively for speed law enforcement by State and Local Police. VASCAR-plus calculates speed using the basic formula

Speed = Distance/Time.

The process of measuring a motorists speed is called clocking. A successful speed measurement attempt is called a clock. VASCAR-plus can be used with the police cruiser stationary (stationary clocking) or with the police cruiser moving (moving clocking).

The VASCAR-plus manual claims an overall speed measurement accuracy of $\pm$ 1 %. This accuracy was recently challenged. Tests were conducted to determine the accuracy of VASCAR-plus time, distance, and speed measurements.

Two VASCAR-plus units were tested to determine timing accuracy. These units were electronically tripped (no human operator). The VASCAR-plus time measurements were compared to the time measurements of an oscilloscope which had a much higher sampling rate. A negative timing error (i.e. measured time less than true time) produces an overestimate of the target vehicle's speed. It was found that 95% of the timing errors were above -0.0422 seconds (lower 90th percentile tolerance limit). This potential timing error results in speed errors that are magnified at higher speeds and are minimized by longer course distances. For example, the potential speed error at 80 mph over a 200 foot course is 2.03 mph, while the potential speed error at 45 mph over a .3 mile course is 0.08 mph.

Six VASCAR certified officers participated in a study to determine the accuracy of VASCAR distance measurements. Three distances (200 feet, .1 mile and .3 mile) were measured. A positive distance error (i.e. measured distance greater than true distance) produces an over estimate of the target vehicle's speed. The distance errors were greater than the 6.3 inch accuracy quoted in the VASCAR manual, but 95 % of the distance errors for each distance were well below .5 % (upper 90th percentile tolerance limit).

Eight VASCAR certified officers participated in several different studies to determine the accuracy of VASCAR speed measurements. The variables and variable values examined in these studies are listed in Table 1. Note that not all variables and/or variable values were examined in each study. The variables and variable values were selected based on the VASCAR user manual, the results of a task analysis of VASCAR operation, and the results of a VASCAR user survey.

Table 2 lists the mean and upper 90th percentile tolerance limits for speed error for the overall study, for all of the moving clocks, and for all the stationary clocks. The corresponding values for percent speed error are in Table 3.

TABLE 1 -- Tested Variables and Variable Values

Variable	Variable Values
Subjects	1 - 8
VASCAR method	Moving Following Approaching from the Rear Stationary Parking Angular
Nominal Speed	45 mph 60 mph 80 mph
Course Distance	200 feet 0.1 mile 0.3 mile
Visual Method	Direct Indirect (through mirrors)
Elevation	Ground Level Elevated (12 feet)
Viewing distance	200 feet 0.1 mile
Gap Distance Between Vehicles	200 feet 1/8 mile
Reference Markers	Vertical - aligned Vertical - unaligned Horizontal Bridge Shadow

TABLE 2 -- Mean and Upper 90th Percentile Tolerance Limits for Speed Error (mph)

Portion of Study	Mean	Upper 90th Percentile
Overall	.426	3.134
Moving	.105	1.540
Stationary	.644	4.074

TABLE 3 -- Mean and Upper 90th Percentile Tolerance Limits for Percent Speed Error

Portion of Study	Mean	Upper 90th Percentile
Overall	.638	4.530
Moving	.164	2.230
Stationary	.959	5.886

For all of the moving clocks greater than 5 seconds in duration, the speed errors were less than + 2 mph. The mean and upper 90th percentile tolerance limits for speed error and percent speed error for the moving clocks greater than 5 seconds in duration are presented in Table 4.

TABLE 4 -- Mean and Upper 90th Percentile Tolerance Limits for Moving Clocks Greater Than 5 Seconds in Duration

Dependant Variable	Mean	Upper 90th Percentile
Speed Error	.150	1.146
Percent Speed Error	.232	1.893

The mean and upper 90th percentile tolerance limits for speed error and percent speed error for the stationary clocks greater than or equal to 4 seconds in duration are presented in Table 5.

TABLE 5 -- Mean and Upper 90th Percentile Tolerance Limits for Stationary Clocks Greater Than or Equal to 4 Seconds in Duration

Dependant Variable	Mean	Upper 90th Percentile
Speed Error	-.072	1.567
Percent Speed Error	-.118	2.188

From the results presented in Tables 2 through 5, VASCAR-plus does not have an accuracy of $\pm$ 1 percent, but an upper 90th percentile tolerance limit (95 percent of the values are less than or equal to this limit) of + 2 mph is achievable.

It is important to note that no one table or figure in this report can stand alone. The raw data, the statistics, the laboratory environment, and the officers' opinions of the different test conditions must all by taken into account before any conclusions can be drawn.

1.0 BACKGROUND

There are at least two methods currently used by police officers to measure vehicle speed. One method is to measure the time it takes a vehicle to cover a known distance. The average speed of the vehicle is then computed using the basic formula

$$\text{Speed} = \text{Distance/Time.}$$

Radar is another way of measuring vehicle speed. Radar is an "instantaneous" speed measurement device. Both systems are used extensively for speed law enforcement by state and local police.

VASCAR-plus, manufactured by Traffic Safety Systems, is a time-distance speed measurement device that is used by many state and local police agencies to enforce traffic laws. VASCAR stands for Visual Average Speed Computer and Recorder. The VASCAR-plus computer calculates an average speed using the basic formula given above. The device allows the user to "drive in" or "dial in" a distance (these two input modes are discussed in greater detail later in this section). The user then "times" a vehicle as it covers the distance. Knowing the distance and the time, the device then calculates the average speed of the vehicle. The process of timing a vehicle over a known distance is called clocking.

Both VASCAR-plus and radar have very distinct advantages as speed measurement devices. One advantage of VASCAR-plus is nondetectability. Radar emits a signal that can be detected by a motorist using a radar detector. The radar detector will warn the motorist to slow down, but the motorist can resume his or her speed when out of the range of the radar. VASCAR-plus does not emit a signal, therefore motorists have no warning that their speed is being monitored. Another advantage of VASCAR-plus is the fact that it calculates average speed. As seen in Figure 1.1, the average speed is always less than or equal to the maximum speed of the vehicle during the distance that the speed is measured. True average speed is equal to the maximum speed only if there is no speed variation during the measured interval. Because it is less than or equal

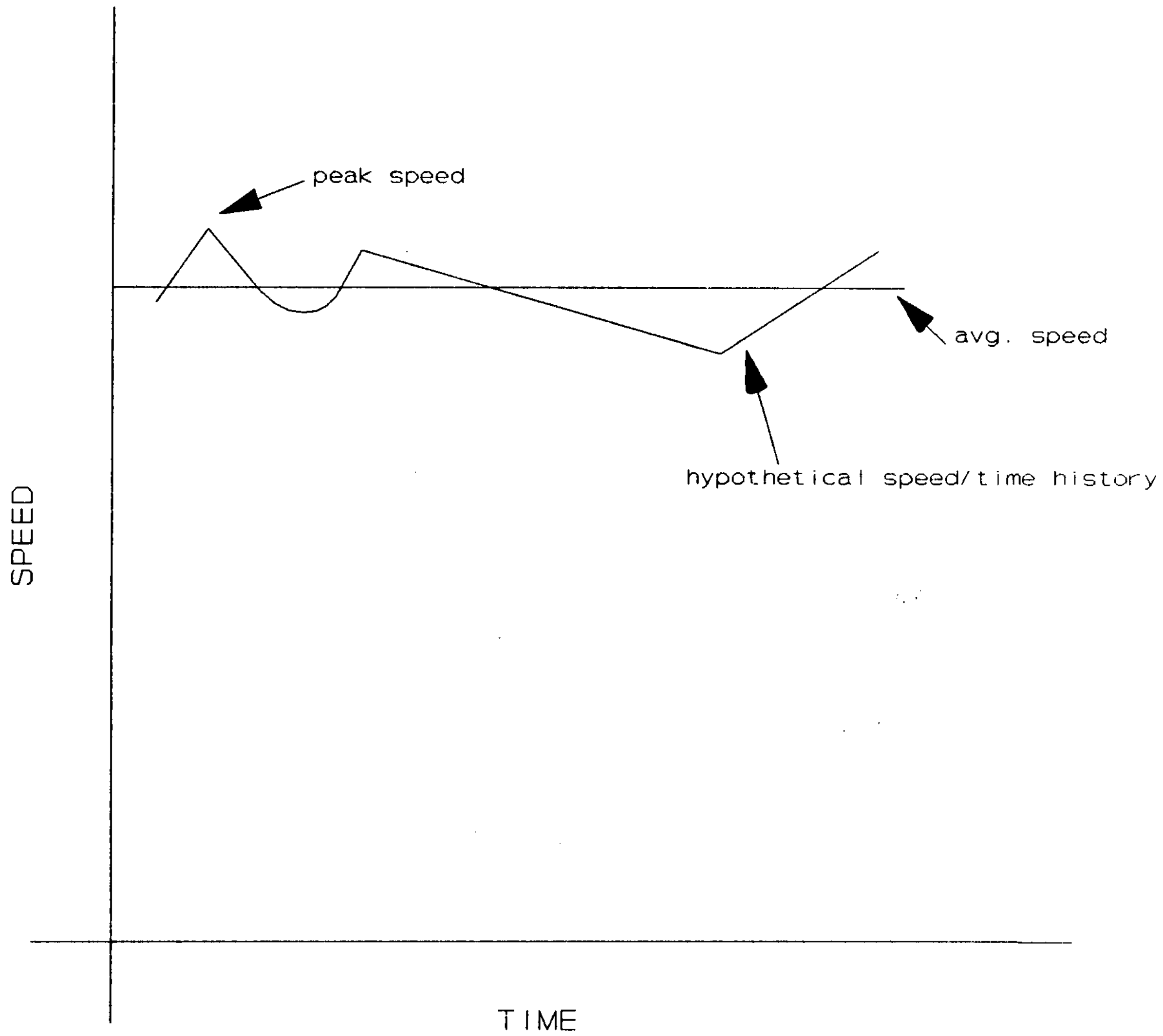


Figure 1.1 - Comparison of a Hypothetical Speed/Time History and Average Speed

to the maximum speed, the average speed benefits the violator. A final advantage of VASCAR-plus is vehicle identification. The user can monitor only one vehicle at a time, so there is no question which motorist's speed is being measured.

The fact that VASCAR-plus can only monitor one vehicle at a time is also a disadvantage. The user has to monitor the vehicle over the entire distance of the clock. Therefore, if there is heavy traffic, the user can only measure the speed of a low percentage of motorists. Radar is an "instantaneous" speed measurement device. The radar unit emits a signal that bounces off a target and returns to the radar. This speed measurement method is much quicker than VASCAR-plus, so the user can measure a higher percentage of motorists' speed in heavy traffic. Based on the advantages of each, both VASCAR-plus and radar are used extensively as law enforcement tools. From the results of a VASCAR user survey, other perceived advantages of both VASCAR-plus and radar are discussed in Section 3.2.

Each VASCAR-plus unit has a red time toggle switch, a black distance toggle switch, a red time recall button, a black distance recall button, five thumbwheel switches, an LED display, and an odometer module that is driven by the vehicle speedometer cable. A VASCAR-plus unit is displayed in Figure 1.2.

Figure 1.2 - VASCAR-plus Control Panel

When "driving in" a distance, VASCAR-plus uses the pulses produced by the odometer module. A typical car speedometer cable turns 1000 times in a mile and the odometer module creates 10 pulses per turn. This produces 10,000 pulses per mile, hence the VASCAR-plus user manual claims a measurement accuracy of one ten-thousandth of a mile, or 6.3 inches in one mile. Not every speedometer cable turns 1000 times per mile, so each car that has a VASCAR-plus unit must be calibrated to read the correct distance (the VASCAR-plus user manual gives a calibration procedure). To "drive in" the distance, the user selects two fixed reference marks. The user then aligns the first fixed reference mark with a reference point on his or her vehicle and switches on the black distance toggle switch. The user then drives to the second fixed reference mark and aligns it with the same reference point on the vehicle he or she used before. The user then switches the black distance toggle switch off. This operation registers the course distance into the VASCAR computer. To dial in the distance, the user enters the known distance on the thumbwheel switches mentioned above.

VASCAR-plus can be used with the police cruiser moving or with the police cruiser stationary. The VASCAR manual describes three moving methods, and three stationary methods.

The three moving methods are:

A. Following - the police cruiser is following the target vehicle

B. Opposite Direction - the police cruiser and target vehicle are approaching each other from opposite directions

C. Approaching from the Rear - the target vehicle approaches the police cruiser from the rear

The three stationary methods are:

A. Parking - the officer sits next to the roadway

B. Angular - the officer sits off to the side of the road and uses two stationary reference points to clock the vehicle

C. T-Intersection - the officer starts the clock from a stationary position, but then follows the target vehicle

For a more detailed explanation of these methods, please see the VASCAR manual and the task analysis in section 3.1.

The manufacturer claims an overall speed measurement accuracy of ± 1 percent. This stated accuracy was recently challenged. Theoretical presentations have been given to support both the accuracy and the errors of the system.

2.0 OBJECTIVE

The objective of this evaluation was to measure the accuracy of the VASCAR-plus speed measurement device. To accomplish this, a task analysis was performed to determine what variables should be considered in the evaluation of VASCAR. Interviews with VASCAR trained officers were also performed to determine how VASCAR is used by law enforcement officers. Based on the results of both the task analysis and the personal interviews, and based on the VASCAR manual, an experimental design was developed to ascertain how key variables affect speed measurement accuracy. Tests were conducted and the results were statistically analyzed.

3.0 DETERMINATION OF VASCAR USE

To determine how VASCAR is used, a task analysis was performed and interviews with VASCAR trained officers were conducted. The task analysis was conducted to determine what an officer has to perform to complete an appropriate VASCAR clock. The task analysis also helped identify variables for evaluation, and potential sources of error and/or distractions that may interfere with the officer's ability to complete a successful clock. The interviews concentrated on how often the officers use the different VASCAR methods and on typical distances they use to make VASCAR clocks. Other topics covered by the interviews were types of training, opinions of VASCAR effectiveness, and the use of VASCAR versus the use of radar. A copy of the personal interview form is in Appendix A.

3.1 Task Analysis

Objective

To better understand how police officers use VASCAR in the field and to obtain information for use in designing an evaluation experiment, a task analysis was performed. Essentially, in a task analysis an operator's basic tasks are subdivided into elements so that knowledge and skill requirements, time lines, potential errors, etc. can be examined. Clearly, such an analysis can become quiet complex depending upon the degree of abstraction applied to the problem.

Participants

The task analysis conducted in this study was based on the observation of four officers from the Columbus, Ohio freeway patrol, who demonstrated VASCAR use during their normal duties. Observations were made both during the day and at night.

Results

The officers demonstrated three of the VASCAR methods described in the operator's training manual. The methods demonstrated were:

Moving:	Following Approaching from the Rear
Stationary:	Parking

Due to the constraints imposed by the freeway environment (i.e., limited access divided highway with concrete center divider) the T-Intersection, Angular Clocking and Opposite Direction methods could not be demonstrated.

The results of the task analysis are presented in Table 3.1 and in Appendix B. The tasks involved in the stationary method are illustrated in Table 3.1. For the analysis in Table 3.1, it was assumed that the course distance was previously entered in the VASCAR computer by "driving it in" or "dialing it in" using the thumbwheel switches on the VASCAR control panel. For stationary methods, clocking targets involved activation of only the time toggle switch. See Figure 1.2 for location of switches.

TABLE 3.1 CLOCK TARGET USING A STATIONARY VASCAR METHOD

Task: Clock Target Using a Stationary VASCAR Method

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Identify Target Vehicle	Visual acuity (required in all task elements) Visually search approaching traffic for a potential target Estimate the target's speed In Parked Mode, visual search is performed using the rear view or left side mirrors (plane mirrors); in the other stationary modes visual search is performed by direct observation of target		Decide if the potential target is likely over the posted speed limit Decide to clock the target if conditions permit	Visibility (e.g., day vs. night, adverse weather) Oncoming traffic can be obscured by vehicles close to the officer Radio "chatter"	Similar vehicles in traffic stream; officer selects wrong vehicle	Officer makes initial speed judgements on an absolute scale and also relative to other vehicles in the traffic stream As visibility is reduced, the distances over which VASCAR can be used are also reduced

Task: Clock Target Using a Stationary VASCAR Method (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Track Target to First Reference Marker	Visually monitor target's progress toward VASCAR course Rear view or left side mirror is used when monitoring target in Parked Mode	Estimate arrival time of target at reference marker	Decide when Time switch should be activated	Other traffic could obscure target or reference marker Radio "chatter"		Depth cues in road scene (e.g., other vehicles or fixed objects adjacent to highway) aid in arrival time estimation
Turn Time Switch ON	Obtain auditory and tactile feedback of switch activation	Push toggle switch into UP position Reaction time	Decide if switch was activated as target passed reference marker	Radio operation requires the same hand used for operating VASCAR controls	Early switch activation could lead to underestimation of true speed Late switch activation could lead to overestimation of true speed	To reduce reaction time delay officers initiate switch activation just prior to the arrival of the target at the reference mark

Task: Clock Target Using a Stationary VASCAR Method (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Track Target to Second Reference Marker	Visually monitor target's progress through course to second reference marker Rear view or left side mirror is used when monitoring target in Parked Mode	Estimate arrival time of target at reference marker	Note if target changes lanes while in course Decide when Time switch should be activated	Other traffic could obscure target or reference marker Radio "chatter"	Lane changing by target could lead to underestimated true speed	
Turn Time Switch OFF	Obtain auditory and tactile feedback of switch activation	Push toggle switch down Reaction time	Decide if switch was activated as the target passed the reference marker	Radio operation requires the same hand used for operating VASCAR controls	Early switch activation could lead to overestimation of true speed Late switch activation could lead to underestimation of true speed	To reduce reaction time delay officers initiate switch activation just prior to the arrival of the target at the reference mark Switch activation errors at both reference markers can either have offsetting effects or additive effects which increase measurement error

Task: Clock Target Using a Stationary VASCAR Method (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Read VASCAR Display	Read speed value displayed Viewing distance is approximately 30 inches Character height is approximately one-half inch		Displayed speed is compared with initial speed judgement made by officer		Error by officer in reading display	Measured speed must have face validity compared with officer's initial judgement of target speed
Assess Validity of Speed Measurement			Decide to accept (or reject) speed measurement based on switch activations, lane maintenance by target and displayed reading			
Decide whether or not to pursue			Decide to pursue target if measured speed is greater than speed limit plus an allowance factor for motorist error	Last second requirement to attend to a more critical event (e.g., accident, violent crime, other emergency)		The decision to pursue a violator depends on the measured speed, the officer's ability to safely pursue in traffic, the police department policy for issuing speeding citations and the need for the officer's services elsewhere

The Following method and the Approaching from the Rear method are illustrated in Appendix B. For these two methods, the officer had to operate both the time and the distance toggle switches. In most circumstances the time switch was operated independently of the distance switch. The descriptions provided in Appendix B also represent a generalized or "typical" sequence of sub-tasks. Depending on actual conditions on the highway, e.g., target vehicle and police cruiser speeds, course distance, availability of reference marks, etc., officers may use slight variations of the sequence presented.

For this task analysis, the VASCAR control/display panel was located to the right of the officer near the center of the car, close to the height of the seat cushion. Adjustment features on the VASCAR mounting brackets allowed each officer some options in positioning the device to best meet individual needs (e.g., seat location, seated eye height, viewing angle, functional reach envelope, etc.).

Officers used their right hand to operate the VASCAR controls, most frequently with the thumb and index finger. For the moving methods of operation, the officers drove the cruiser with the left hand and simultaneously operated the VASCAR controls with the right hand. Radio communications were also performed with the right hand, when required.

3.2 Personal Interview Approach and Results

Objective

Personal interviews were conducted as an observational study to assist the development of the courses used in the experimental study. The survey concentrated on how often the different VASCAR methods were used, typical course distances used by officers, types of reference markers, and officers' opinions of VASCAR.

Participants

A sample of twenty-one officers from across the United States was contacted for this survey. All of the officers currently use the VASCAR-plus. Six of the officers were from local police agencies, while the remaining fifteen were from state police agencies. Twenty officers were trained and certified, while one was currently going through training. The officers were selected as randomly as possible, but the selections did not produce a probability sample.

Results

The officers were asked about the type of training they received. The amount of training each officer received did vary. Not every officer could remember how much training they had received. Of the officers that replied, most had received at least eight hours of classroom training. The amount of supervised and unsupervised training ranged from 12 to 160 hours. The officers that made statements about their certification requirements mentioned the certification test outlined in the VASCAR manual.

The distribution for how often the contacted officers use VASCAR is shown in Figure 3.1. From this figure, over 75% of the contacted officers used VASCAR on a daily basis.

The distribution of officers based on level of VASCAR experience is shown in Figure 3.2. The level of experience ranged from 1 month to 18 years. The officers were asked to rate their own VASCAR skills on a scale from 1 to 10, with 1 being a novice and 10 being an expert. Nineteen officers responded. A distribution of the officers based on their self rating is given in Figure 3.3. Self rated skill ranges (mean $\pm$ one standard deviation) for officers with different levels of experience are given in Figure 3.4. The ranges presented in this graph suggest that an officer's opinion of his or her own VASCAR skills would tend to improve during the first one to two years of experience, but may level out after this period. Several officers stated that it takes a certain amount of time to become comfortable with using VASCAR.

A distribution of officers determined by the types of roadways on which they use VASCAR is given in Figure 3.5. From this figure, all of the contacted officers used VASCAR on the freeway and some also used it on other types of roadways.

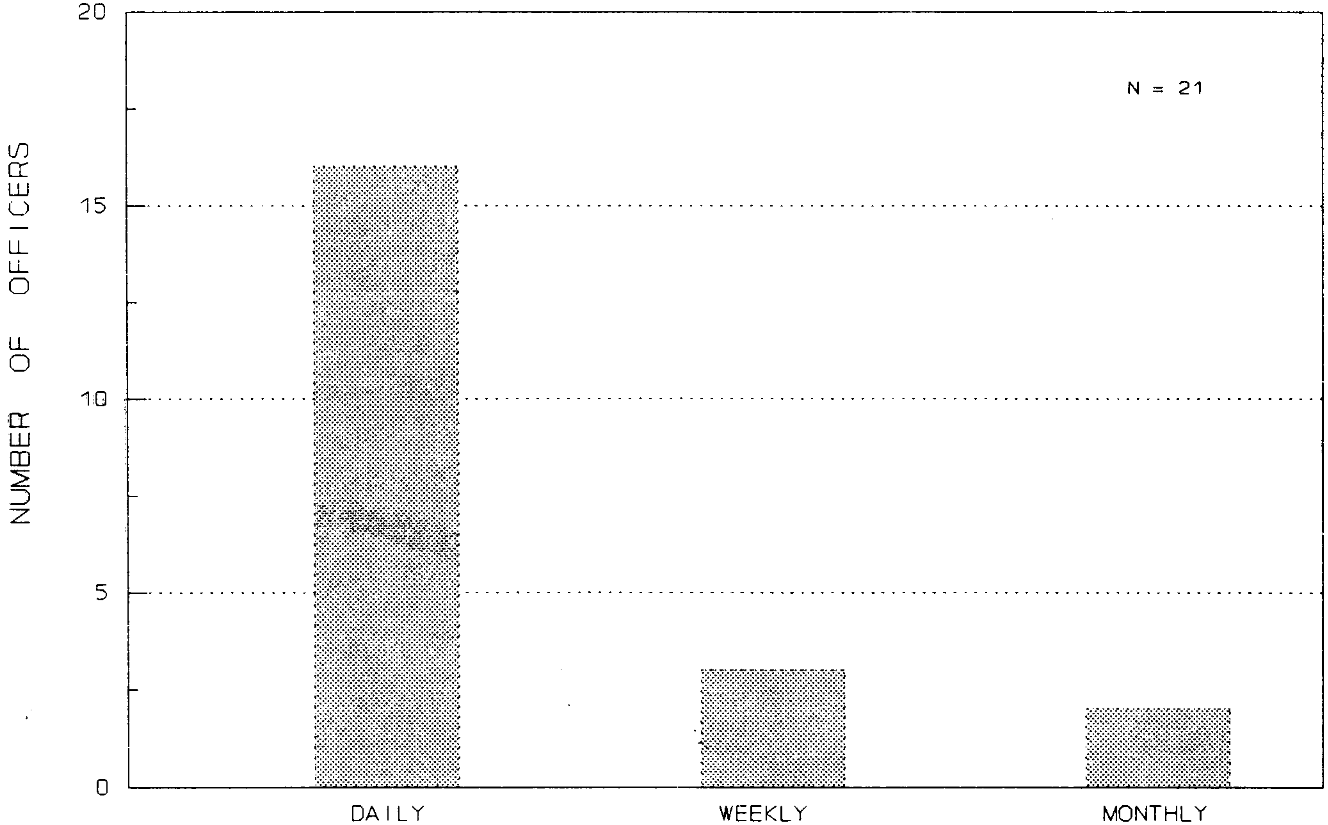


Figure 3.1 - Officer Distribution for the Level of VASCAR Use

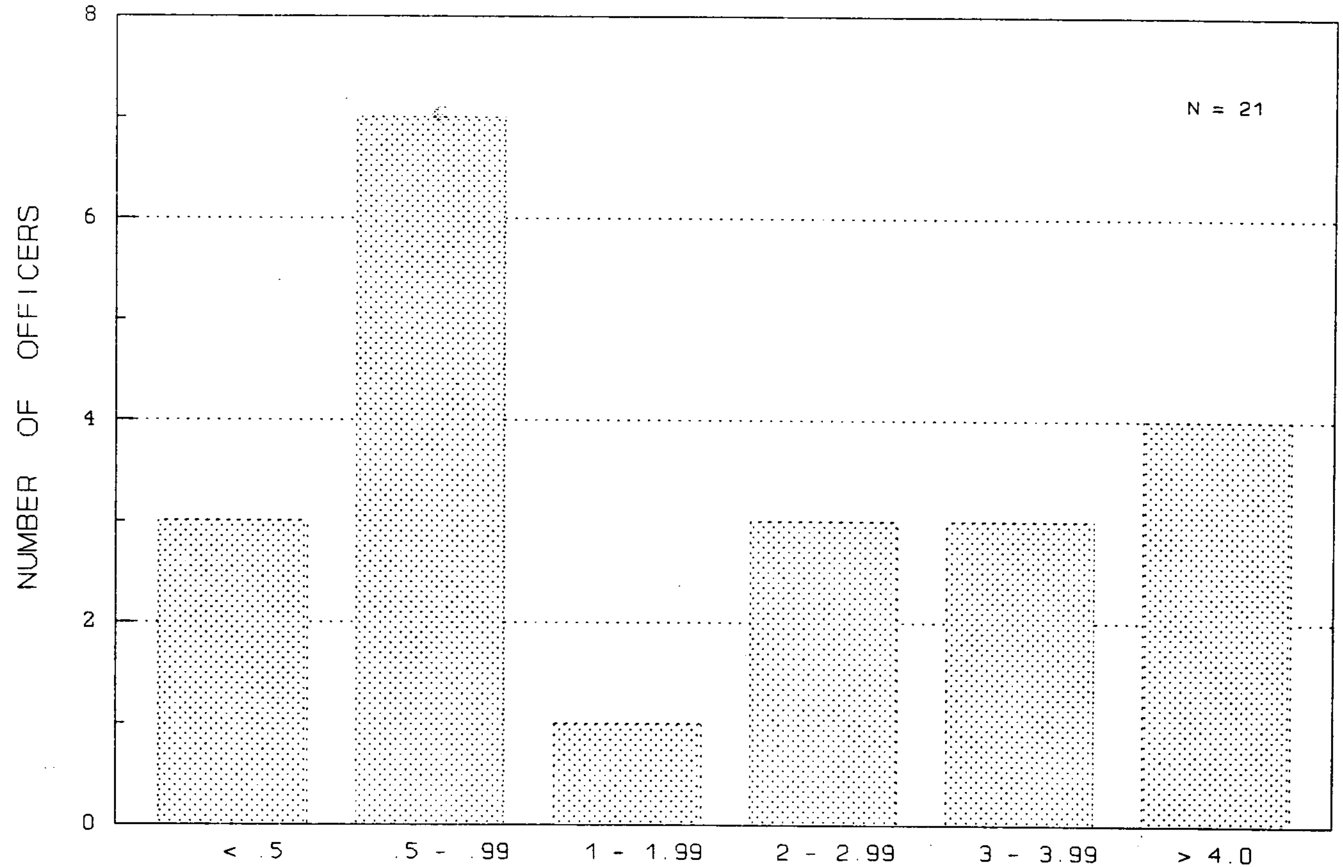


Figure 3.2 - Officer Distribution for Level of VASCAR Experience

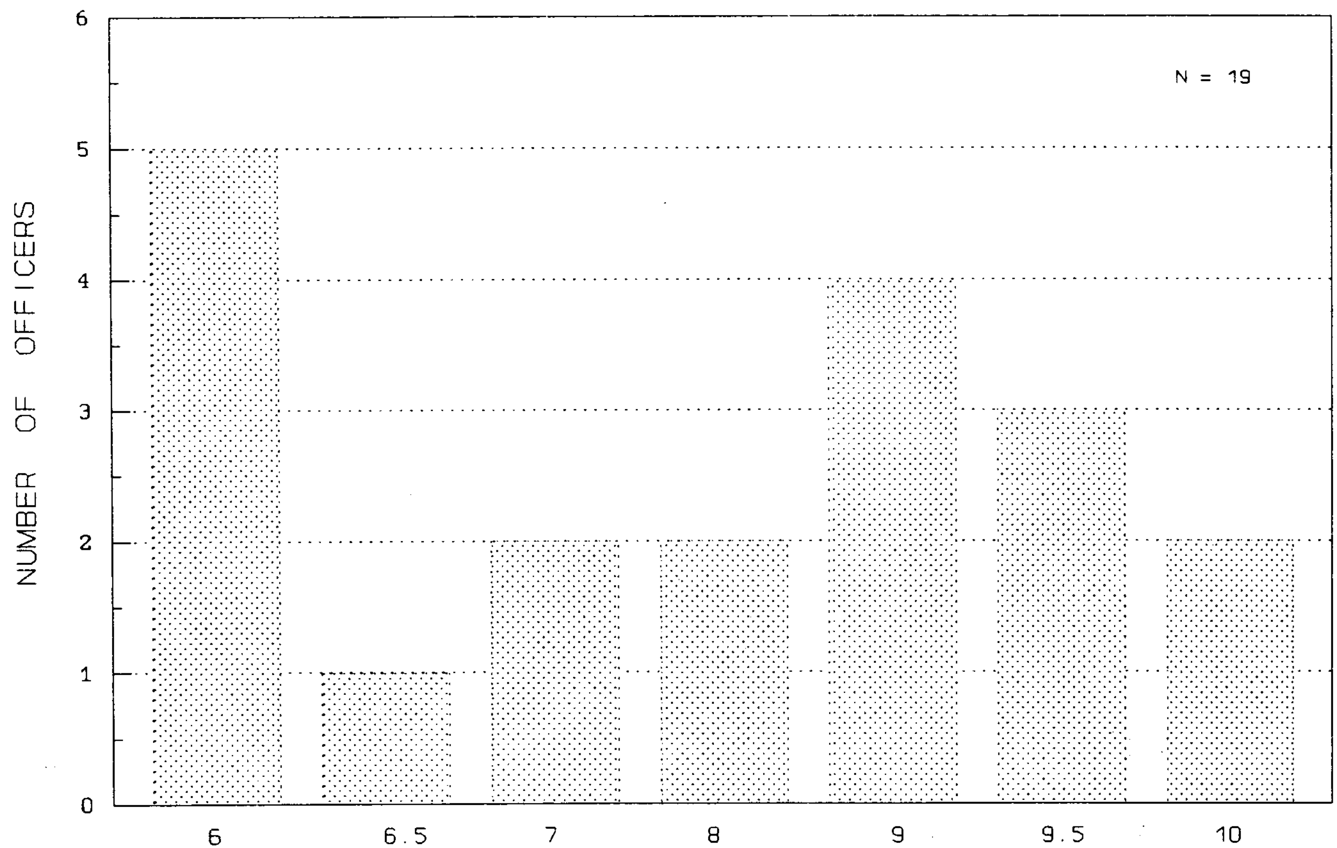


Figure 3.3 - Officer Distribution for Self Rated VASCAR Skills

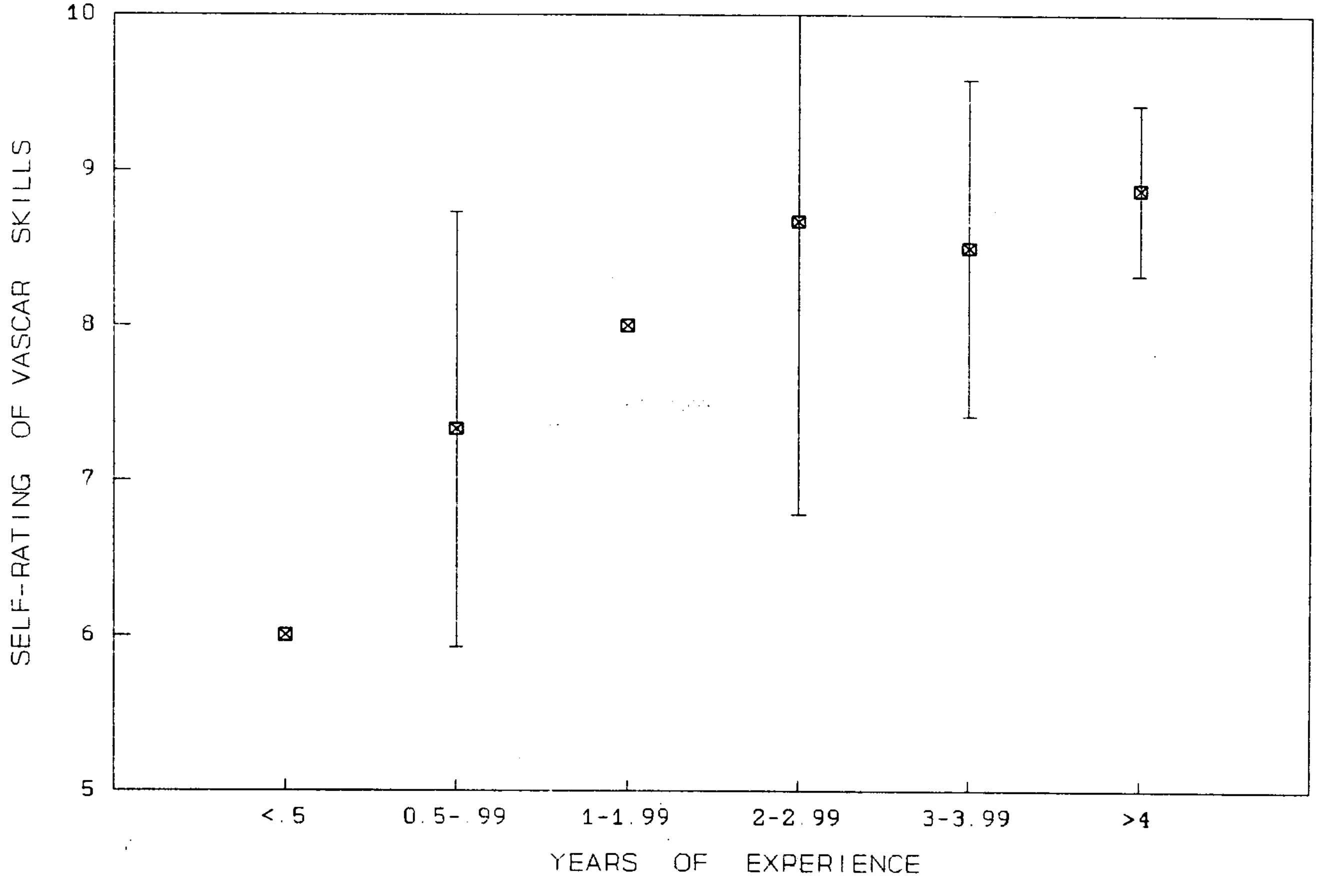


Figure 3.4 - Officer Self Rated VASCAR Skills as a Function Experience (mean ± one std. dev.)

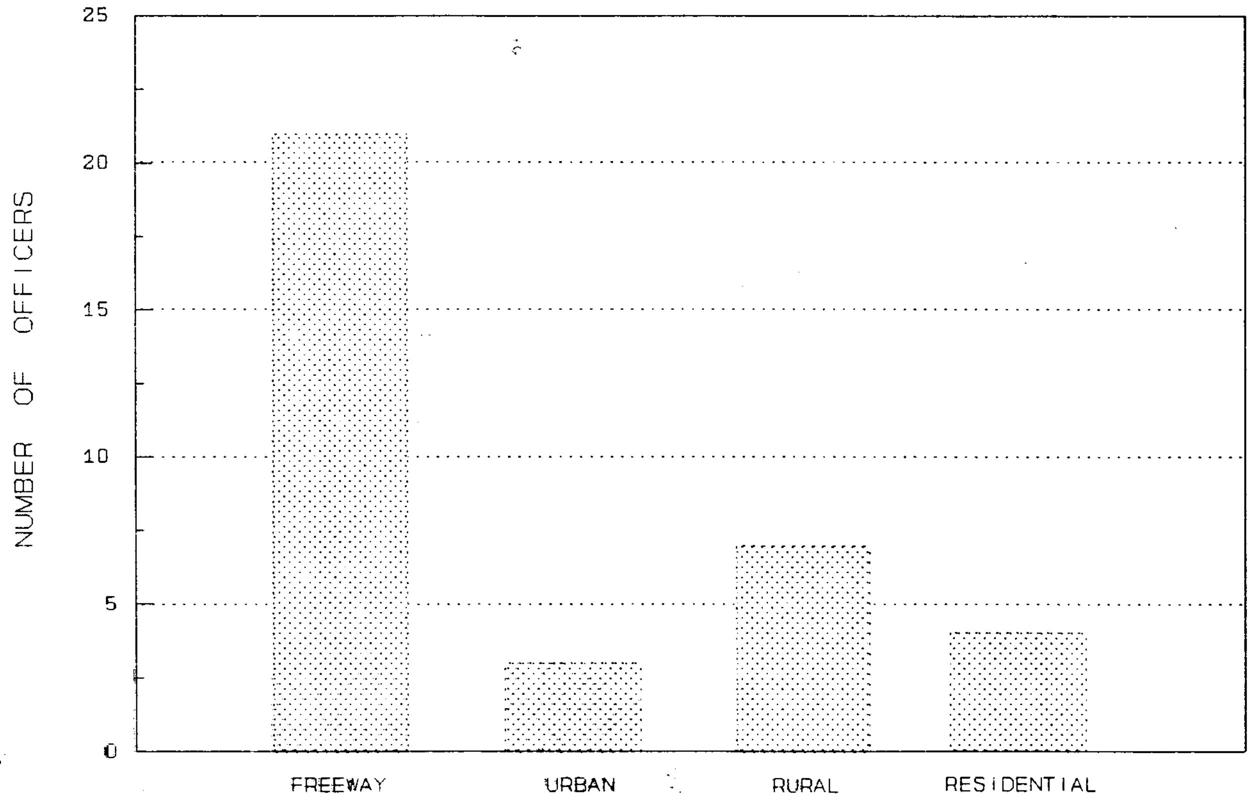


Figure 3.5 - Officer Distribution for Type of Roadways Patrolled

The mean percentage use for each of the VASCAR speed measurement methods for both local and state police is given in Table 3.2. On average, local and state police used each of the VASCAR methods a similar amount of the time (a t-test was performed and the hypothesis that the two means, for each method, were similar could not be rejected at the 5% level). Based on these comparable percentages, the local and state police responses concerning percentage use were combined as one group.

TABLE 3.2 -- Mean Percentage Use of VASCAR Speed Measurement Methods for Local and State Police Officers

Method	Local	State
Moving	50.8	53.0
Following	30.0	30.1
Opposite Direction	3.1	3.3
Approach from Rear	17.7	19.6
Stationary	49.2	47.0
Parking	29.6	26.6
T-Intersection	0.4	5.0
Angular	19.2	15.3

After combining the local and state police responses, the mean and standard deviation for the percentage use of each method were calculated. The results are presented in Table 3.3. A range of use for each method is given in Figure 3.6. These ranges represent the mean $\pm$ one standard deviation for the percent use of each method. From this figure, the percentage use of moving and stationary methods were very comparable. Also from this figure, Following, Approaching from the Rear, Parking, and Angular methods were much more prevalent than Opposite Direction and T-Intersection methods. For the Opposite Direction method, the officers said they did not use it either because radar was better for this method, or they worked divided highways with concrete barriers which kept them from turning around to chase a vehicle moving in the opposite direction.

The results presented in Figure 3.7 show the distribution of officers as a function of the VASCAR method with which they had the greatest confidence, while the results presented in Figure 3.8 show the distribution for the VASCAR method with which they had the least confidence. From Figure 3.7, most of the contacted officers had the greatest confidence with either the Following or the Parking

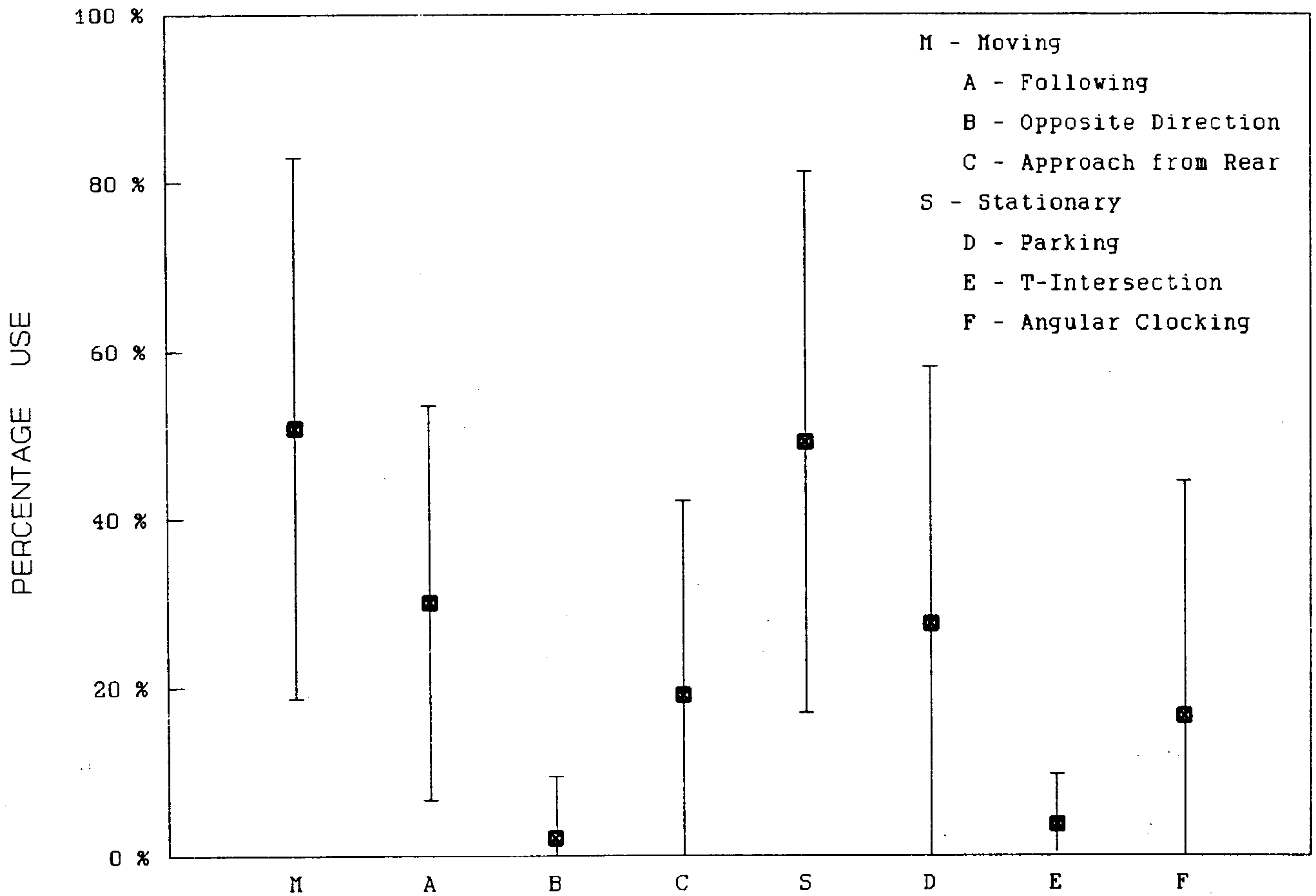


Figure 3.6 - Range of Use for Each VASCAR Method (mean ± one std. dev.)

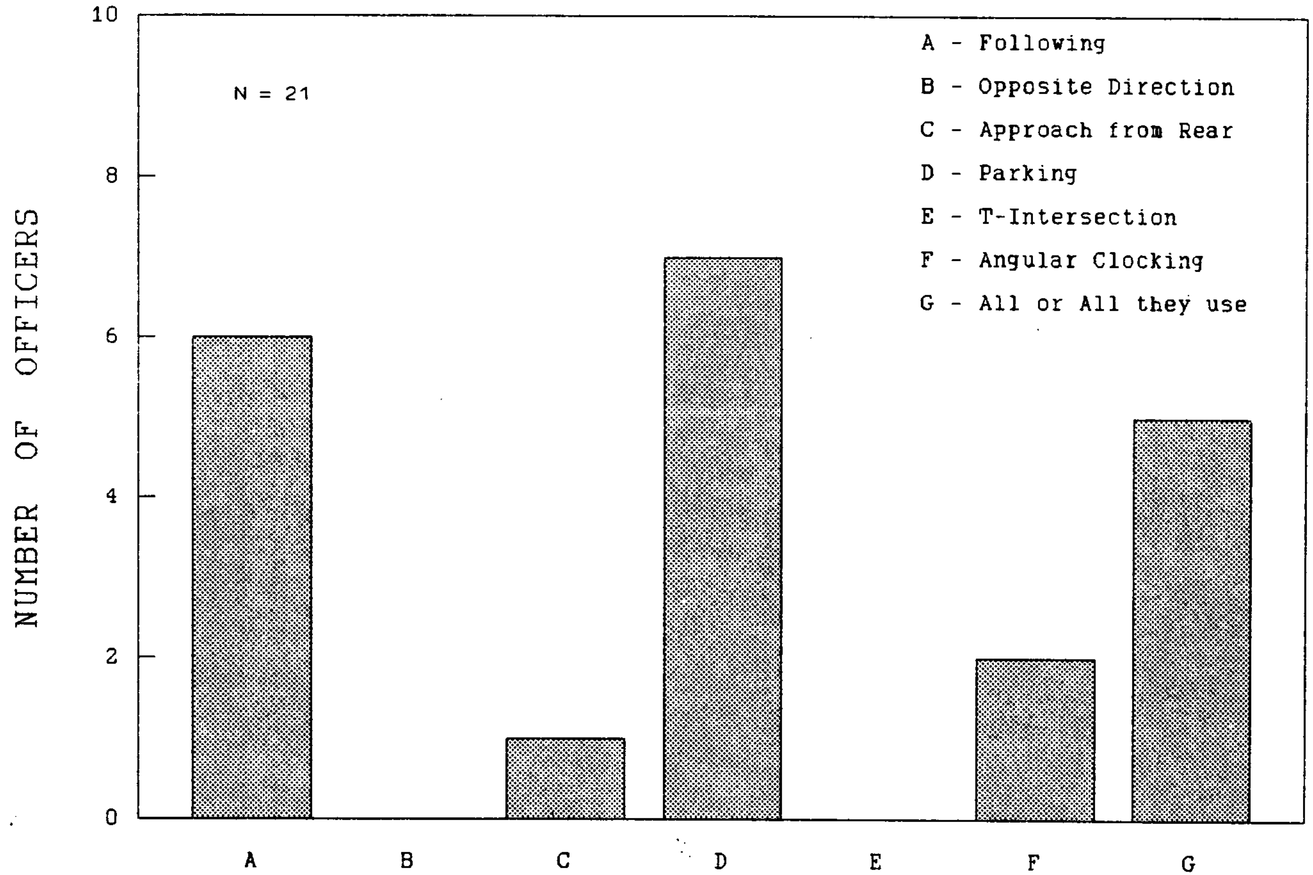


Figure 3.7 - Officer Distribution for the VASCAR Method with the Greatest Confidence

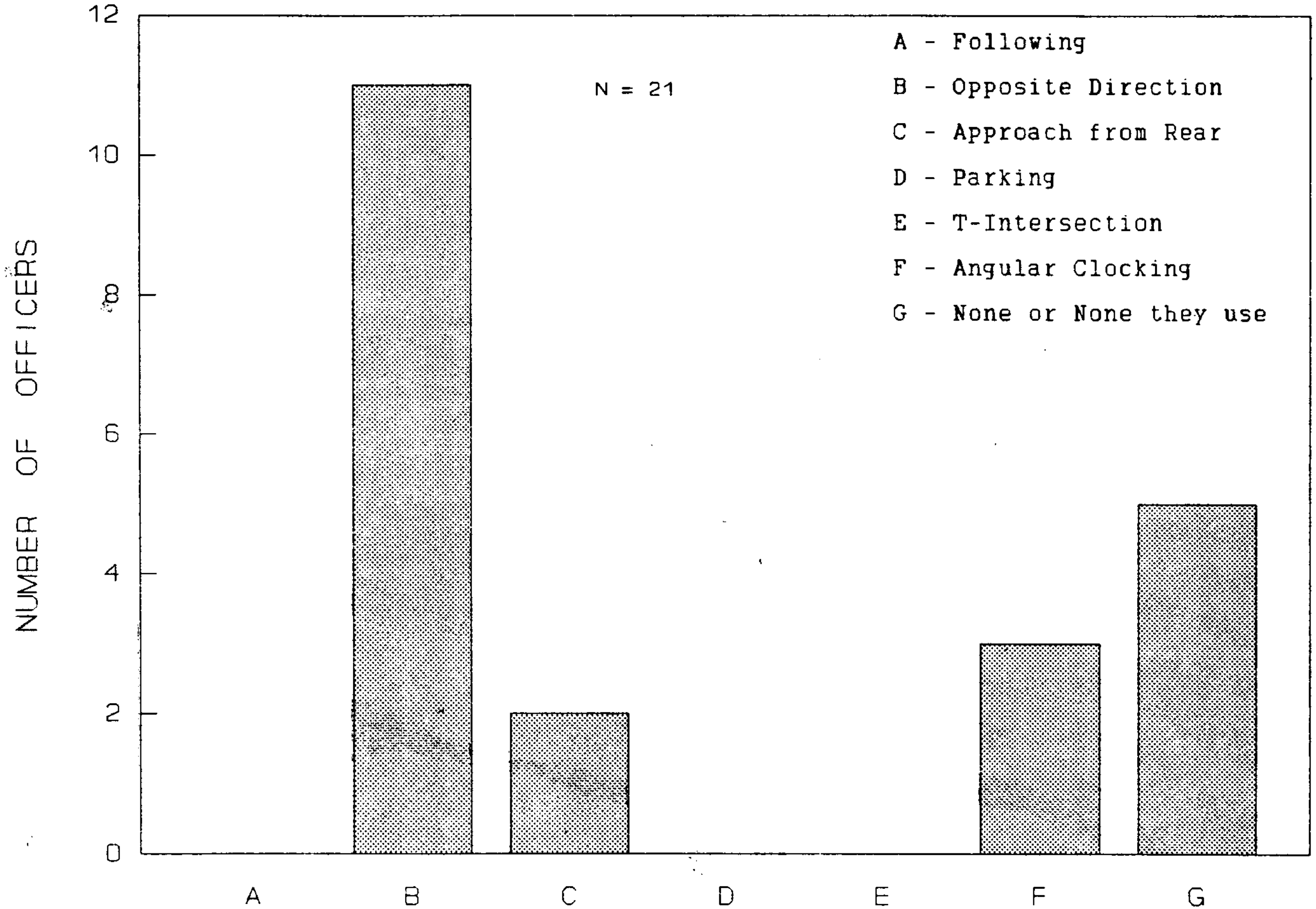


Figure 3.8 - Officer Distribution for the VASCAR Method with the Least Confidence

method. From Figure 3.8, over half of the officers had the least confidence in the Opposite Direction method.

TABLE 3.3 -- Mean and Standard Deviation for the Percentage Use of VASCAR Speed Measurement Methods for all Officers

Method	Mean	Std. Dev.
Moving	52.4	32.2
Following	30.1	23.4
Opposite Direction	3.3	6.2
Approach from Rear	19.0	23.1
Stationary	47.6	32.2
Parking	27.5	30.5
T-Intersection	3.6	6.0
Angular	16.5	28.0

The results presented in Figure 3.9 show the six most prevalently used references during daylight hours. Other references used during the day (only 1 or 2 officers responded) included a dip in the road, discarded tire treads, trees, light poles, bridge abutments, tape, skid marks, expansion joints, and debris along roadway.

The references used at night were limited to objects on the side of the road like signs, mile markers, guardrails, and poles. Any object that headlights illuminate could be used as a reference marker.

The officers were asked how often they used "dialing in the distance" vs. "driving in the distance" for stationary clocks. On average, the officers drove in the distance more than twice as often as dialing in the distance.

Information concerning course lengths and viewing distances is displayed in Figures 3.10-13. The local and state police officers are grouped together for these figures. The values along the horizontal axis represent distance ranges (.05 - .99 represents .05 to .99 mile) From the results presented in Figure 3.10, the shortest course distances ranged from 200 feet to one half mile. From Figure 3.11, the longest course distances ranged from .19 miles to 4 miles. The

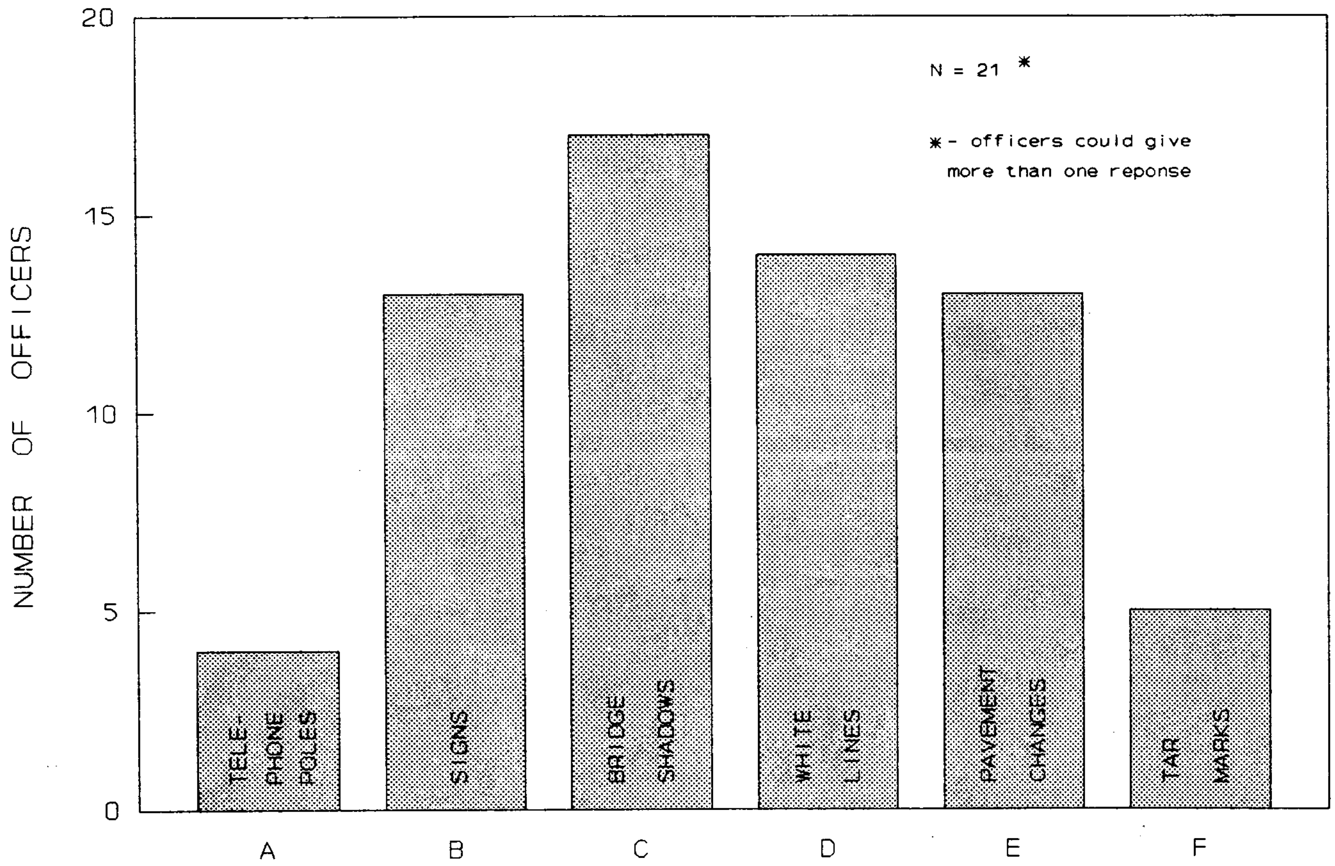


Figure 3.9 - References Most Often Used by Officers During Daylight Hours

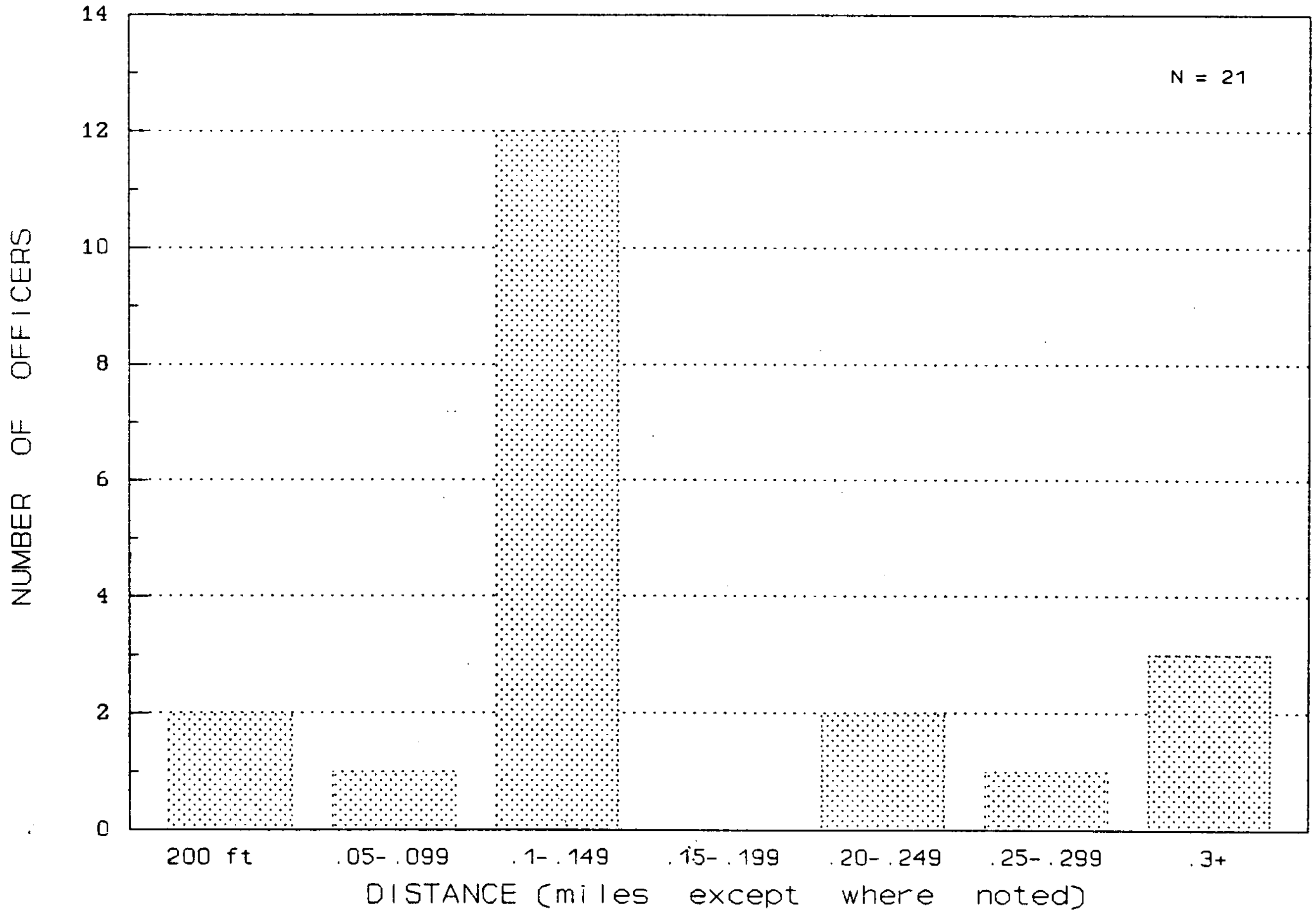


Figure 3.10 - Officer Distribution for the Shortest VASCAR Course Distance Used

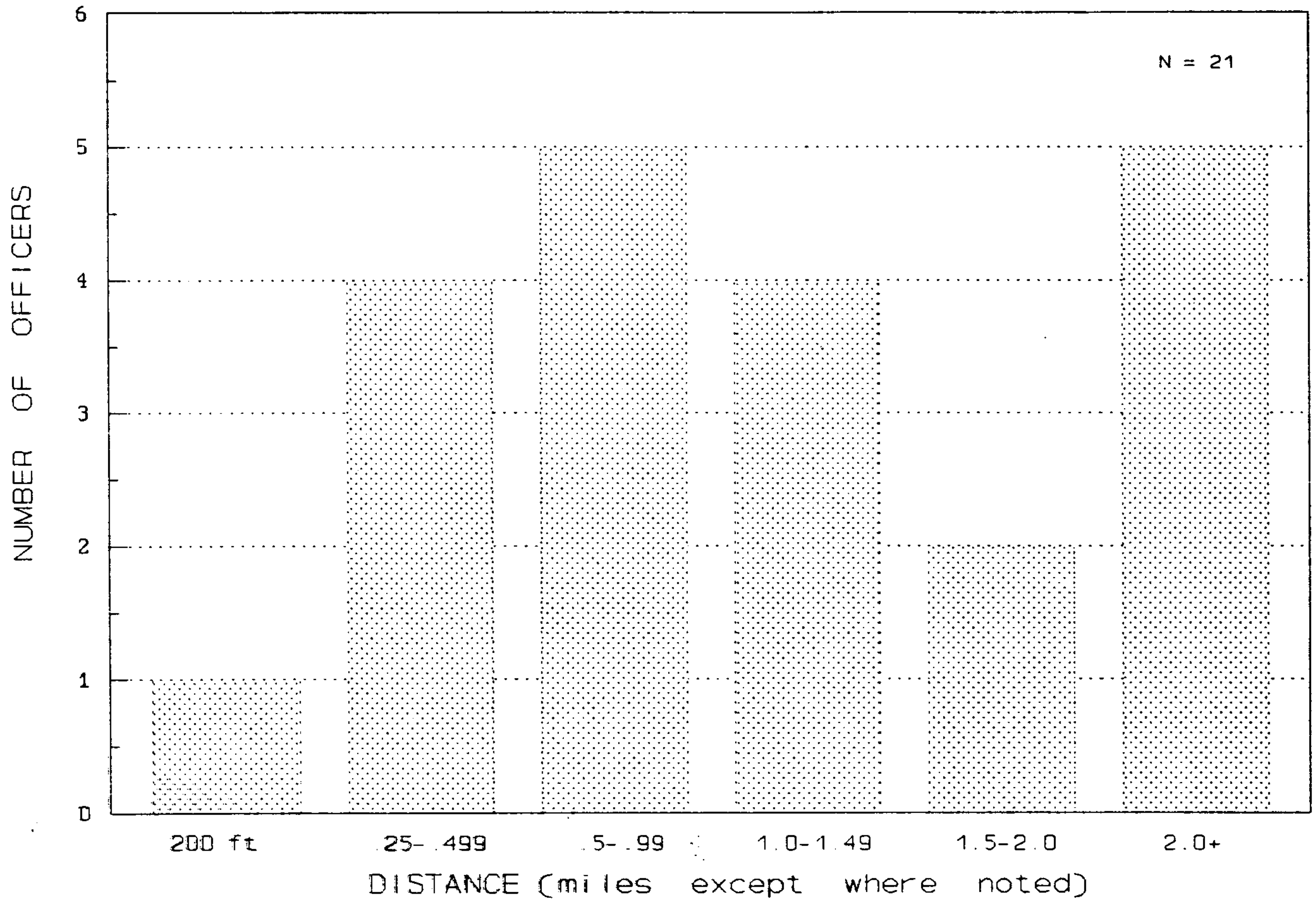


Figure 3.11 - Officer Distribution for the Longest VASCAR Course Distance Used

longest stationary course distance was .75 miles. From Figure 3.12, the preferred course distances ranged from 250 feet to 1.9 miles. The range of values for the maximum viewing distance, the distance from the officer's eye to a reference point, is shown in Figure 3.13. The maximum viewing distance ranged from 200 feet to .75 miles.

The mean and median values for the four distances discussed above are listed in Table 3.4.

TABLE 3.4 -- Mean and Median Course and Viewing Distances (miles)

Distance	Mean	Median
Shortest Course	.093	.1
Longest Course	1.29	.75
Preferred Course	.29	.25
Maximum Viewing Distance	.30	.25

The amount of time spent using VASCAR at night is shown in Figure 3.14. From this figure, it appeared that officers either use VASCAR infrequently or quite frequently at night. This was probably a function of the way police departments operate. Some departments have fixed shifts while others have rotating shifts. When asked whether their choice of VASCAR method was in any way determined by day vs. night time use, thirteen of the twenty-one officers said it was not influenced, four officers said VASCAR was easier to operate during the day, and one officer said it was easier to operate at night. Only two officers made comment on how it influenced their VASCAR method choice; one said he mostly used following clocks at night, the other said angular clocking was harder to use at night. One officer said he preferred using it at night because he was less visible to violators.

When asked whether their choice of VASCAR method or references was influenced by weather conditions, 4 officers responded that there was no influence while the other officers had answers ranging from shortening their viewing distances and only using certain methods in bad weather, to not using VASCAR at all in the rain.

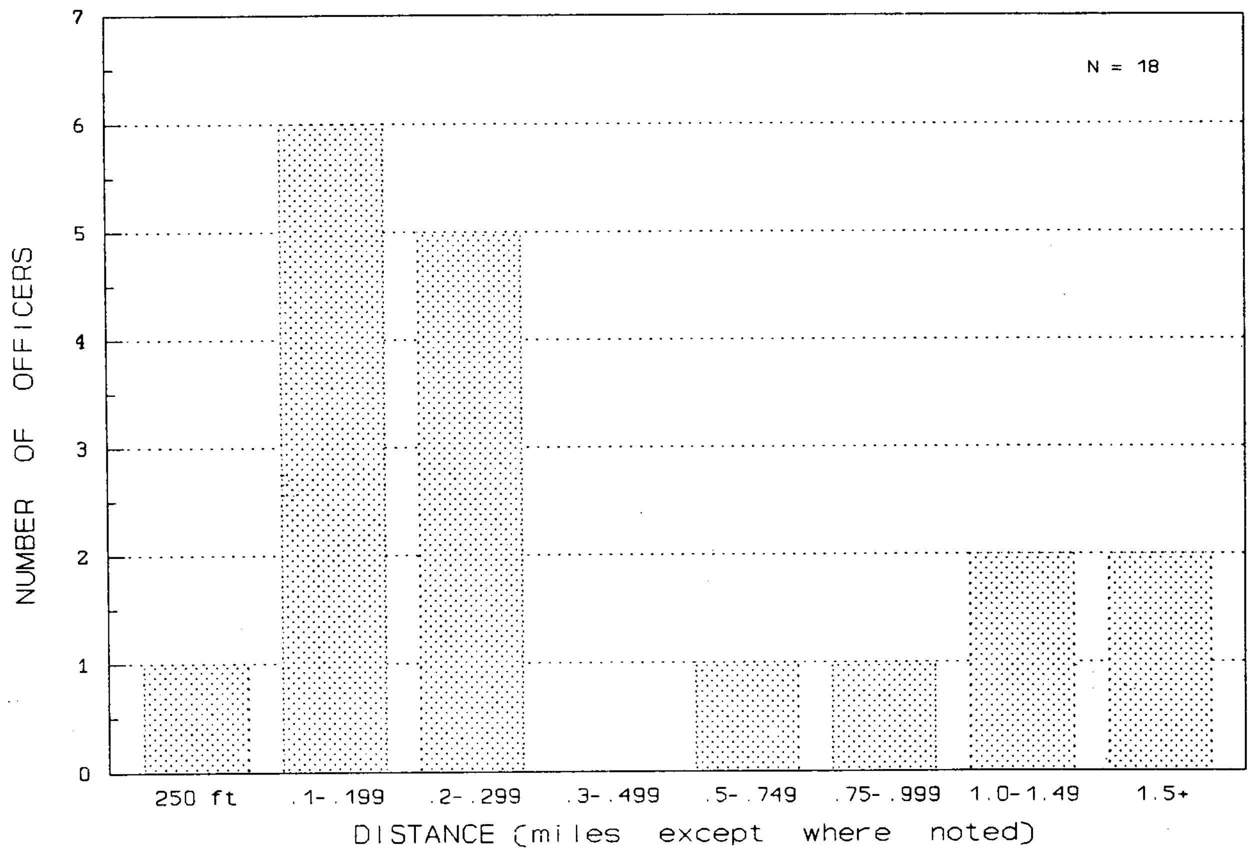


Figure 3.12 - Officer Distribution for the Preferred VASCAR Course Distance Used

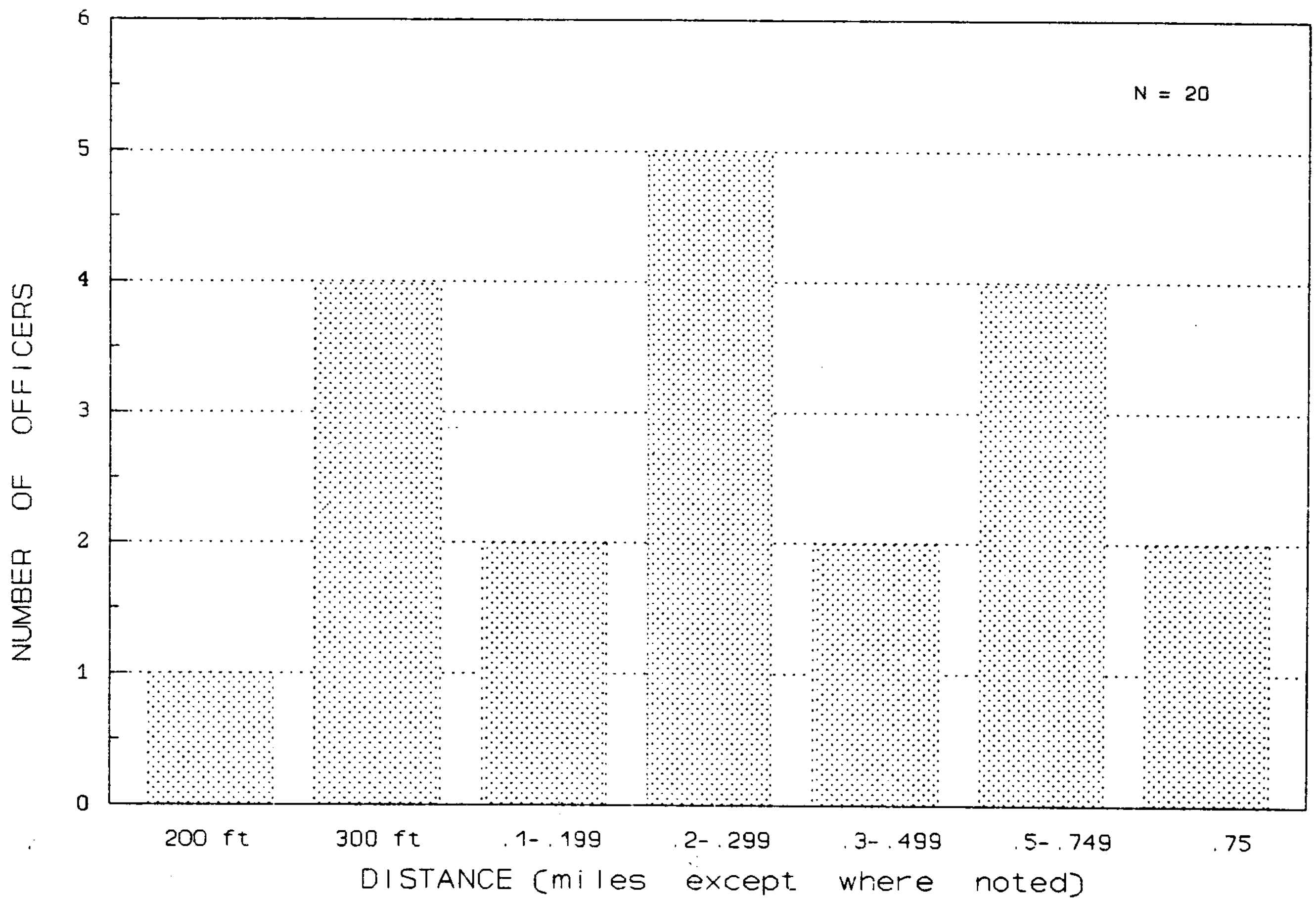


Figure 3.13 - Officer Distribution for the Maximum Viewing Distance Used

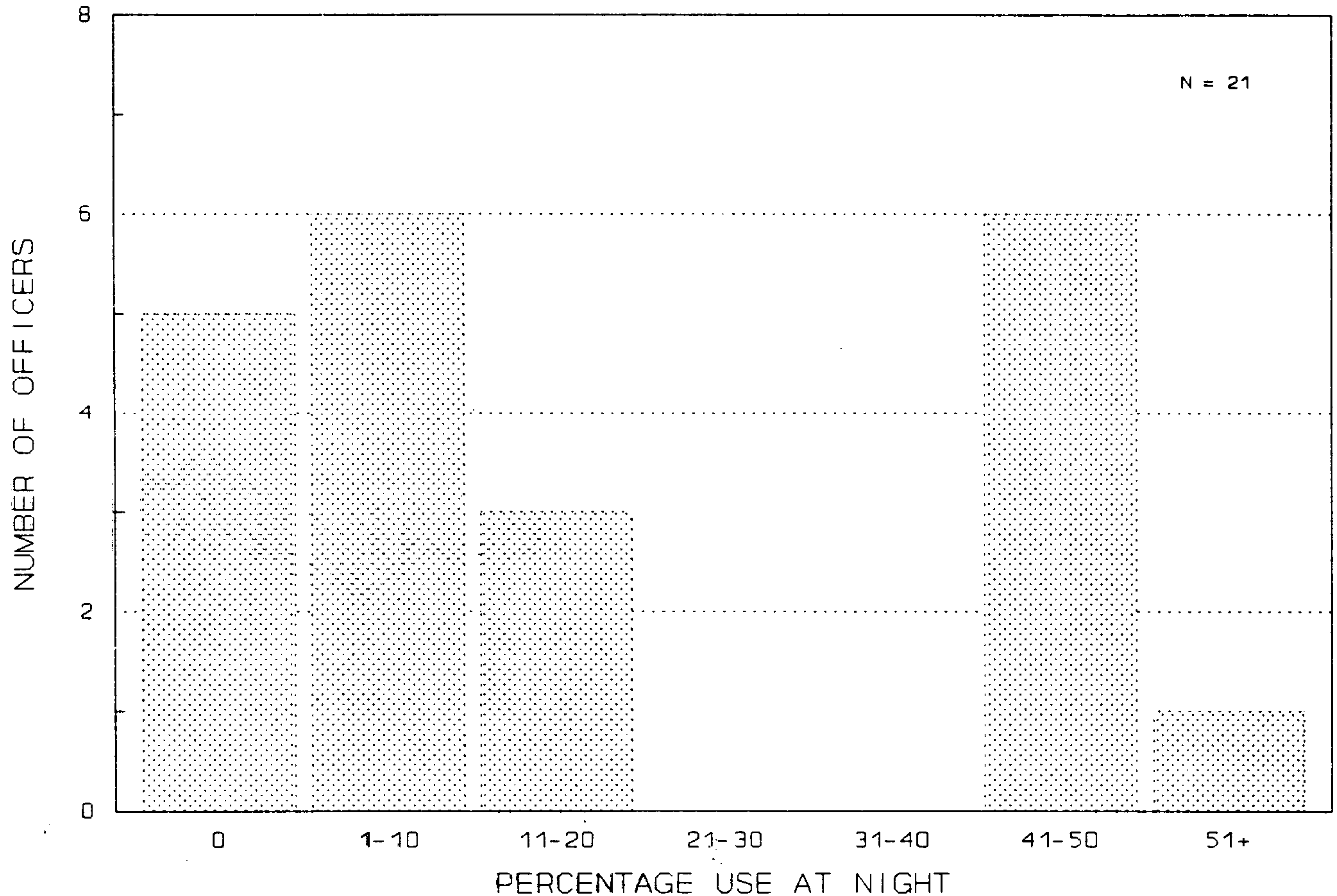


Figure 3.14 - Officer Distribution for Percent Night Time use of VASCAR

The frequency of calibration checks of VASCAR units is shown in Figure 3.15. All but two of the officers either calibrated or checked the calibration at least once per day. These responses are based on each individual officer's use. If the officer only used it once a month, he or she calibrated on the day that VASCAR was used.

A distribution of officers based on a self assessment of their speed measurement accuracy is given in Figure 3.16. From this figure, there was a wide range of self assessed speed measurement accuracy. When the officers were asked whether their speed accuracy was a function of course length, target vehicle speed, and/or VASCAR method, 11 of the 21 officers said it was course length dependant, 4 said it depended on the target vehicle speed, and 17 said it was dependant upon VASCAR method.

Of the 21 officers surveyed, 12 had defended a VASCAR based speeding citation in court. These 12 were asked how defendants or defense attorneys attacked their VASCAR speed estimates. Seven responded that they attacked the officers ability (human error of some sort). Only one tried to attack the VASCAR device itself. Other responses to this question were not directly attributable to VASCAR.

When asked what the strengths of VASCAR were, the most common responses were: that VASCAR is accurate, that the officer has a high degree of confidence in which vehicle he or she is clocking, that VASCAR is better for use in high volumes of traffic than radar, and that the calculation of average speed gives the benefit of doubt to the motorist. The number of officers that gave each of the above responses is shown in Figure 3.17.

When asked what the weakness of VASCAR were, the most common responses were: the time it took to set up or to use (6 officers) and the potential for human errors (5 officers). Other cited weaknesses (1 or 2 officers) included the length of training, the inability to use without references, the inability to use certain methods under certain conditions, the greater requirements for the operator when compared to radar, and the cost of the VASCAR units.

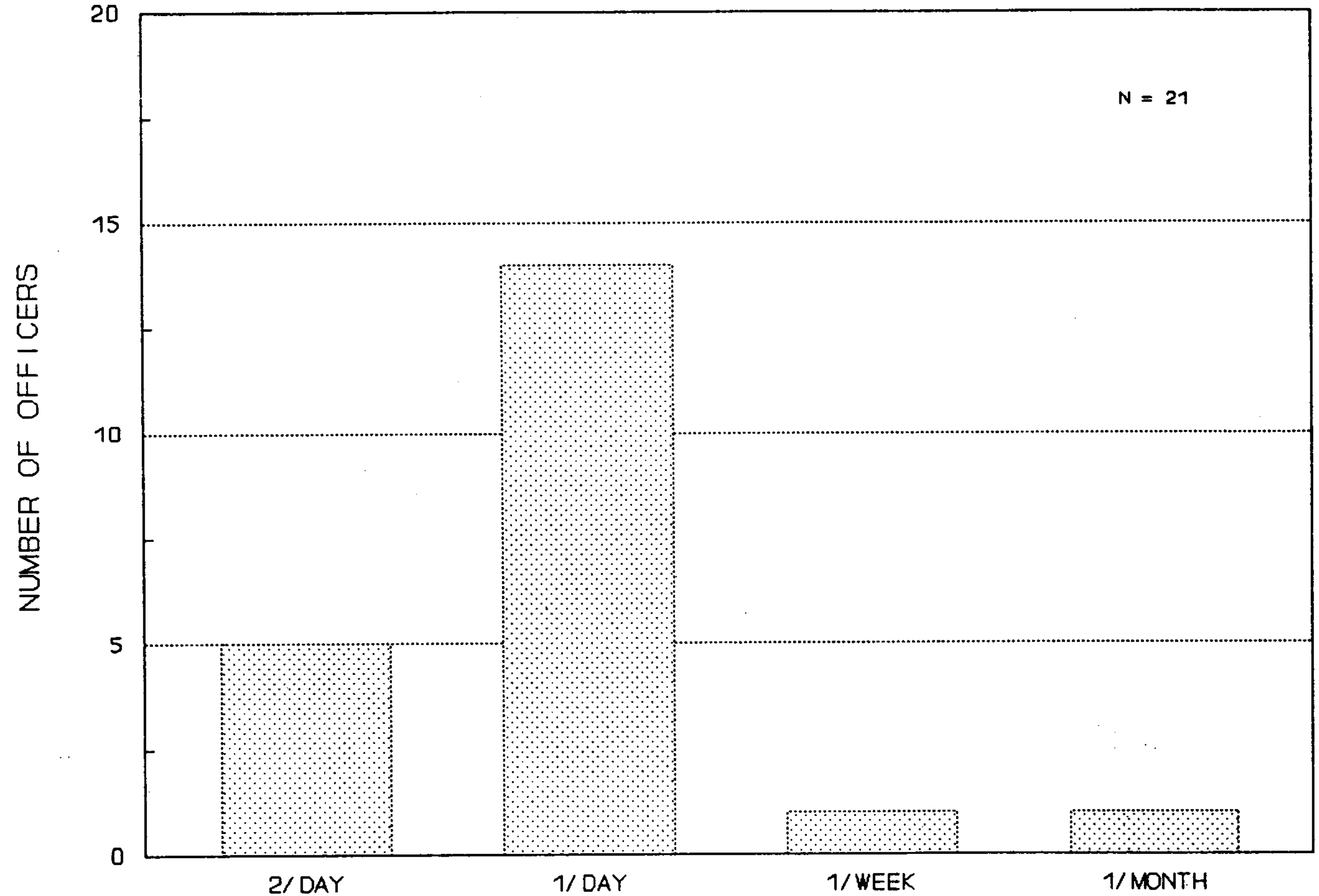


Figure 3.15 - Officer Distribution for the Frequency of Calibration

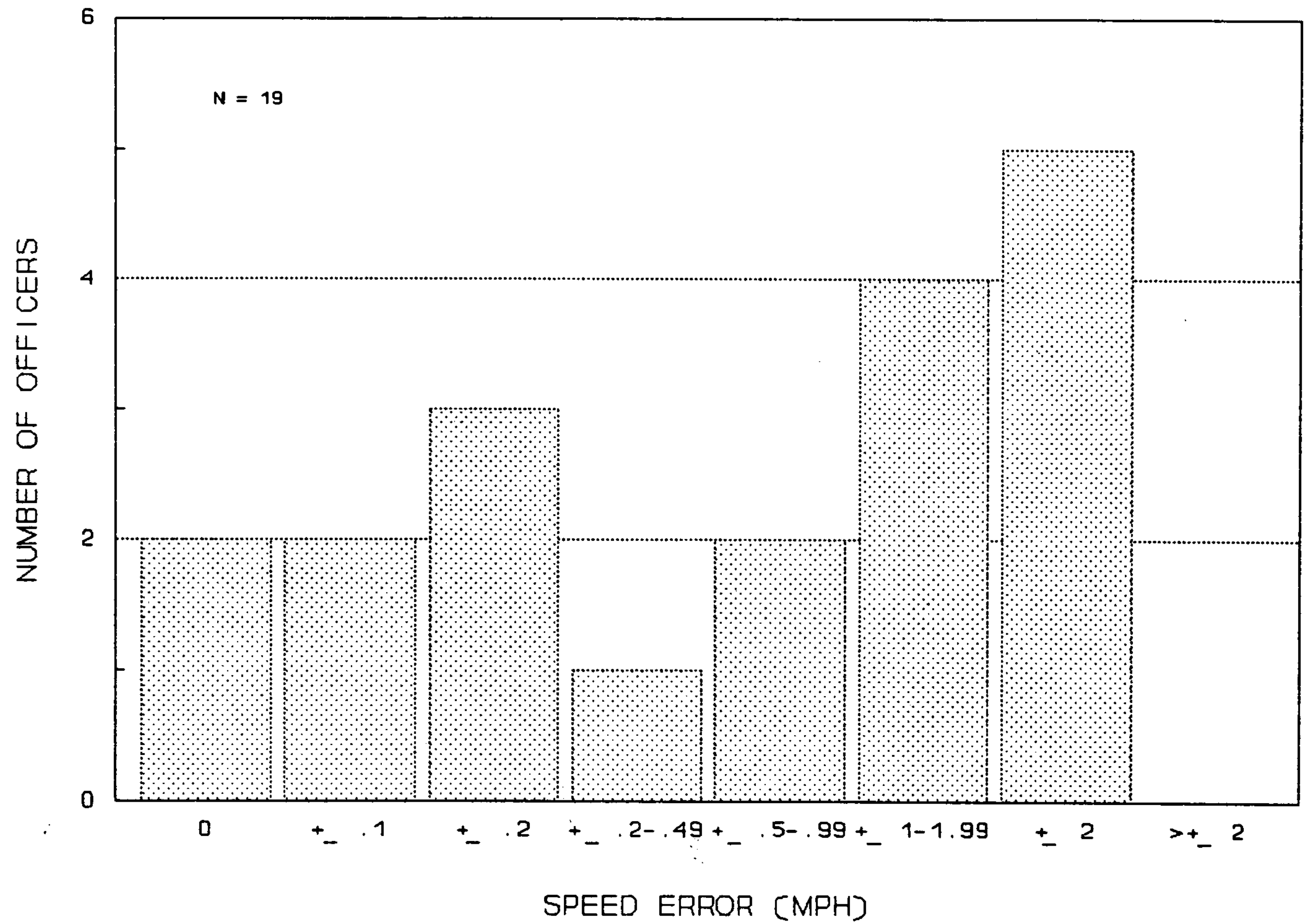


Figure 3.16 - Officer Distribution for Self Estimate of Speed Error

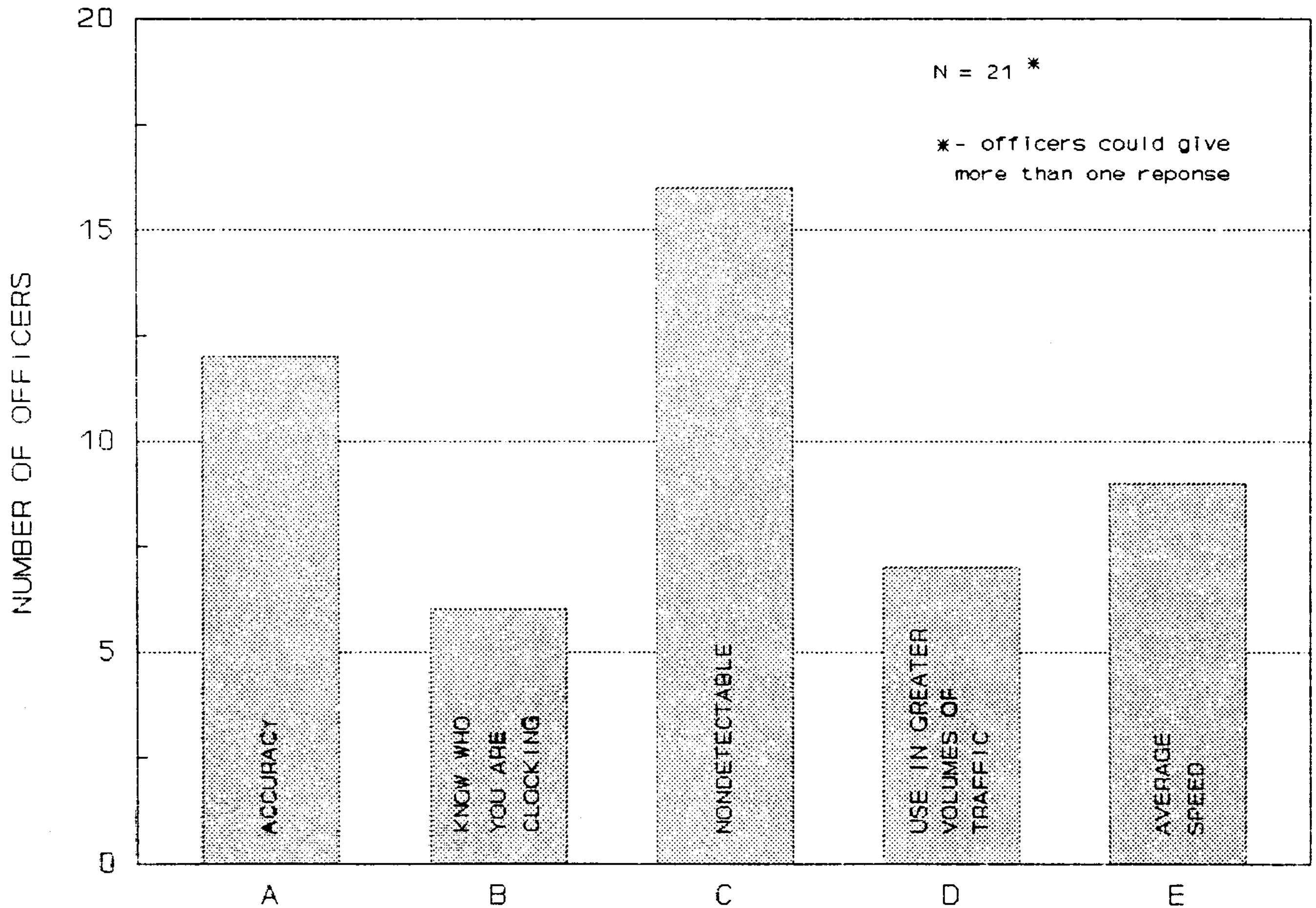


Figure 3.17 - Strengths of VASCAR

When asked if they had ever experienced a failure in their VASCAR equipment, 8 of the 21 officers responded 'yes'. The failures included shorts in the wiring from the car battery to the VASCAR unit, the VASCAR computer going out, the odometer module breaking, and a lost speed upon fast acceleration (a single officer stated this happened to him one time). No officer stated they had an erroneous speed due to the VASCAR unit itself. Their VASCAR units either gave the correct speed or did not give a speed at all.

All 21 of the surveyed officers also used radar to establish vehicle speeds. The officers were asked "Under what circumstances is VASCAR preferred over radar?", and "Under what circumstances is radar preferred over VASCAR?". The most common responses to these questions are given in Figures 3.18 and 3.19.

The officers were given the statement "It's been said that some officers prefer not to use VASCAR. Why do you think some officers avoid the use of VASCAR?". Some of the officers thought that the training time and the time to set-up certain courses might keep certain officers from wanting to use it. Some of the officers thought if the officer had not spent enough time using VASCAR, he or she might not be familiar enough with it's operation to feel comfortable using it. Some officers stated that an officer's lack of confidence in his or her own ability might be a reason why they may avoid using VASCAR.

To close the survey, the officers were asked if all their opinions on VASCAR had been stated. Most of the officers had favorable things to say about VASCAR. Some officers said they enjoyed having both VASCAR and radar and think they make a good team. Others went as far as saying they would prefer to have VASCAR over radar. The only negative statements made were that radar was easier to use and one officer stated that he wished the distance and time inputs were buttons instead of switches.

4.0 EXPERIMENTAL DESIGN AND PROCEDURE

Objectives

1. Determine accuracy of VASCAR-plus timing mechanism.

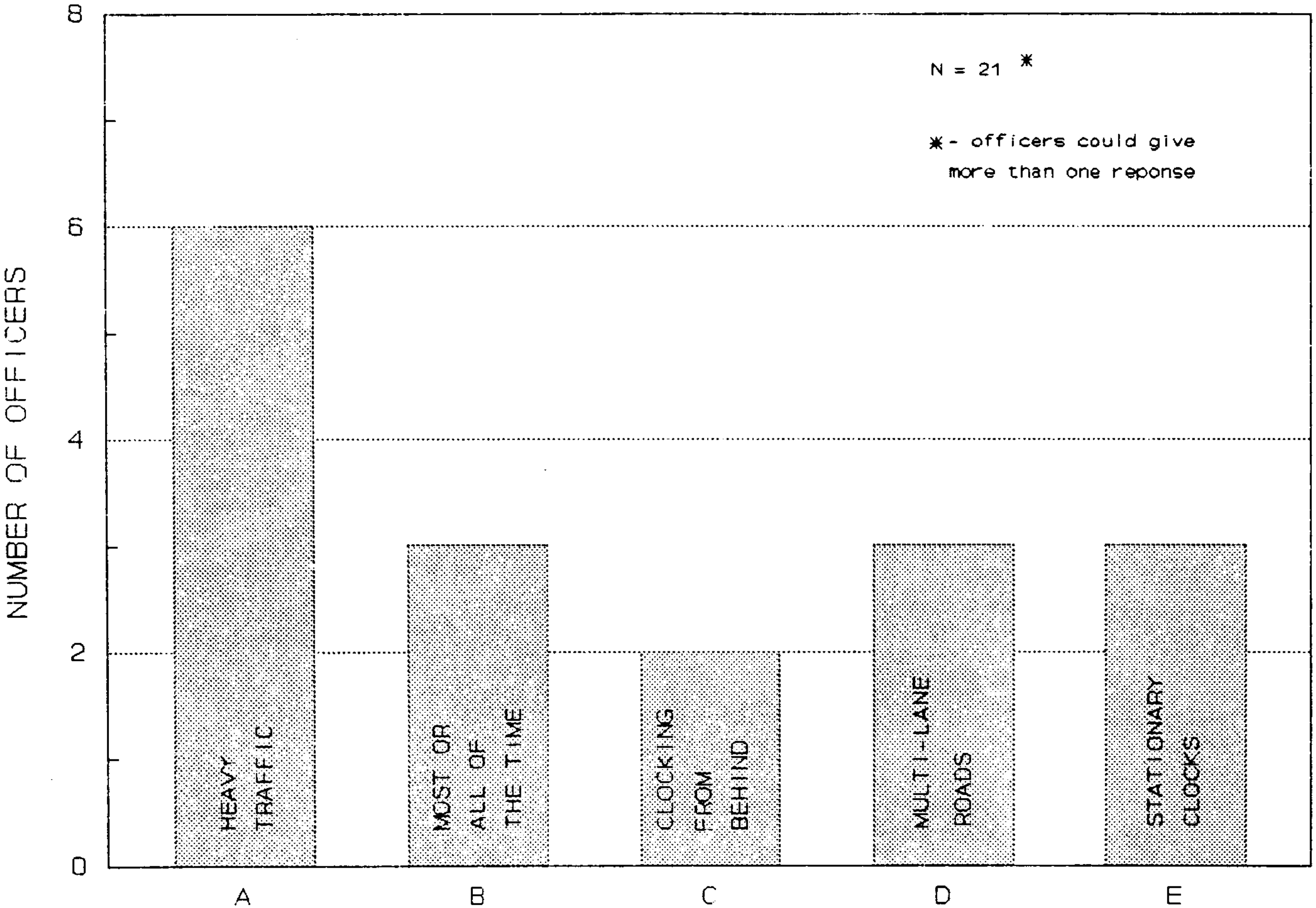


Figure 3.18 - When VASCAR is Preferred Over Radar

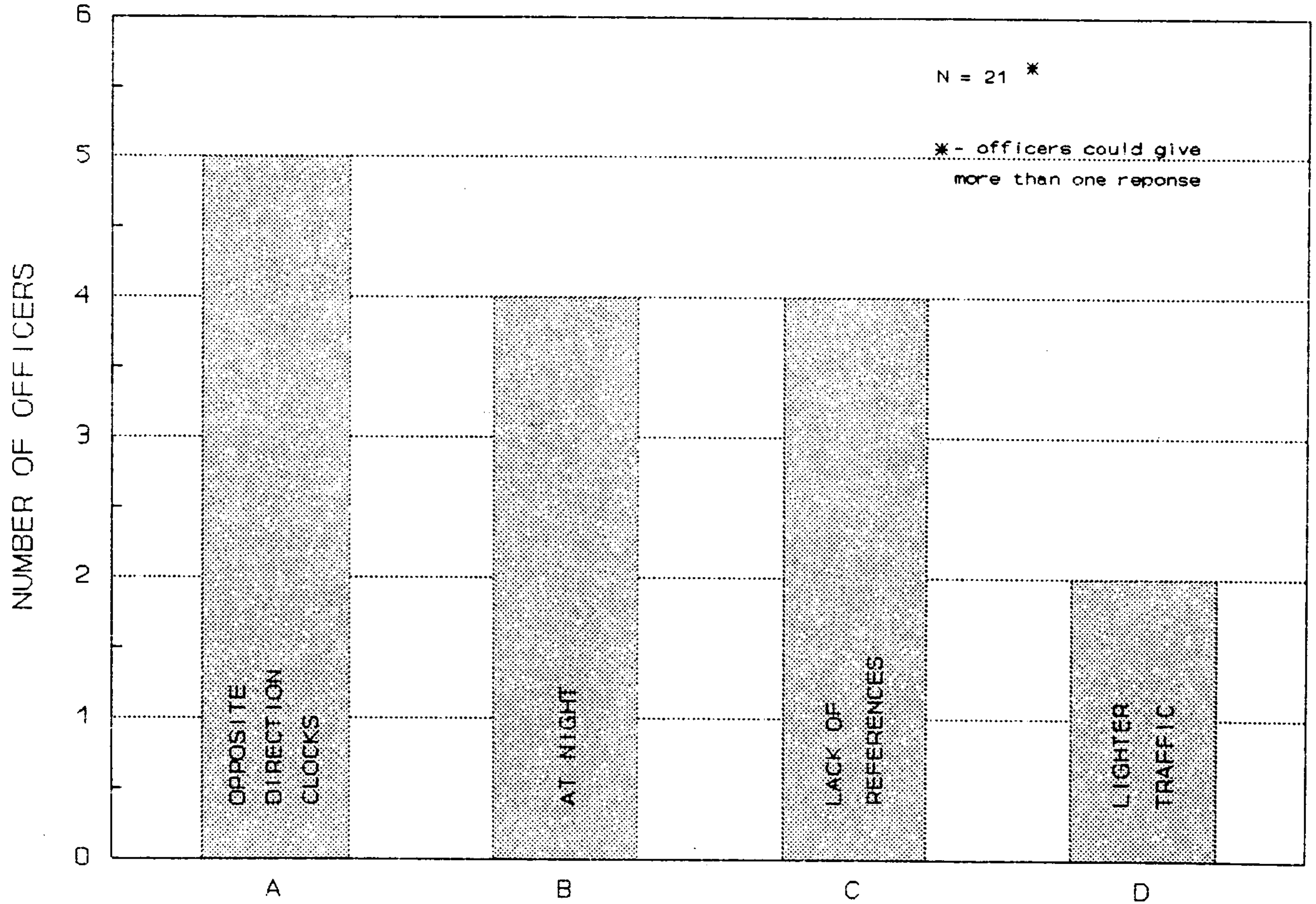


Figure 3.19 - When Radar is Preferred Over VASCAR

2. Determine distance measurement accuracy of VASCAR-plus odometer module.

3. Determine speed measurement accuracy for several VASCAR-plus methods.

4.1 Experimental Design of VASCAR Time and Distance Measurements

VASCAR Timing

According to the manufacturer, VASCAR-plus collects data every 36 milliseconds (i.e., a 36 millisecond resolution). Since this is the case, the VASCAR-plus stored time is in milliseconds (1/1000 of a second). VASCAR-plus displays the stored time to 1/100 of a second. To properly assess the accuracy of the VASCAR timing mechanism, the stored time to 1/1000 of a second must be determined.

To determine the stored time to 1/1000 of a second, the manufacturer says to first divide the displayed time by .036 (or 36 milliseconds). This number is then rounded to the next highest integer. This integer value is then multiplied by .036. The resulting value is the stored time. As an example:

> VASCAR Displayed Time = 4.60
>
> To get the number of 36 msec time increments, divide the displayed time by .036 and then round to the next highest integer.
>
> 4.60/.036 = 127.77
>
> Number of .036 msec time increments = 128
>
> To get the VASCAR stored time, multiply this number by .036.
>
> VASCAR Stored Time = 128 x .036 = 4.608

To determine the validity of the manufacturer's method for determining the stored time, bench tests were performed in which VASCAR displayed speeds were compared to speeds calculated using the VASCAR displayed time and to speeds calculated using the VASCAR "stored" time. If the VASCAR displayed speeds match the speeds calculated using the VASCAR "stored" times, then the manufacturer's method for determining the stored time would be considered valid. For these bench tests, a .2500 mile distance was entered on the VASCAR thumbwheels. Then, the VASCAR time switch was toggled to produce times ranging from approximately 3 to 4.5 seconds. These times produced speeds large enough to show the differences between speeds calculated using the VASCAR displayed time and speeds calculated using the VASCAR stored time.

After these tests were completed, additional bench tests were conducted to determine the accuracy of the VASCAR timing device. Two VASCAR units and a Nicolet oscilloscope were simultaneously triggered using two trip switches. The Nicolet oscilloscope's sample rate was set to 1 msec. A total of 58 tests were performed with times ranging from approximately 1 to 4 seconds.

Time error was used to judge the accuracy of the VASCAR-plus timing device:

Time Error = VASCAR time - True Time

VASCAR Distance

Tests were performed to determine the accuracy of VASCAR distance measurements. Some human error was involved in these tests because vehicle position at each reference mark is estimated by the user. The human error was minimized by having the operators line the vehicle up with reference markers at the beginning and the end of the course. Six subjects participated in this study. Course distances of 200 feet, .1 mile, and .5 mile were each measured 4 times by the subjects.

Distance error was used to judge the accuracy of VASCAR distance measurements:

Distance Error = VASCAR distance - True Distance

4.2 Variables

Based on the results of the personal interviews and the task analysis, the following were identified as potential variables affecting the accuracy of VASCAR speed measurement:

- VASCAR method
- Target vehicle speed
- Course distance
- Type of reference marker
- Distance of the eye to the course or reference marker
- Gap distance - distance between two moving vehicles
- Visual method (direct vs. indirect-through use of mirror)
- Officer vehicle elevation
- Officer differences
- Repetition effect - variation from successive trials
- Replication effect - variation from different days
- Weather conditions
- Day vs. night use

To investigate the effects of some of these variables, six studies were designed. The six studies were moving, night moving, bridge, parking, angular, and reference marker alignment. Each study focused on one or more of variables listed above. Subject differences were examined in all the studies. Replication of a set of test conditions occurs when the test conditions are repeated in a new randomized order, after a period of time has passed. For the testing conducted in this study, replicates were generally separated by a 24 hour period. Due to time constraints and weather conditions, sometimes 2 replicates were performed on the same day. The replicates were separated by a 4 hour period. Replication effects were examined in all of the studies except the bridge study. Replication effects include the possibility of learning and/or fatigue.

4.3 Experimental Design and Setup of VASCAR Speed Measurements

In all of the studies mentioned below, the nominal speed represented a speed range. For subjects 1 through 4, the speed range was the nominal speed $\pm$ 2 mph; for subjects 5 through 8, the speed range was the nominal speed $\pm$ 7 mph. These different speed ranges occurred due to concern that the earlier subjects may have known the target vehicle speed (due to repetition) before the clock was finished.

Differences in the results between the two groups are discussed in the test results section of this report.

Another study compared the effect of blind (VASCAR display covered) and normal (display uncovered) speed measurements. This study was not considered to be an appropriate test of VASCAR. The results of the task analysis showed that the displayed speed is compared with the initial speed judgement made by the officer. If the display is hidden, the subject is not able to make this comparison. The results of this study are presented in Appendix C.

In all of the following studies, speed error was used to judge the accuracy of VASCAR speed measurements:

Speed Error = VASCAR speed - True Speed

Moving Study

Variables

A. Two VASCAR methods: Following and Approaching from the Rear

B. Course distance at two levels: .1 and .3 mile (528 and 1584 feet).

C. Target vehicle speed at three levels: 45, 60, and 80 mph.

This variable list and number of levels resulted in a 2 x 2 x 3 full factorial design, resulting in 12 combinations of conditions. As with all the studies, it was intended that each officer replicate this study four times.

Under ideal conditions it would be best to randomly present the 12 conditions to the officers. Due to the time it takes to set up the different conditions, this was not practical. For this study, a course distance was first randomly selected, then each combination of VASCAR method and speed was randomly selected. The VASCAR method was not completely randomized for each officer. For efficiency, one officer was performing a Following clock, while the other was performing an Approaching from the Rear clock. An example of the order of trials for this study and the other studies is in Appendix D.

The test configuration is detailed in Figure 4.1. In Figure 4.1, and the figures that follow, T is the target vehicle, S_1 is subject 1, and S_2 is subject 2. In Figure 4.1, subject 1 is performing a Following clock while subject 2 is performing an Approaching from the Rear clock in an adjacent lane. Subject 2 uses the side or rear view mirror, depending on the gap distance between vehicles, to maintain visual contact with the target vehicle.

Night Moving Study

Variables

A. Target vehicle speed at three levels: 45, 60, and 80 mph

All other variables were held constant. The course distance was .3 mile and the VASCAR Following method was used. These values were chosen to allow a direct comparison between day and night time conditions. Each subject was randomly given each of the speed conditions twice.

The test configuration for the night moving study is detailed in Figure 4.2. The only differences between following clocks in the moving study and the clocks in the night moving study was the light condition and the reference marker. In the moving study, the subject generally used the photocell reflector plate (see section 4.4) as the reference marker. In the night moving study, the subjects used the target vehicle headlights reflecting off the white pole (Figures 4.1 and 4.2).

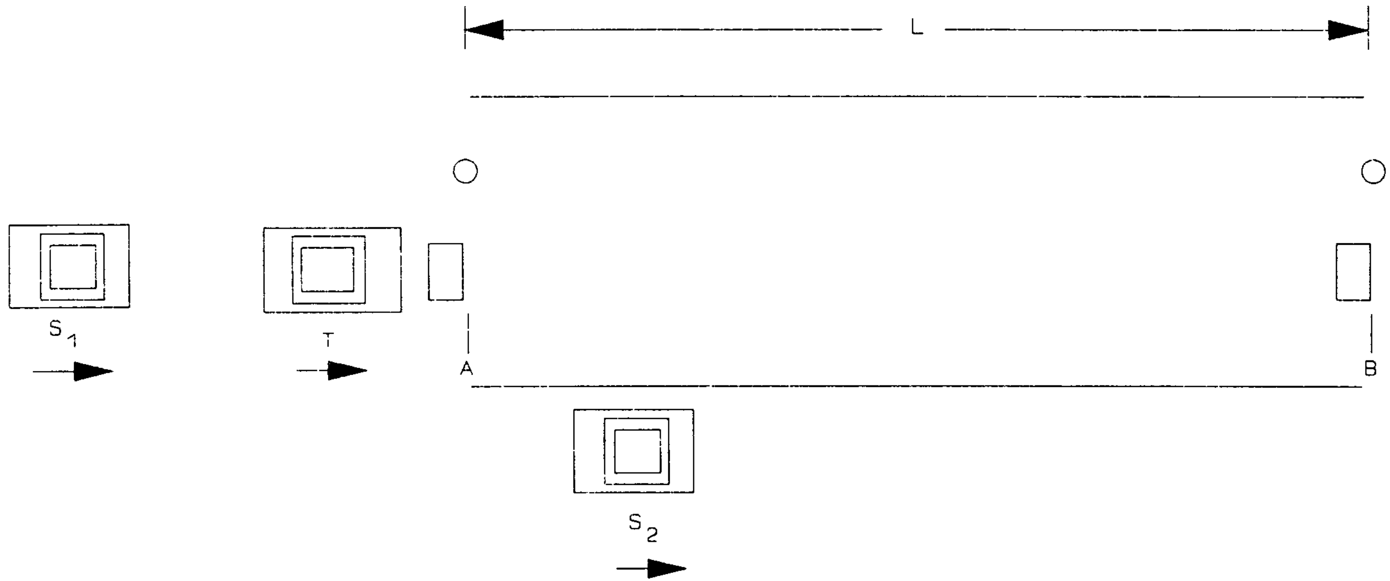
Bridge Study

Variables

A. Target vehicle speed at two levels: 60 and 80 mph.

B. Vascar method at two levels: Following and Parking.

C1. For the Following clocks - two gap distances: 250 feet and 1/8 mile



L =Course Length, 528 ft or 1584 ft

○ =Orange Cone

▭ =Photocell Reflector Plate

Figure 4.1 - Test Configuration for the Moving Study

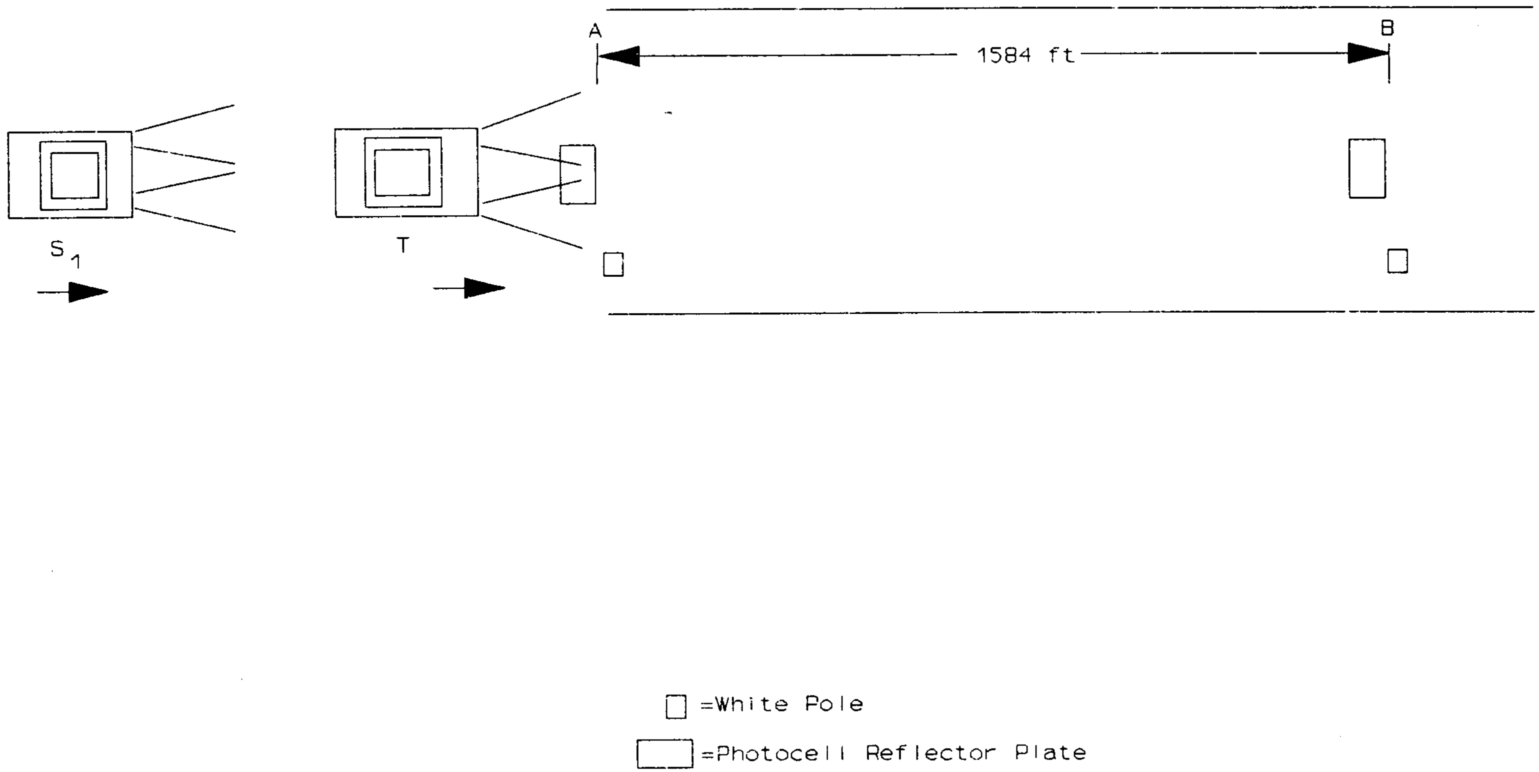


Figure 4.2 - Test Configuration for the Night Moving Study

C2. For the Parking clocks - two viewing methods: direct and indirect (mirror)

This variable list and number of levels gave 8 combinations of conditions. The course distance was held constant at .3 mile (1584 feet).

These conditions were presented as randomly as possible. There was only one constraint on the randomization; while one officer was performing a Following clock, the other officer was performing a Parking clock. Figure 4.3 contains details of the test conditions.

For the Following clocks, two gap distances were chosen to study the effect of viewing distance. The shorter gap distance was the same as the gap distance in the moving study. This allowed a direct comparison between the "bridge" shadow and the photocell reflector plate reference markers.

The "bridge shadow" used in this study was not a real bridge shadow. To simulate a bridge shadow, tarps were placed on one side of 4' x 6' x 8' sections of scaffolding. The shadow cast by each section of scaffolding was 6' wide. For subjects 1 and 2 there was only one section of scaffolding at each end of the course. For subjects 3 through 6 there were two sections of scaffolding; therefore, the bridge shadow was twice as wide. The shadow was widened because subjects 1 and 2 felt it was unrealistically narrow.

Parking Study

Variables

A. Target vehicle speed at two levels: 60 and 80 mph.

B. Course distance at two levels: 200 feet and .1 mile (528 feet).

This variable list and number of levels gave a 2 x 2 full factorial design resulting in 4 combinations of conditions. The test conditions are detailed in Figure 4.4. As seen in Figure 4.4, this study also used a "bridge" shadow. This bridge shadow was the same bridge shadow used in the bridge study.

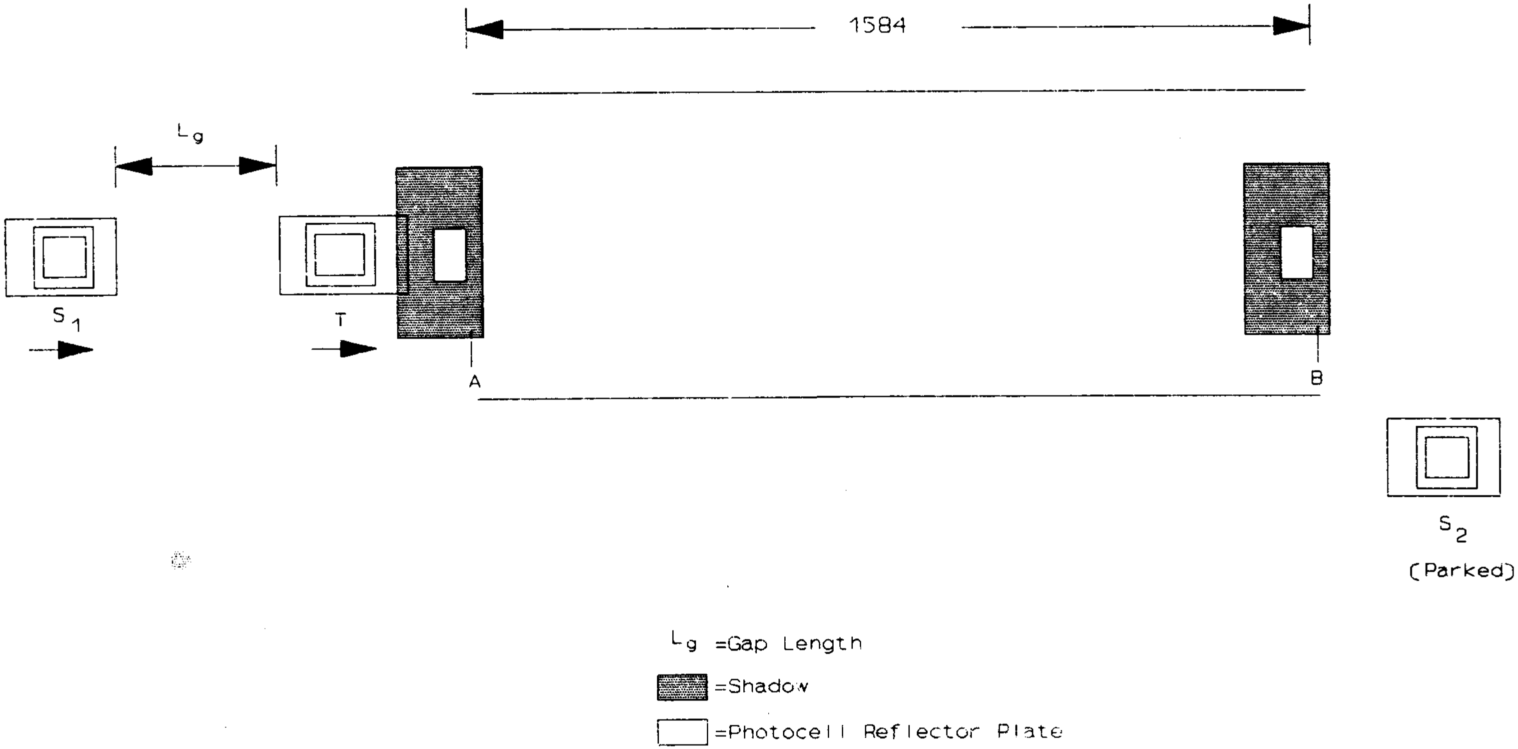


Figure 4.3 - Test Configuration for the Bridge Study

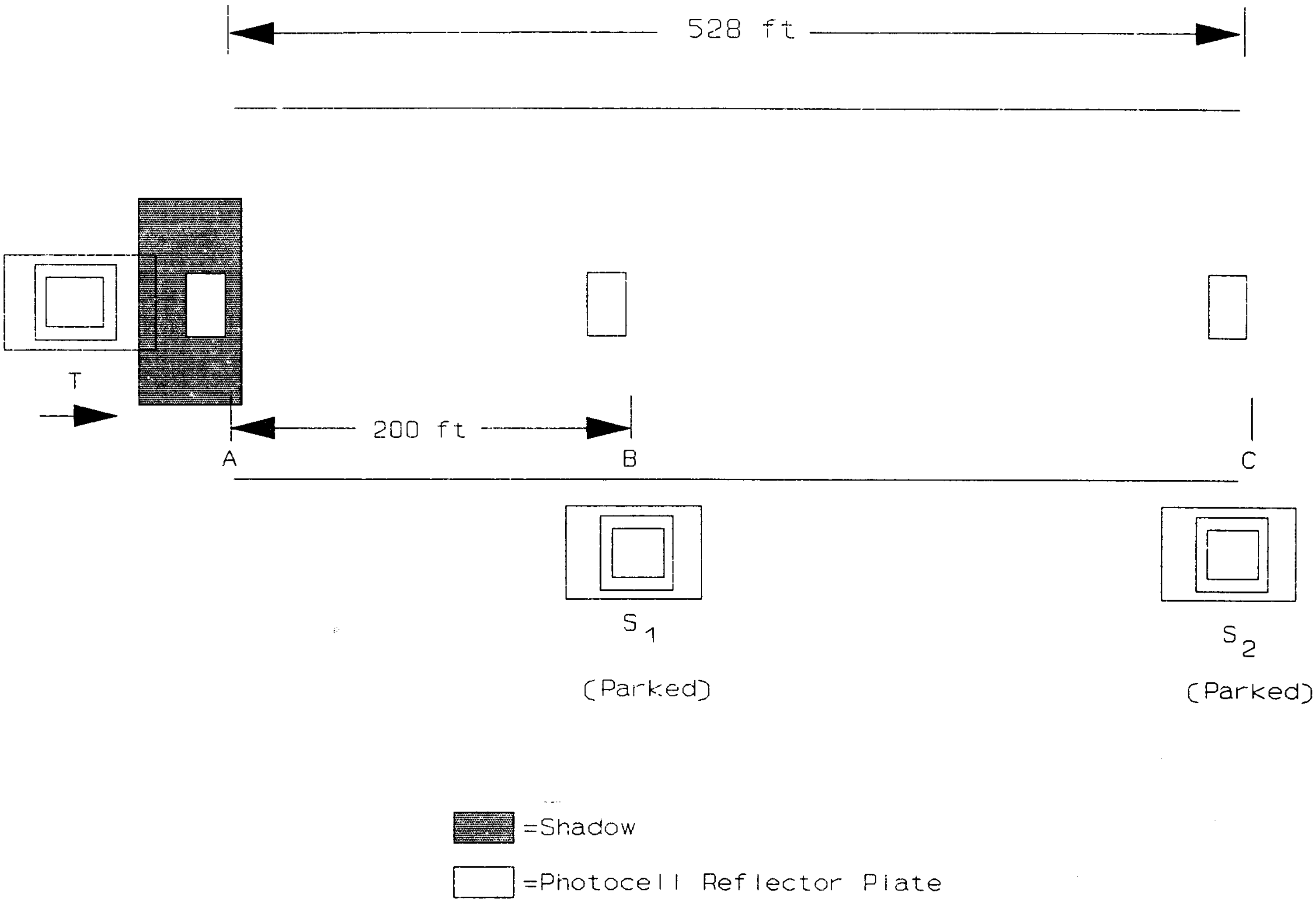


Figure 4.4 - Test Configuration for the Parking Study

For this study, the subjects were first randomly assigned a course distance. The target vehicle then drove by twice at the selected speed levels. The order of presentation of the two vehicle speeds was random. The subjects then switched positions and again the target vehicle drove by at the two speed levels.

Angular Study

Variables

A. Target vehicle speed at three levels: 45, 60, and 80 mph.

B. Course distance at two levels: 200 feet and .1 mile (528 feet).

C. Viewing distance at two levels: 200 feet and .1 mile (528 feet).

D. Elevation at two levels: ground level and elevated (12 feet).

This variable list and number of levels gave a 3 x 2 x 2 x 2 full factorial design resulting in 24 combinations of conditions. Figure 4.5 contains details of the test conditions.

The officers were first randomly assigned a viewing distance. They were then randomly assigned an elevation level; one officer on the ground and the other elevated 12 feet. A course distance was randomly selected, then the three target vehicle speeds were randomly presented to the officers. The course distance was then changed, and again the three speeds were randomly presented. The officers then switched elevation levels and repeated the process. The officers then changed viewing distances and again repeated the process.

Reference Marker Alignment Study

This study arose due to subjects' 3 - 6 concerns with the angular study. In the angular study, the white pole was not placed in the subjects' line of sight for the 200 foot course distance. The officers said they would not set up a course like this. In this study, the 200 foot viewing distance, 200 foot course distance, and ground level conditions of the angular study were repeated, except for the location of the white pole. In the angular study the white pole was in line with the photocell reflector plate, while in the reference marker alignment study the white pole was in the subjects' line of sight (Figures 4.5 and 4.6).

Variables

A. Target vehicle speed at three levels: 45, 60, and 80 mph.

For this study the viewing distance and the course distance were both held fixed at 200 feet. The officer was at ground level. The details of this study are shown in Figure 4.6. The three target vehicle speeds were randomly presented to the officers.

This study allowed a direct comparison between having the pole aligned and not aligned for subjects 7 and 8.

4.4 Experimental Protocol for Speed Measurement Studies

The experimental protocol consisted of three steps:

1. Give instructions to the subjects
2. Conduct the experimental studies detailed in the previous section
3. Debrief the subjects at the conclusion of all testing

Subject Instructions

Before any testing was conducted, the subjects were given a statement concerning the testing procedure and protocol. A copy of this statement is given in Appendix E. The testing procedure and protocol statement informed the subjects of the types of clocks they would be making, the risk involved in operating a vehicle at high speeds, the purpose of the study, and their right to discontinue the testing at any time. The subjects were not given details of the particular testing scenarios before testing was conducted.

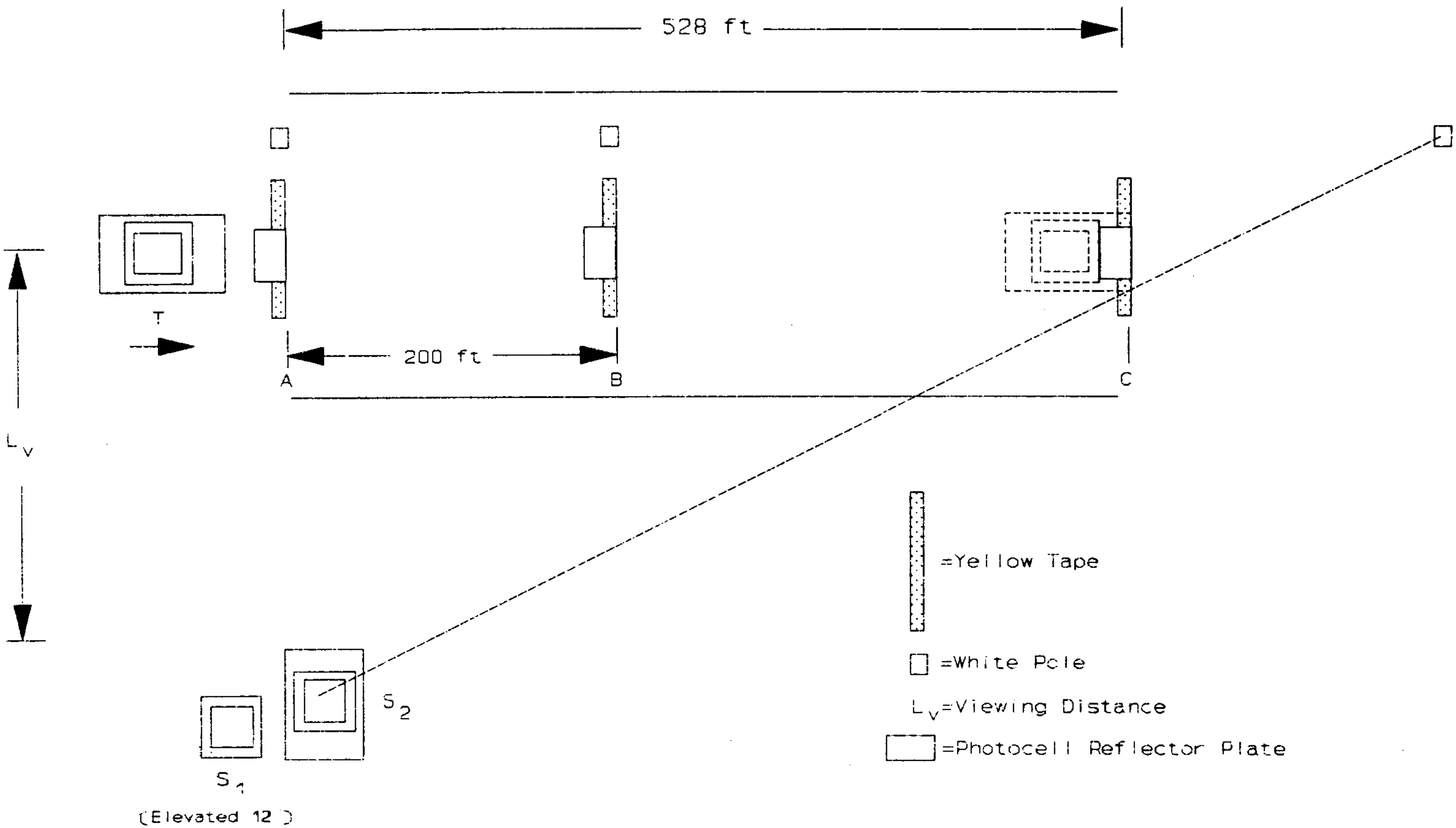


Figure 4.5 - Test Configuration for the Angular Study

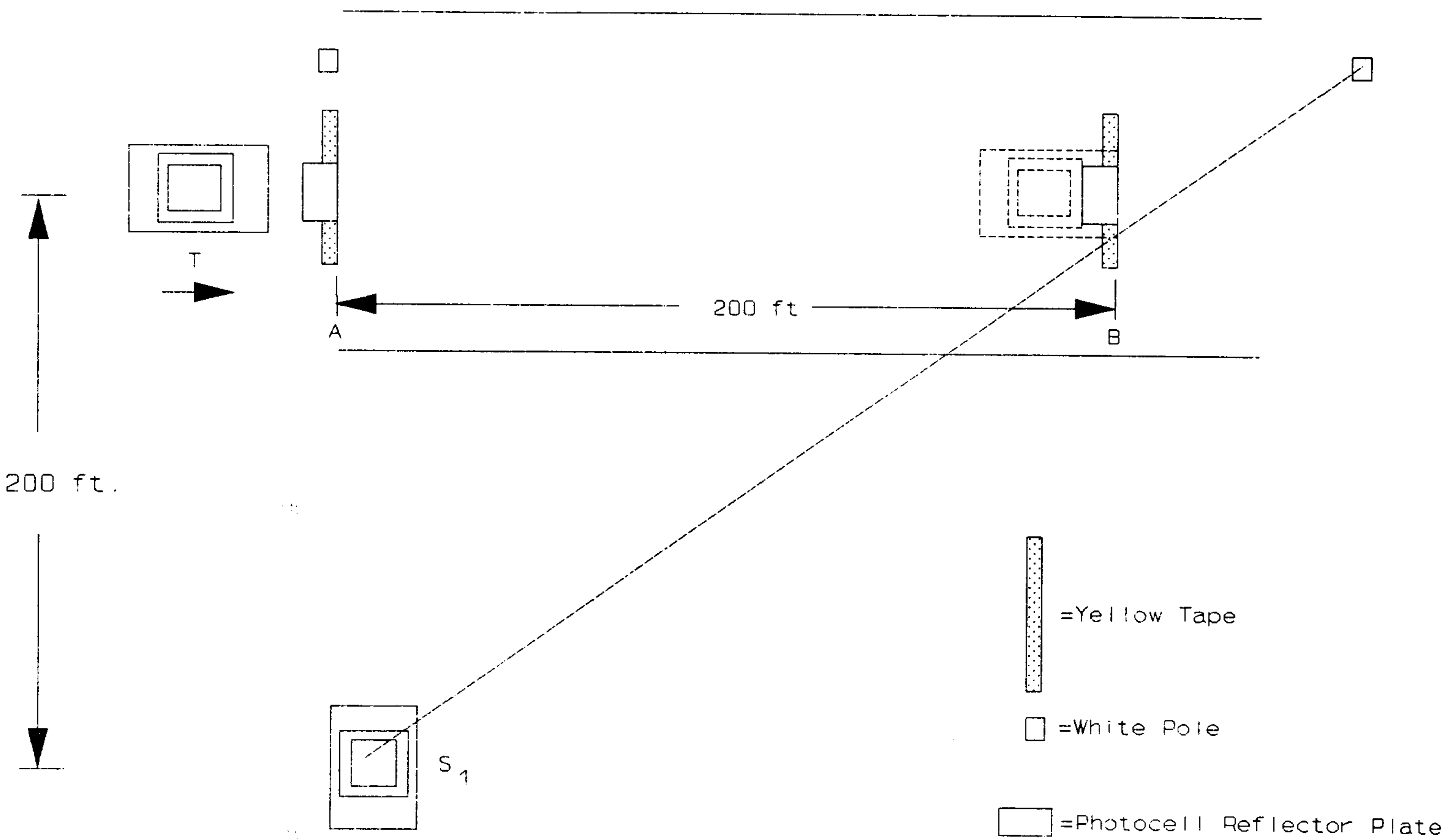


Figure 4.6 - Test Configuration for the Reference Marker Alignment Study

Experimental Run

Immediately prior to conducting each experimental session, the subjects were shown the particular course configuration. They were allowed 2 to 3 practice runs to warm up, then testing began. Prior to any moving tests, the subjects calibrated their VASCAR-plus units. In the stationary studies, the subjects were told the course distance to "dial in". At no time were the officers told the speed of the target vehicle. The subject's speed, time, and distance estimates were recorded by a data collector that rode in the vehicle with each officer. In some of the moving tests, the officers were told when the target vehicle would be "above highway speeds" (80 mph nominal speed). This was done due to the short distance available to get the vehicles up to the desired speed. The subjects were not given any results of their performance until weeks after the testing was completed.

It is important to note that in these studies, it was not possible to exactly duplicate real world conditions. The task analysis stated several limiting factors that did not occur during the testing. Other vehicles obscuring objects and radio chatter were two of the limiting factors. The subjects did have to communicate with the control tower and other vehicles by radio, but this communication was probably less than what is heard by an on duty officer. It is also important to note that depth cues, like other vehicles and objects adjacent to the course, were not available in this study, but are available in the real world. Such cues help officers anticipate the arrival of a target vehicle at a reference mark. This permits compensation for reaction time delay.

Measurement of True Speed

While the subjects measured speed with VASCAR-plus, the target vehicle true speed was measured using a SUNX RS-120H photocell. The photocell was mounted to the front of the vehicle. The photocell triggered on two reflector plates which were placed at the beginning and end of the course. The photocell signal was monitored by an RTI-815 analog acquisition board. The acquisition board had a 5 megahertz quartz crystal. The sample frequency was scaled to 1000 hertz (1 millisecond resolution). An onboard computer collected and stored the signal.

A computer software program used the stored signal to determine the true time. Since all of the clocks were made on courses with known distances, the computer software program calculated the true speed by dividing the known course distance by the true time.

The photocell system timing accuracy was measured by comparing it to the timing of a Nicolet oscilloscope with electronic trip switches. The photocell system was found to be as accurate as the oscilloscope system. Appendix F contains a comparison of the two systems.

Subject Debriefing

After the testing was completed, the subjects were debriefed. Except for subjects 1 and 2, the subjects were debriefed separately. During the debriefing the subjects were asked questions concerned with any problems they may have encountered, the realism of the study, and the confidence they had in their VASCAR speed estimates. A sample debriefing guide and the results of the debriefings are in Appendix G. Some of these results are presented in Chapter 5.

4.5 Subjects

Two subjects from each of the following departments participated in this study:

1. Columbus Police Department - Columbus, Ohio
2. Arizona Department of Public Safety - Highway Patrol Bureau
3. Indiana State Police Department
4. Wisconsin State Patrol

Each set of subjects had one subject with a low level of VASCAR experience (< 1.5 years) and one subject with a high level of VASCAR experience ($\geq$ 7 years). All of the subjects were VASCAR certified, meaning they have passed their departments requirements for operating VASCAR. Selected subject characteristics and individual subject percentage use and typical course distances for each VASCAR method are in Appendix H.

The subjects that participated in each speed measurement study are shown in Table 4.1. All of the subjects did not participate in each of the studies primarily due to weather conditions and due to changes in testing conditions. Weather conditions only affected the studies that required a bridge shadow. When the sun was not shining, the simulated bridge shadow testing could not be performed. There was a wide range of weather conditions for the other studies. The weather conditions included sun, clouds, rain, and snow flurries.

TABLE 4.1 -- Subjects that Participated in Each Study

Study	Subjects that Participated
Moving	1 - 8
Night Moving	3 - 8
Bridge	1 - 6
Parking	3 - 6
Angular	3 - 8
Align	7 & 8

5.0 EXPERIMENTAL RESULTS

Several statistical terms are used to present the results. The following definitions will aid in understanding the results:

Mean - the average; the arithmetic sum of all values being considered, divided by the total number of values in the data set.

Variance - is a measure of the variability of the data set; a formula for the variance is given in Appendix E.

Standard Deviation - the square root of the variance; it is also a measure of the variability of the data set.

Type I Error - falsely concluding that something is an effect (the alternative hypothesis) when it is not.

p - the probability of committing a Type I error; $p \leq 0.05$ is used to determine if a variable is a statistically significant effect; $0.05 < p \leq 1.0$ is used as a range for nearly significant effects.

Two Sided Upper 90th Percentile Tolerance Limit with 95 Percent Confidence - 95 percent of the population is less than or equal to this limit with 95 percent confidence.

Two Sided Lower 90th Percentile Tolerance Limit with 95 Percent Confidence - 95 percent of the populations is greater than or equal to this limit with 95 percent confidence.

The upper 90th percentile tolerance limit with 95 percent confidence (upper 90th percentile tolerance limit) is used when assessing speed measurement errors. Ninety-five percent of the speed errors will be less than or equal to this limit. The upper 90th percentile tolerance limit is used because it represents the speed error that overestimates the true speed (biased against the violator). The lower 90th percentile tolerance limit represents the error that underestimates the true speed (biased for the violator).

The lower 90th percentile tolerance limit is used when assessing time measurement errors. This limit is used because it results in the largest speed errors. The VASCAR timing device produces negative timing errors. Negative timing errors produce estimates of vehicle speed that are higher than the true speed. The largest negative timing errors (lower 90th percentile) produce the largest speed errors that are biased against the violator. Figures 5.1.a and 5.1.b show respectively the locations of the upper and lower 90th percentile tolerance limits for a normal distribution. The shaded region in these figures represents 95 percent of the population.

To calculate a tolerance limit, two conditions must be met.

1. All assignable causes of variability must be detected and eliminated so the remaining variability may be considered random.

2. Certain assumptions must be made concerning the nature of the statistical population under study - for this study a normal distribution is assumed.

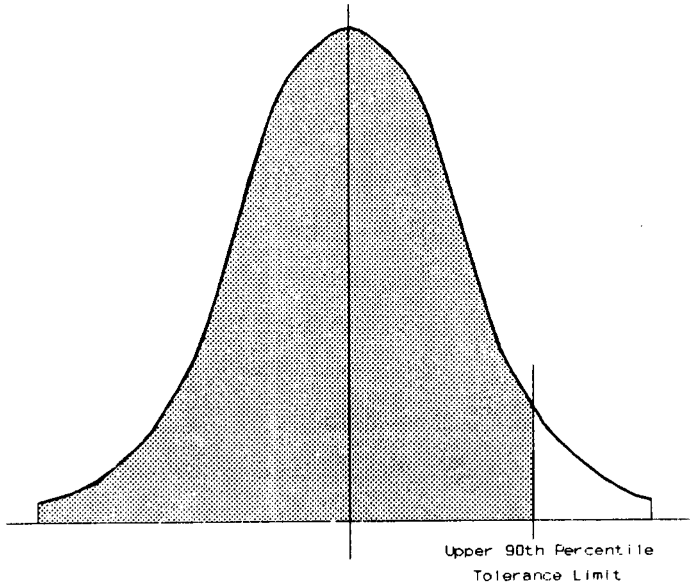


Figure 5.1.a - Upper 90th Percentile Tolerance Limit

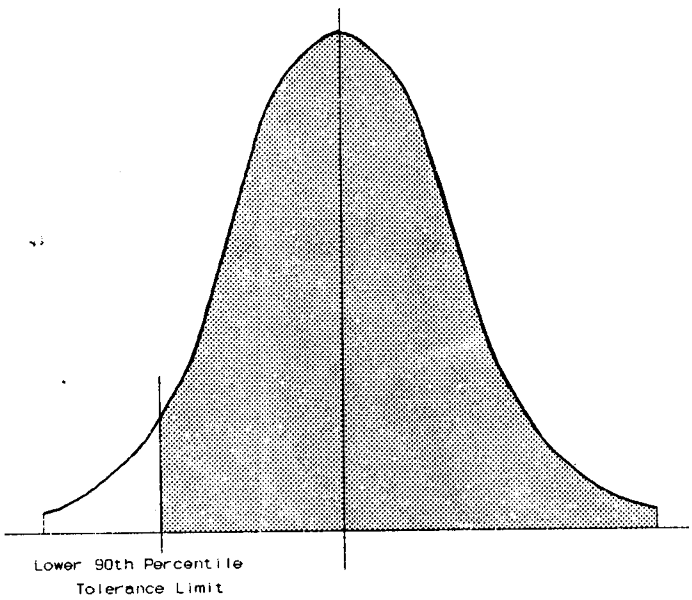


Figure 5.1.b - Lower 90th Percentile Tolerance Limit

Definitions for other statistical terms are in Appendix I. All of the raw data and statistical results are also in Appendix I. For more thorough statistical definitions, see [1]

In this analysis the variable p is used to determine statistical significance. Also, a .5 mph difference in the upper 90th percentile tolerance limit is used to determine practical significance.

A second statistical analysis can be found in Appendix J. This analysis considers the lack of complete randomization for the experiment.

5.1 Experimental Results of VASCAR Time and Distance Measurements

VASCAR Timing

The first series of bench tests was performed to verify that the VASCAR stored time can be retrieved from the displayed time. The stored time was calculated as described in Section 4.1. A comparison of VASCAR displayed speed, speed calculated using VASCAR displayed time, and speed calculated using VASCAR stored time is shown in Table 5.1

TABLE 5.1 -- Comparison VASCAR Displayed Speed and Speed Calculated Using VASCAR Displayed and Stored Times

			Speed Calculated Using	
Displayed Time (sec)	Stored Time (sec)	Displayed Speed (mph)	Displayed Time (mph)	Stored Time (mph)
3.34	3.348	268.8	269.46	268.82
3.31	3.312	271.7	271.90	271.73
3.70	3.708	242.7	243.24	242.72
4.82	4.824	186.5	186.72	186.57
3.16	3.168	284.0	284.81	284.09
3.45	3.456	260.4	260.87	260.41
3.78	3.78	238.0	238.09	238.09
3.09	3.096	290.6	291.26	290.69
4.64	4.644	193.7	193.96	193.79
3.81	3.816	235.8	236.22	235.84
4.42	4.428	203.2	203.62	203.25

1 Ostle, B., "Statistics in Research," 2nd Edition, The Iowa State University Press, 1963.

As seen in Table 5.1, the speed calculated using the stored time agreed with the VASCAR displayed speed, while the speed using the displayed time did not. This suggests that the function given in Section 4.1 to calculate the stored time is correct. Since this is the case, the stored time was used to determine the VASCAR timing errors.

A second series of bench tests was performed to determine VASCAR timing errors. Two VASCAR units were tested. The mean and variance for timing errors for each unit were found to be the same. The mean and the lower 90th percentile tolerance limit for timing error are listed in Table 5.2. Using the value for the lower 90th percentile tolerance limit for timing error, percent speed errors for different speeds and course distances were calculated and are plotted in Figure 5.2. These speed errors were due only to potential VASCAR timing errors. No distance measurement error or human error is included for the errors in Figure 5.2. From section 3.3, the mean value for preferred course distance was .3 mile. The potential percent speed errors due to the timing mechanism for this course distance are below .5 %.

TABLE 5.2 -- VASCAR Timing Errors

Descriptive Statistic	Time Error (sec)
Mean	-.0223
Lower 90th Percentile	-.0422

VASCAR Distance

The following variables were studied to see if they had an effect on VASCAR distance measurements:

Course Distance
Subject

Course distance was the only variable found to be significant. The upper 90th percentile tolerance limits for distance errors are plotted in Figure 5.3. The results presented Figure 5.3 show that the tolerance limits for distance

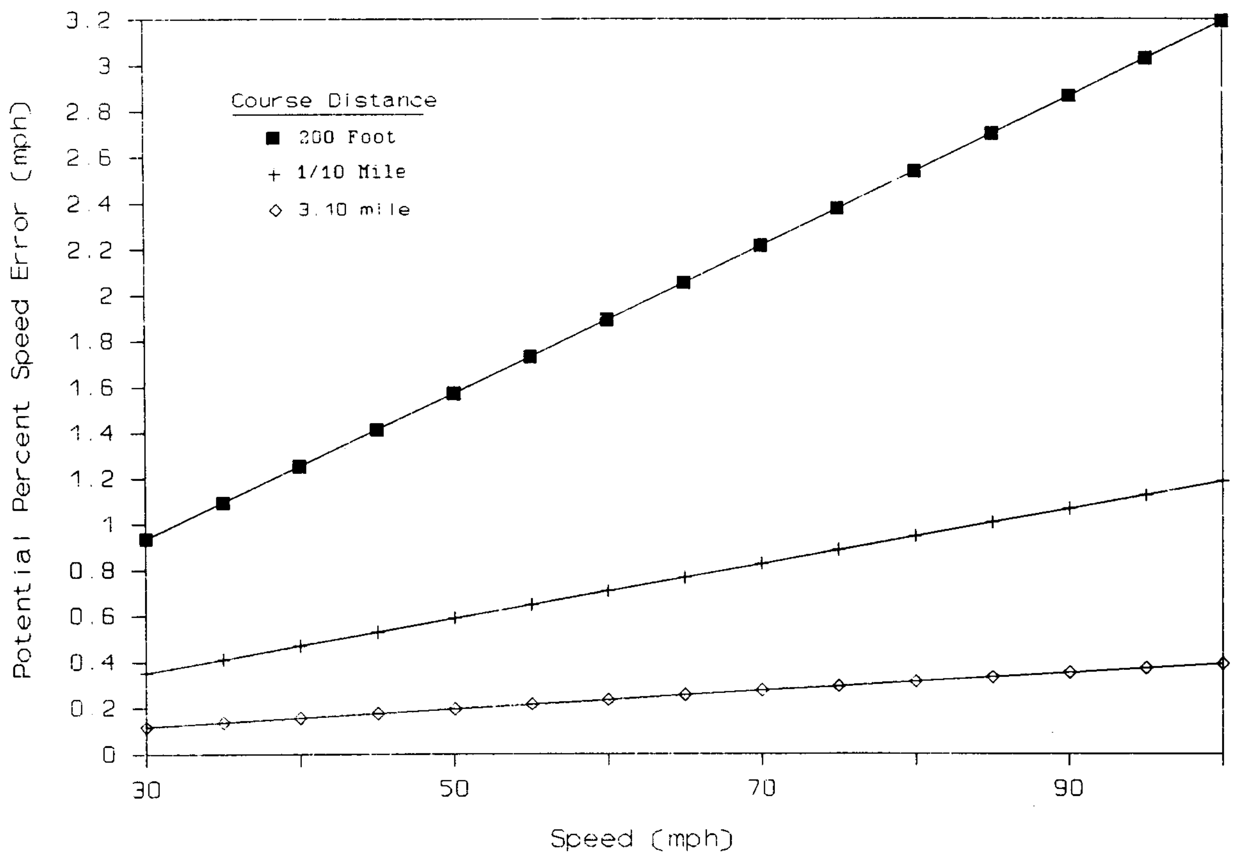


Figure 5.2 - Potential Percent Speed Errors due to the Lower 90th Percentile Timing Errors for the VASCAR Timing Mechanism

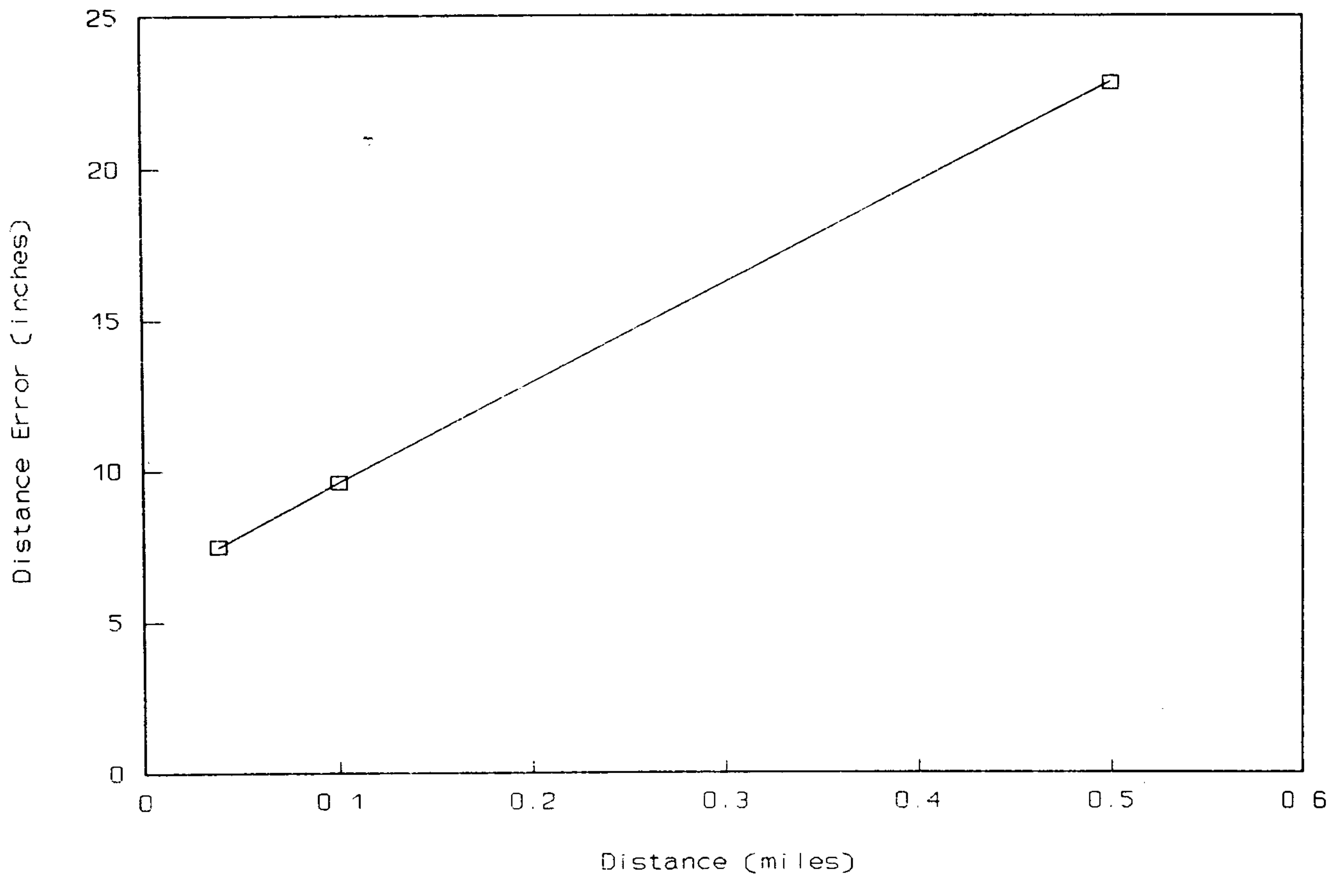


Figure 5.3 - Upper 90th Percentile Tolerance Limits for Distance Error

error tended to increase as distance increased. The upper 90th percentile tolerance limit for percent distance error is plotted in Figure 5.4. The results presented in this figure show that the tolerance limit for percent distance error tended to decrease as distance increased. The tolerance limits presented in these figures show that VASCAR does not have a distance measurement accuracy of 6.3 inches in one mile, as stated by the manufacturer, but the distance measurement error is well below .5 percent.

5.2 Experimental Results of VASCAR Speed Measurements

Moving Study

The following variables were investigated in the moving study to see if they had a significant effect on the moving clocks:

Group - Subjects grouped by nominal speed presentation ranges (± 2 or ± 7 mph)
Course Distance
Nominal Speed
VASCAR Method
Subject Number
Replications

Eight subjects participated in this study. Each subject replicated the different test conditions four times. This resulted in a total of 384 trials.

An analysis of variance indicated the following variables and interactions between variables were statistically significant ($p \leq 0.05$):

Course Distance
VASCAR Method
Subject Number
Interaction ~~of~~ Course Distance with VASCAR Method
Interaction of Nominal Speed with VASCAR Method
Interaction of Course Distance with Nominal Speed with VASCAR Method

The fact that subject effects were significant in the moving study is not that surprising. This illustrates the variability between subjects often observed in human factors experiments.

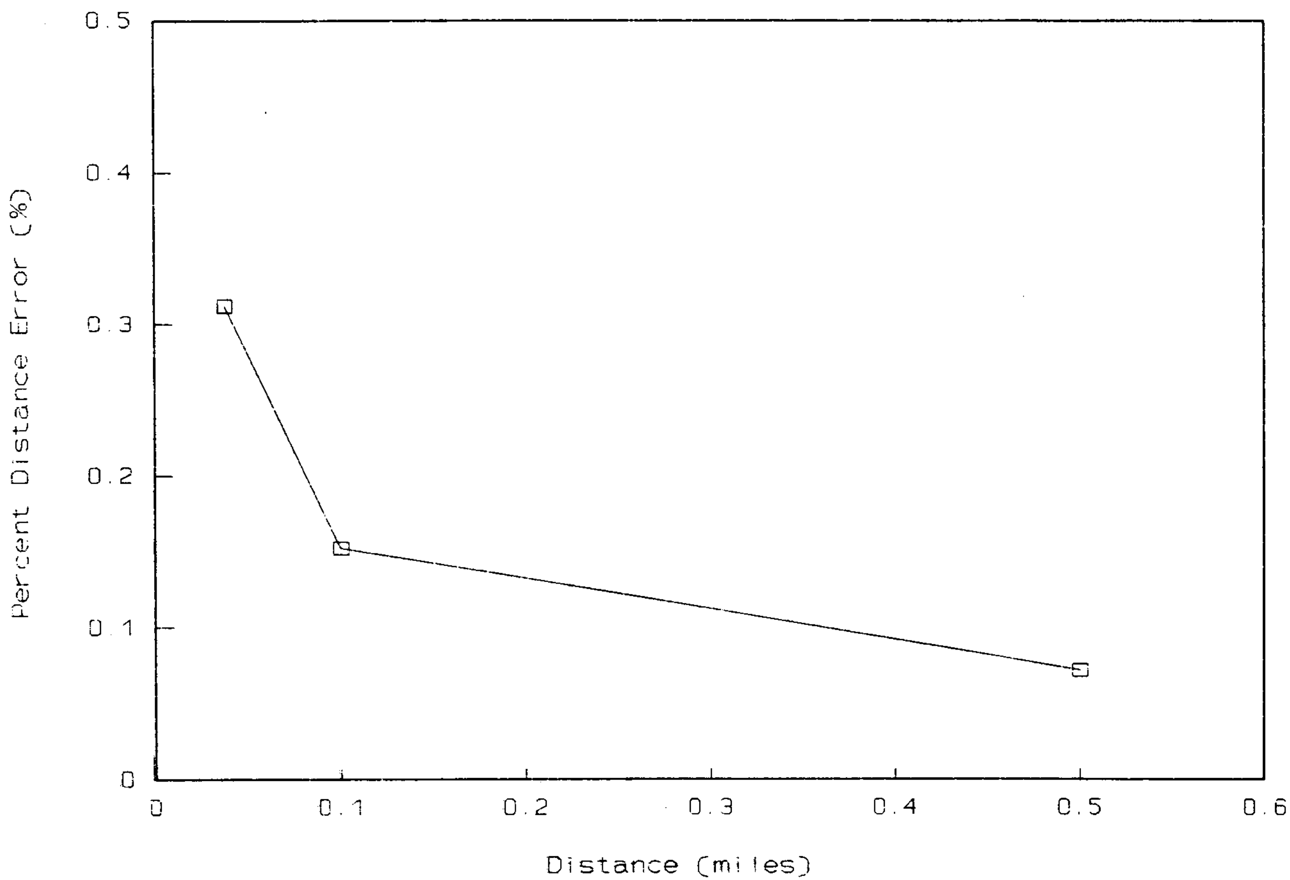


Figure 5.4 - Upper 90th Percentile Tolerance Limits for Percent Distance Error

A components of variance analysis was performed for this study. The results are presented in Figure 5.5. The differences in subjects accounted for only 3 percent of the variance. There was no replication effect observed. This suggests that little learning or fatigue occurred during the study.

Group (speed range presentation) was not a statistically significant effect. The mean and standard deviation for speed error for each group are presented in Table 5.3.

TABLE 5.3 -- Mean and Standard Deviation for Speed Error for (mph) the Moving Study - Grouped by Nominal Speed Range

Speed Range	Subject Numbers	Speed Error	
		Mean	Std. Dev.
± 2	1 - 4	.090	.866
± 7	5 - 8	.034	.880

Since VASCAR method and several interactions involving VASCAR method were statistically significant, another analysis was performed on the data after it was separated by VASCAR method. For Following clocks, the following variables and interactions between variables were found to be statistically significant ($p \leq 0.05$):

Subject Number
Course Distance
Nominal Speed
Interaction of Course Distance with Nominal Speed

The only statistically significant variable for Approaching from the Rear clocks was:

Nominal Speed

Upper 90th percentile tolerance limits for speed error were calculated for each combination of VASCAR method, course distance, and nominal speed. These values are graphically presented in Figure 5.6. These values and values for the mean, variance, mean square error, and observed 95th and 99th percentile speed errors are tabulated in Appendix I.

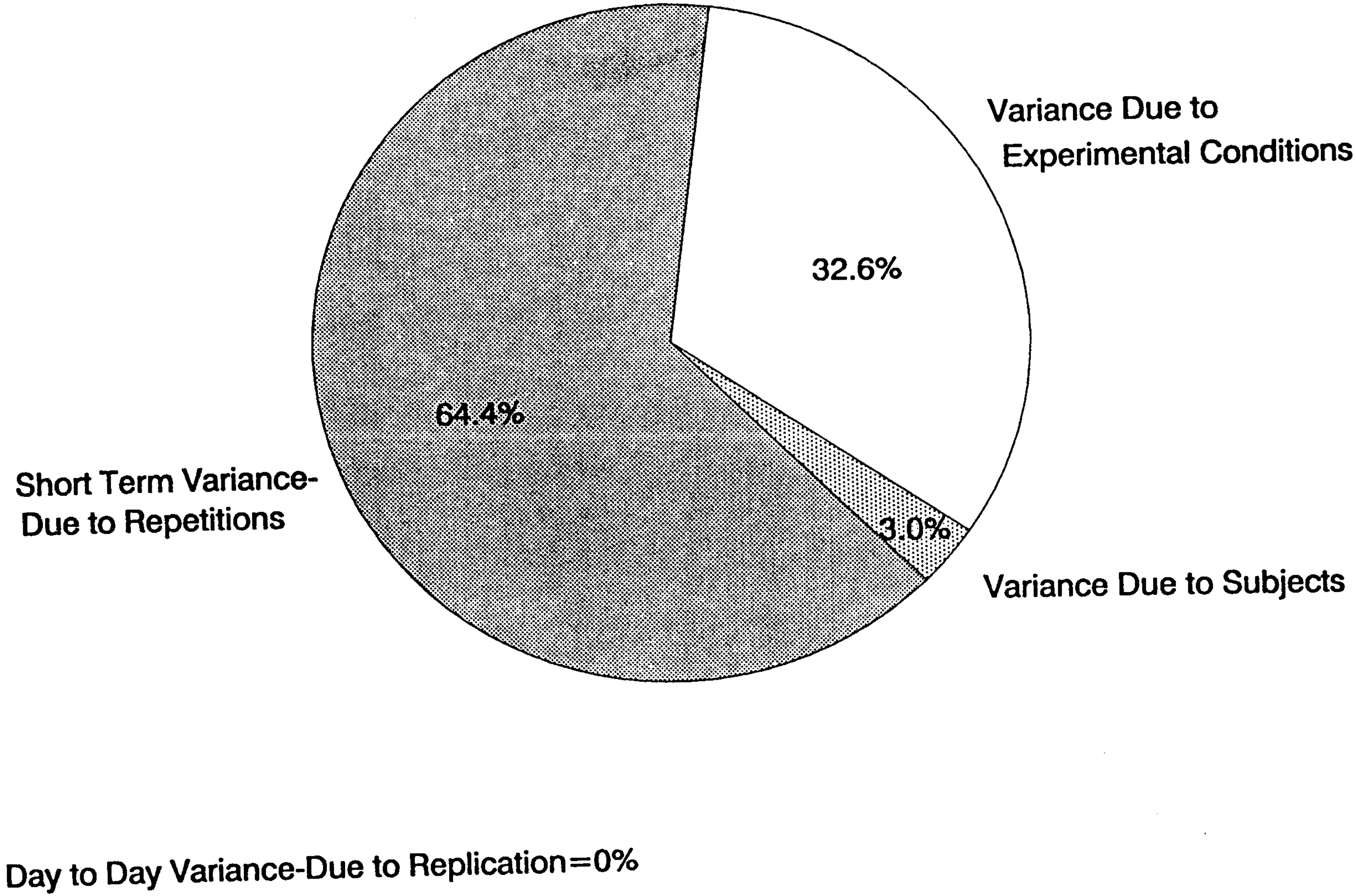


Figure 5.5 - Components of Variance for the Moving Study

From Figure 5.6, the upper 90th percentile tolerance limits increased as the speed increased and decreased as course distance increased. The tolerance limits for the Following method were slightly lower than those for the Approaching from the Rear method at 45 and 60 mph (.126 to .319 mph lower), but were slightly higher at 80 mph (.205 to .351 mph higher). Since the tolerance limits for Following and Approaching from the Rear are within .5 mph of each other, there was no practical difference between the two VASCAR methods.

The speed error for each clock in this study is plotted as function of the clock duration in Figure 5.7. In Figure 5.7, all the clocks that were greater than 5 seconds in duration had less than a + 2 mph speed error. This figure clearly shows that speed errors decrease as the time in the course increases.

The subjects were asked to indicate the realism of each aspect of the study on scale from 1 to 5, 1 being not at all realistic and 5 being very realistic. The range of values and mean values are presented in Table 5.4. On average, the officers felt the .3 mile long clocks were more realistic than the .1 mile clocks.

TABLE 5.4 -- Range and Mean Values for Subject Rating of Realism for the Moving Study

Conditions	Range	Mean
Following, .1 mile	2 - 5	3.25
Following, .3 mile	3.5 - 5	4.56
Approach from Rear, .1 mile	2 - 5	3.88
Approach from Rear, .3 mile	3 - 5	4.50

When asked what parts of the study were not realistic, one subject stated that the Approaching from the Rear clocks were less difficult than the Following clocks because it was easier to anticipate the target vehicle crossing the reflector plate when it was Approaching from the Rear. Referring to Figure 4.1, the subject following the target vehicle (S_1) had to react to the plate coming underneath the target vehicle. The subject in front of the target vehicle (S_2) could maintain visual contact with the reflector plate until the target vehicle passed it. This subject thought the Approaching from the Rear clock was more of an anticipation to the target vehicle crossing the reflector plate, and the

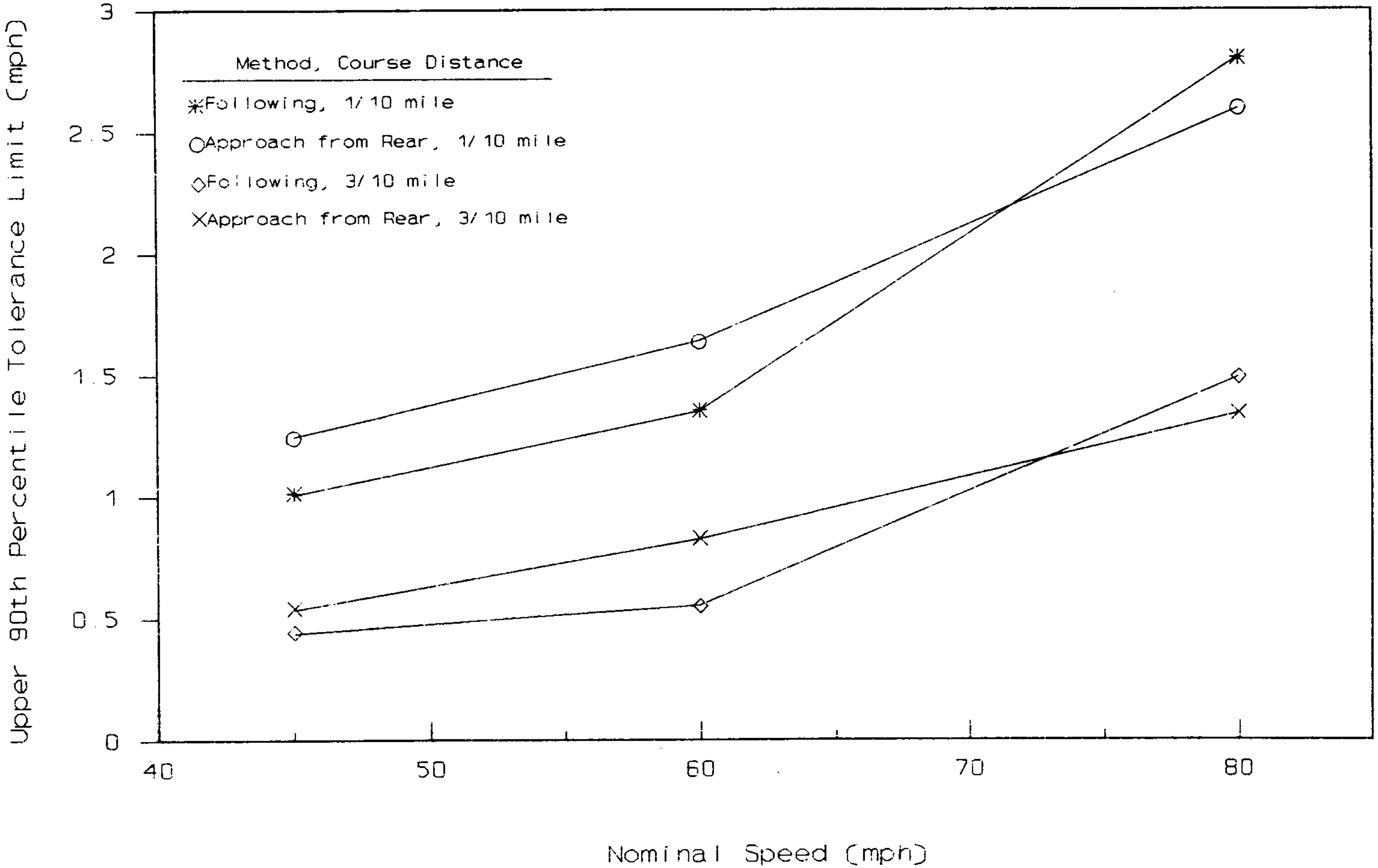


Figure 5.6 - Upper 90th Percentile Tolerance Limits for Speed Error-The Moving Study

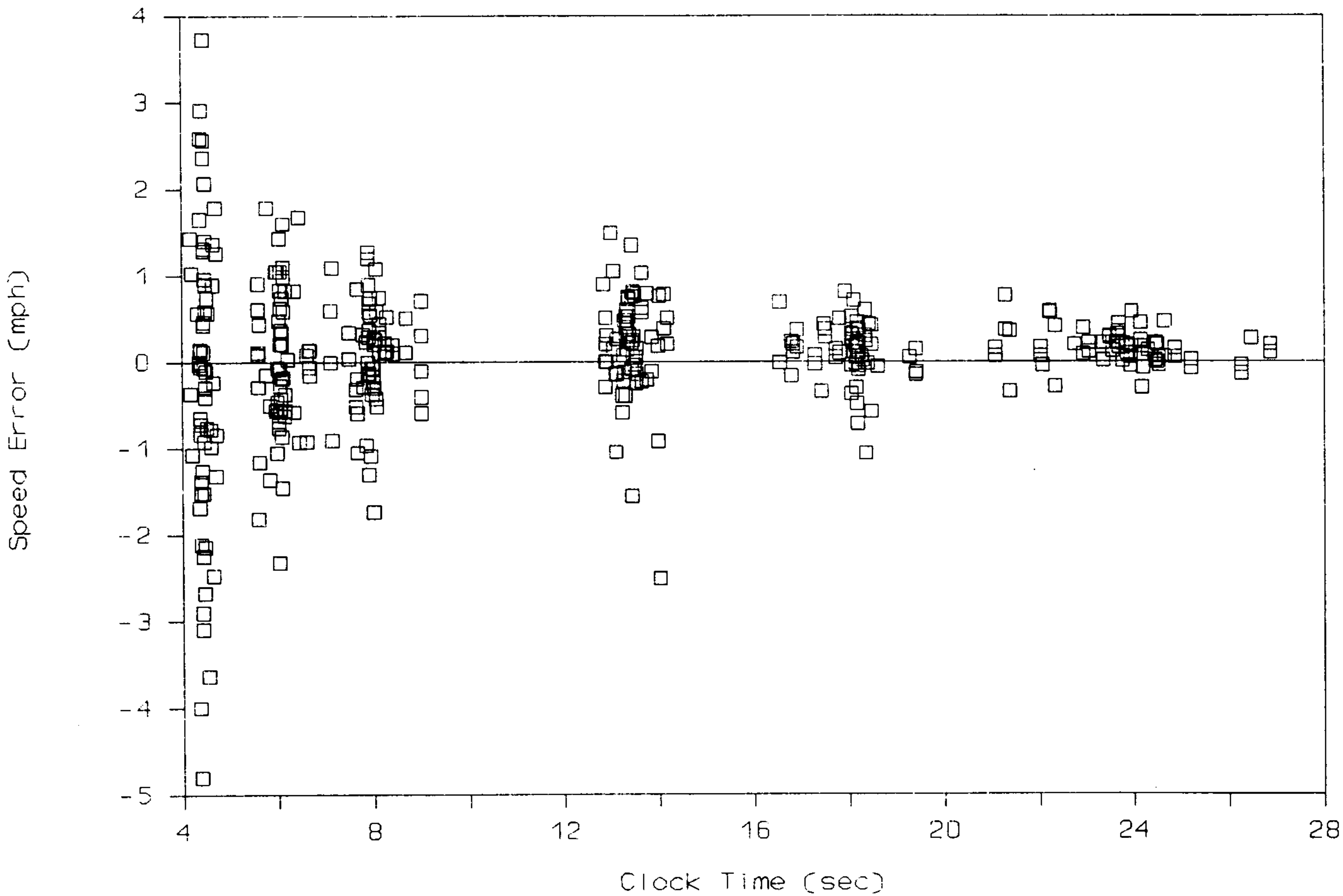


Figure 5.7 - Speed Error as a Function of Clock Duration for the Moving Study

Following clock was more of a reaction to the reflector plate appearing from underneath the target vehicle. At 80 mph, the subjects had less time available to detect the reflector plate and to estimate when the time switch should be turned on and off. This may explain why the upper 90th percentile tolerance limits at 80 mph were lower for the Approaching from the Rear method than those for the Following method.

When asked how they would re-design the study, several officers stated they would improve the reference markers. Instead of using the reflector plate, they would have preferred a line going all the way across the lane of traffic. They thought this would be more realistic and would produce an anticipation of the target vehicle crossing the reference marker instead of a reaction to the reference marker appearing from underneath the car. In the real world, reference markers like tar marks, pavement changes, and expansion joints do run all the way across the road.

Based on their own intuition, the subjects were asked to rank the different types of clocks from the most accurate to the least accurate. All of the subjects felt the .3 mile clocks would be more accurate than the .1 mile clocks. Seven of the eight subjects felt the Following clocks would be more accurate than the Approaching from the Rear clocks. A complete list of the subjects' ratings is in Appendix G.

Night Moving Study

As with the moving study, all of the subjects results were grouped together for the statistical analysis. The following variables were examined in the night moving study:

Subject Number
Nominal Speed
Light Condition - using .3 mile long Following clocks from moving study as a comparison

Six subjects participated in this study. Each subject repeated each test condition twice. This resulted in a total of 36 trials.

The following interaction between variables was found to be statistically significant ($p \leq 0.05$):

Interaction of Light Condition with Nominal Speed

Upper 90th percentile speed errors were calculated for each nominal speed for both day and night time conditions. These values are graphically presented in Figure 5.8. From Figure 5.8, the upper 90th percentile speed error increased as speed increased for both day and night light conditions. The night moving clocks upper 90th percentile speed errors were all less than .35 mph different than the comparable day time clocks. This suggests that there was no practical difference between day and night time Following clocks.

The speed error for each clock in this study is plotted as a function clock duration in Figure 5.9. All of the clocks in this study had errors between $\pm$ 2 mph.

The subjects were asked to judge the realism of the night moving study. All of the subjects that participated said this study was very realistic. They each rated this study as a 5 on a scale 1 to 5. The subjects did not suggest any improvements for this study.

Bridge Study - Moving Portion

The following variables were investigated in the moving portion of the bridge study:

Subject Number
Nominal Speed
Gap Distance

Six subjects participated in this study. Four subjects either repeated or replicated each test condition twice, while the other two replicated each test condition three times. This resulted in a total of 56 trials.

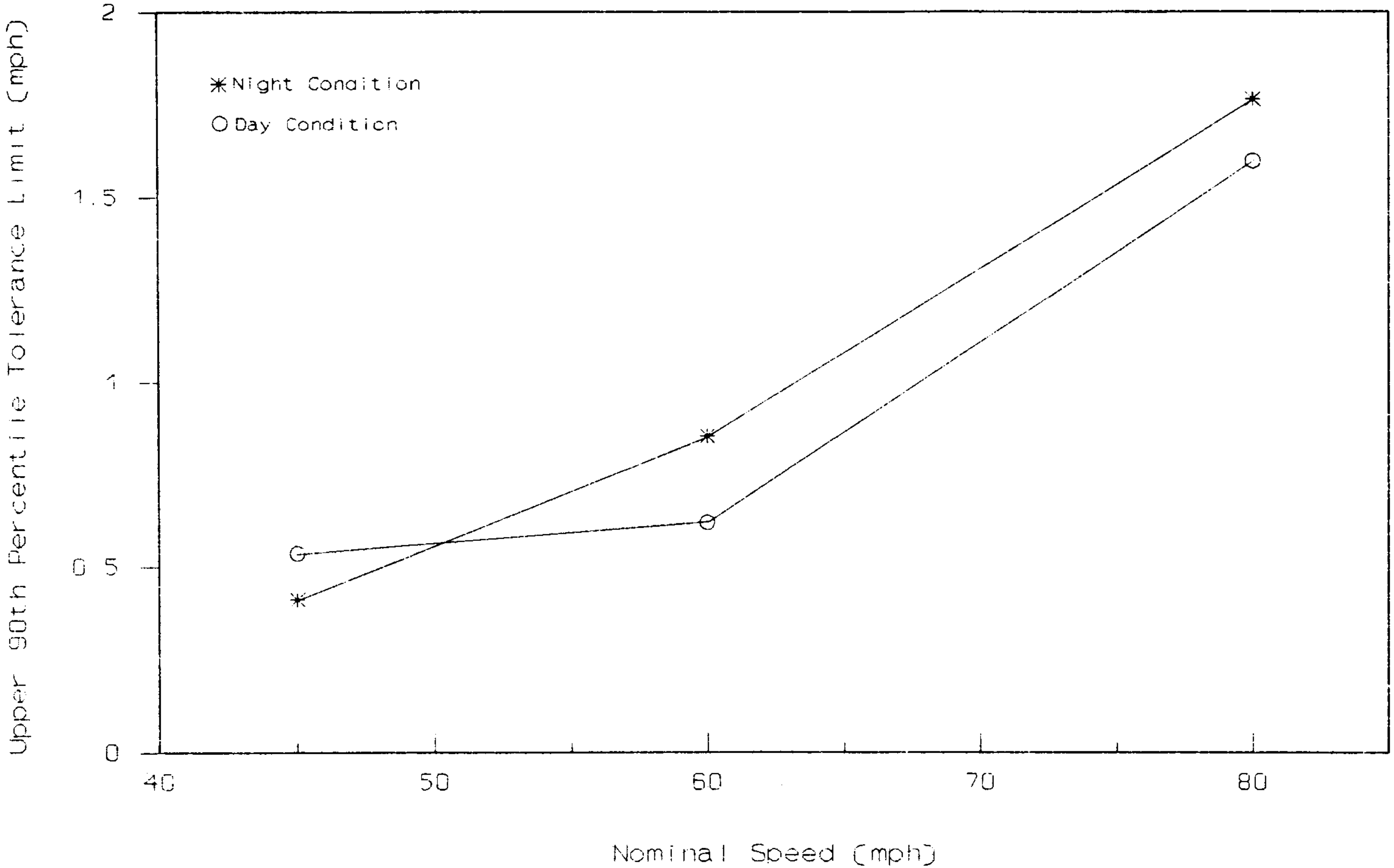


Figure 5.8 - Upper 90th Percentile Tolerance Limits for Speed Error - Day and Night Time Following Clocks

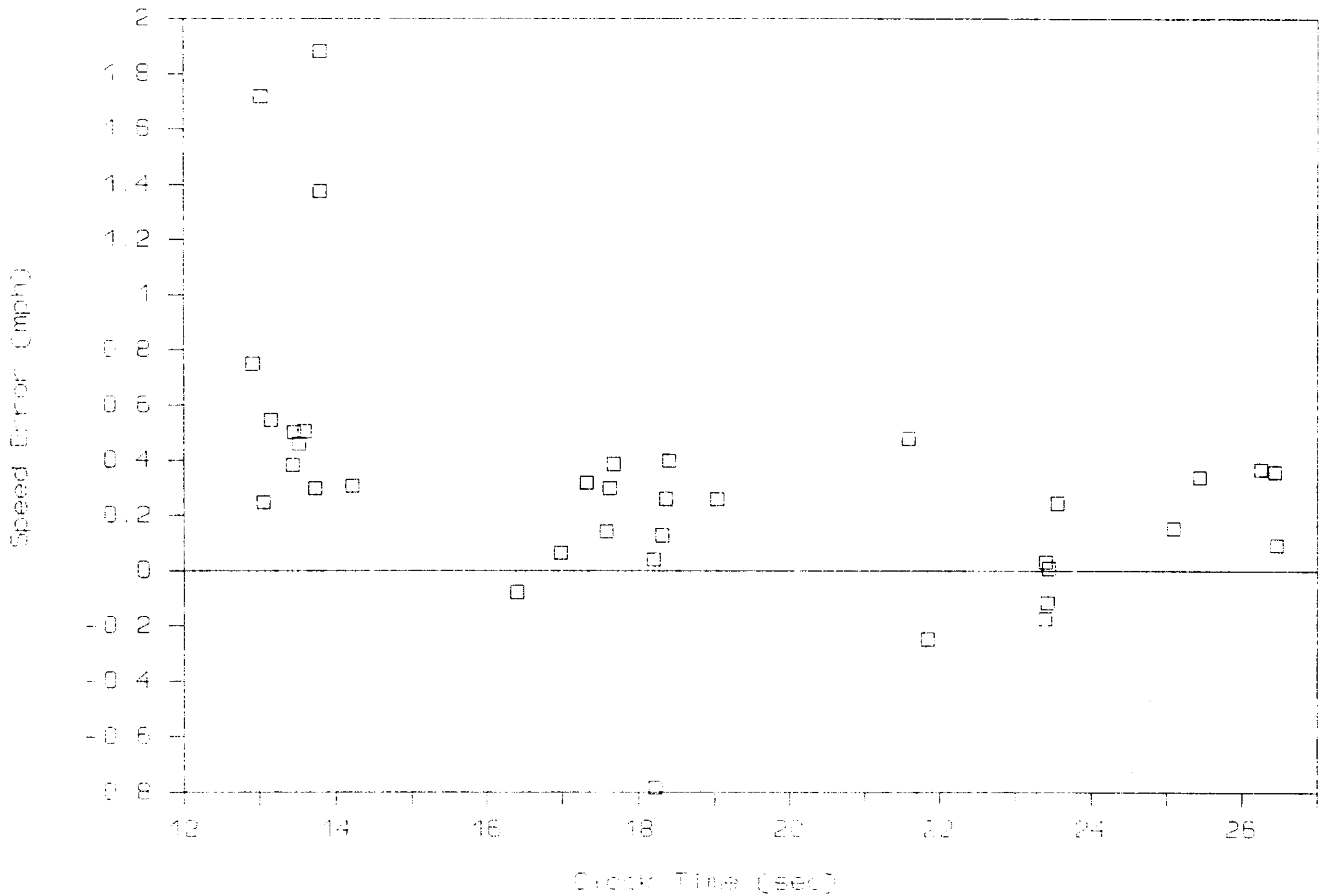


Figure 5.9 - Speed Error as a Function of Clock Duration for Moving Night Clocks

The following interaction between variables was found to be significant ($p \leq 0.05$):

Interaction of Subject Number with Nominal Speed

The interaction between Subject Number with Nominal Speed was also significant for the Following clocks in the moving study. Gap distance was not a statistically significant variable. This suggests that as long as the subject could see the bridge shadow cross the vehicle, the gap distance between the vehicles did not influence the accuracy of the VASCAR clock.

Speed error is plotted as a function of clock duration in Figure 5.10. All of the clocks in this study had errors between $\pm$ 2 mph.

The subjects' rankings of the realism of this study are in Table 5.5. The first set of rankings are for subjects 1 and 2 while the second set are for subjects 3 - 6. As stated in Chapter 4, subjects 1 and 2 had bridge shadows that were only half as wide as those for subjects 3 - 6. Subjects 3 - 6 ranking of the moving portion of the study was much higher than subjects 1 and 2, which suggests that the double width of bridge shadow significantly increased the realism of the moving portion of the bridge study.

TABLE 5.5 -- Range and Mean Values for Subject Rating of the Realism for the Moving Portion of the Bridge Study

Conditions	Range	Mean
Subject 1 and 2		
Short Gap Distance	1	1.00
Long Gap Distance	1	1.00
Subjects 3 - 6		
Short Gap Distance	2 - 5	4.25
Long Gap Distance	4 - 5	4.75

Most of the subjects comments on the bridge study were concerned with the stationary portion. The only comments concerning the moving portion of the study was the size of the bridge shadow. They felt it should have been longer and wider.

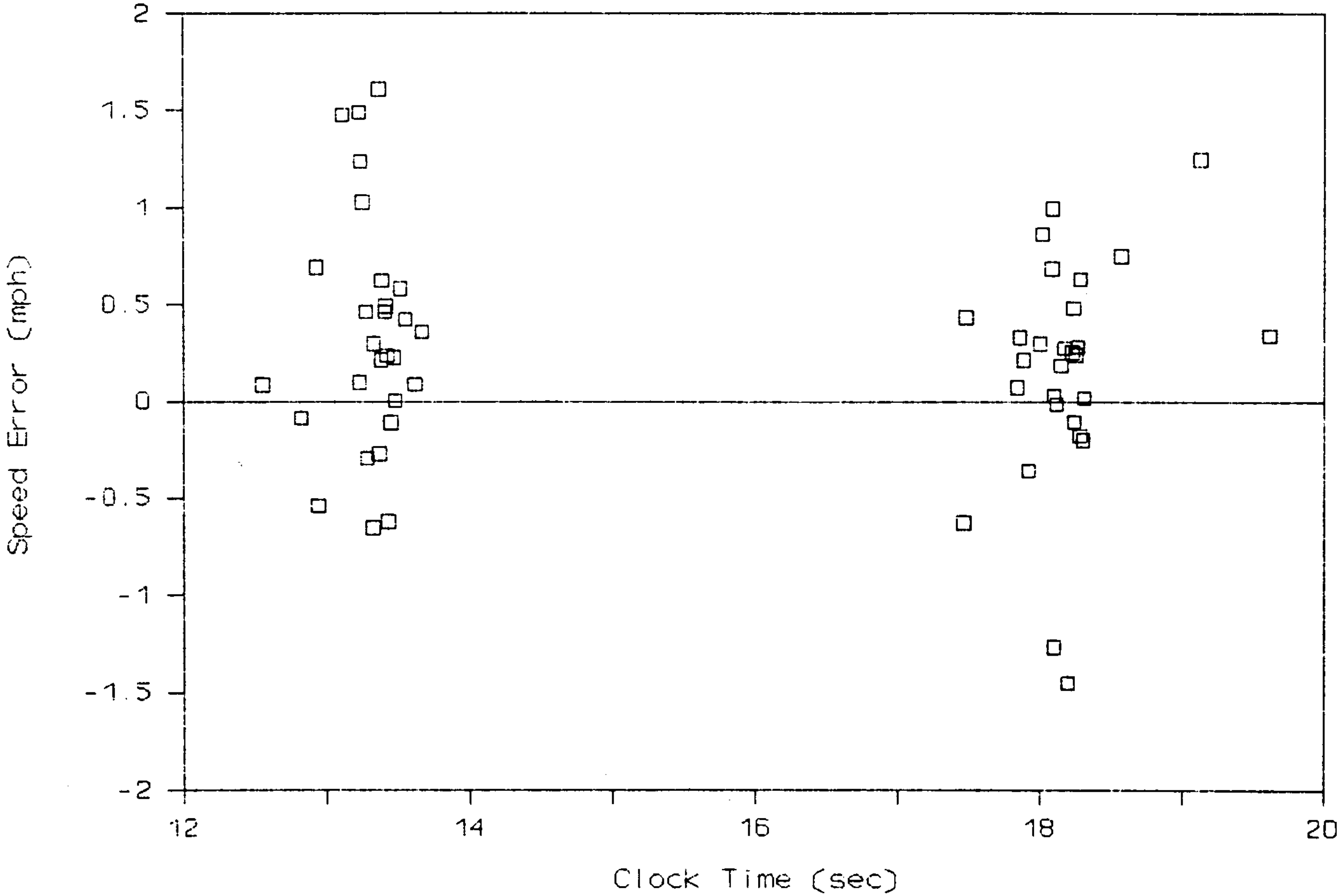


Figure 5.10 - Speed Error as a Function of Clock Duration for the Moving Portion of the Bridge Study

The subjects generally gave similar rankings for the accuracy of these clocks as they gave for the .3 mile following clock of the moving study. Most of the subjects felt there was little difference between the two gap distances. Only one subject (subject 5) did not rank the two gap distances consecutively.

Bridge Study - Stationary Portion

The following variables were examined in the stationary portion of the bridge study:

Subjects
Nominal Speed
Viewing Method - Direct vs. Indirect (mirrors)

The stationary portion of the bridge study had the same number of trials as the moving portion (56 trials).

The following variables and interactions between variables were found to be statistically significant ($p \leq 0.05$):

Subject Number
Nominal Speed
Interaction of Subject Number with Viewing Method
Interaction of Subject Number with Nominal Speed
Interaction of Subject Number with Viewing Method with Nominal Speed

The variable viewing method was not found to be statistically significant, but several interactions between variables with viewing method were. The upper 90th percentile tolerance limit for each combination of viewing method and nominal speed is presented in Figure 5.11. The upper 90th percentile tolerance limits for the indirect vision method were slightly higher than those for the direct vision method (less than .41 mph higher). This suggests that there is no practical difference for the interaction between nominal speed with viewing method.

Speed error is plotted as a function of clock duration in Figure 5.12. There was one outlier in the data that is marked in this figure. This outlier was probably due to a secondary shadow. During certain parts of the day, the test center control tower would cast a shadow across the course of the target vehicle. This shadow occurred before the first bridge shadow (see Figure 5.13). The subjects had trouble distinguishing between the two shadows. They would start their clocks using the shadow from the control tower only to realize they had started early. Most of the time this was caught. The clock marked as an outlier in Figure 5.12 was the only one that was not. This outlier was not used in calculating the tolerance limits, nor was it used to determine what variables were significant.

The subjects' ranking of the realism of this portion of the bridge study are in Table 5.6. As with the moving portion, the first set of rankings is for subjects 1 and 2, while the second set is for subjects 3 - 6.

TABLE 5.6 -- Range and Mean Values for Subject Rating of the Realism for the Stationary Portion of the Bridge Study

Conditions	Range	Mean
Subject 1 and 2		
Direct Vision	1	1.00
Indirect Vision	1	1.00
Subjects 3 - 6		
Direct Vision	2 - 3	2.25
Indirect Vision	2 - 3	2.25

The double width of the bridge shadow did not increase the subjects ranking of the realism of this portion of the study as much as in the moving portion of the study. The subjects had very strong comments concerning this portion of the bridge study. They felt the bridge shadows were much to small. The shadow at the beginning of the course was not visible. They said they were reacting to the shadow crossing the vehicle instead of anticipating the vehicle passing through the shadow. This would explain why most of the clocks had positive speed errors. (see Figure 5.12) Since the subjects were reacting to the first bridge shadow, the time of their clocks were likely less than the true time. This shorter time produced a higher estimated speed.

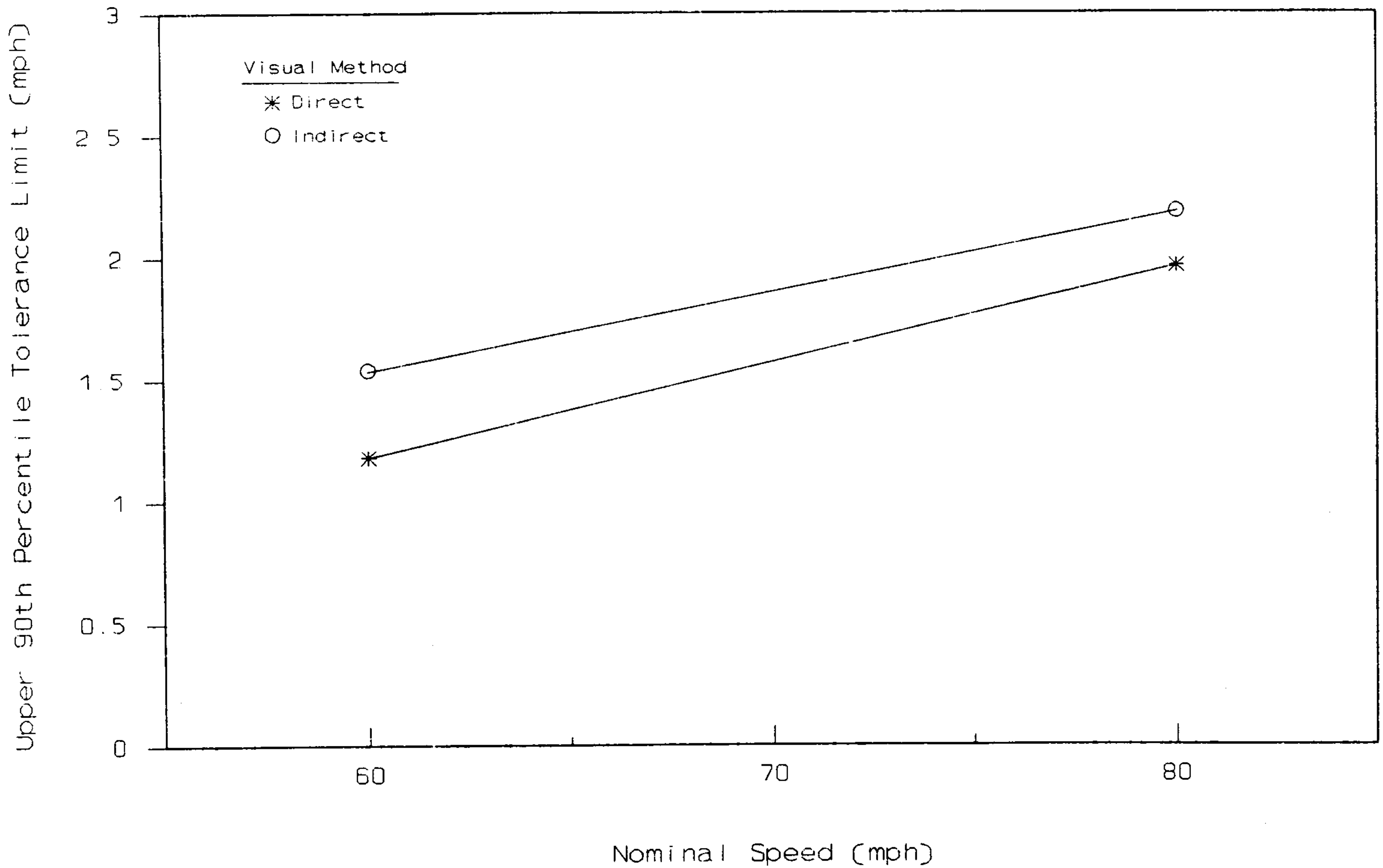


Figure 5.11 - Upper 90th Percentile Tolerance Limits for Speed Error - The Stationary Portion of the Bridge Study

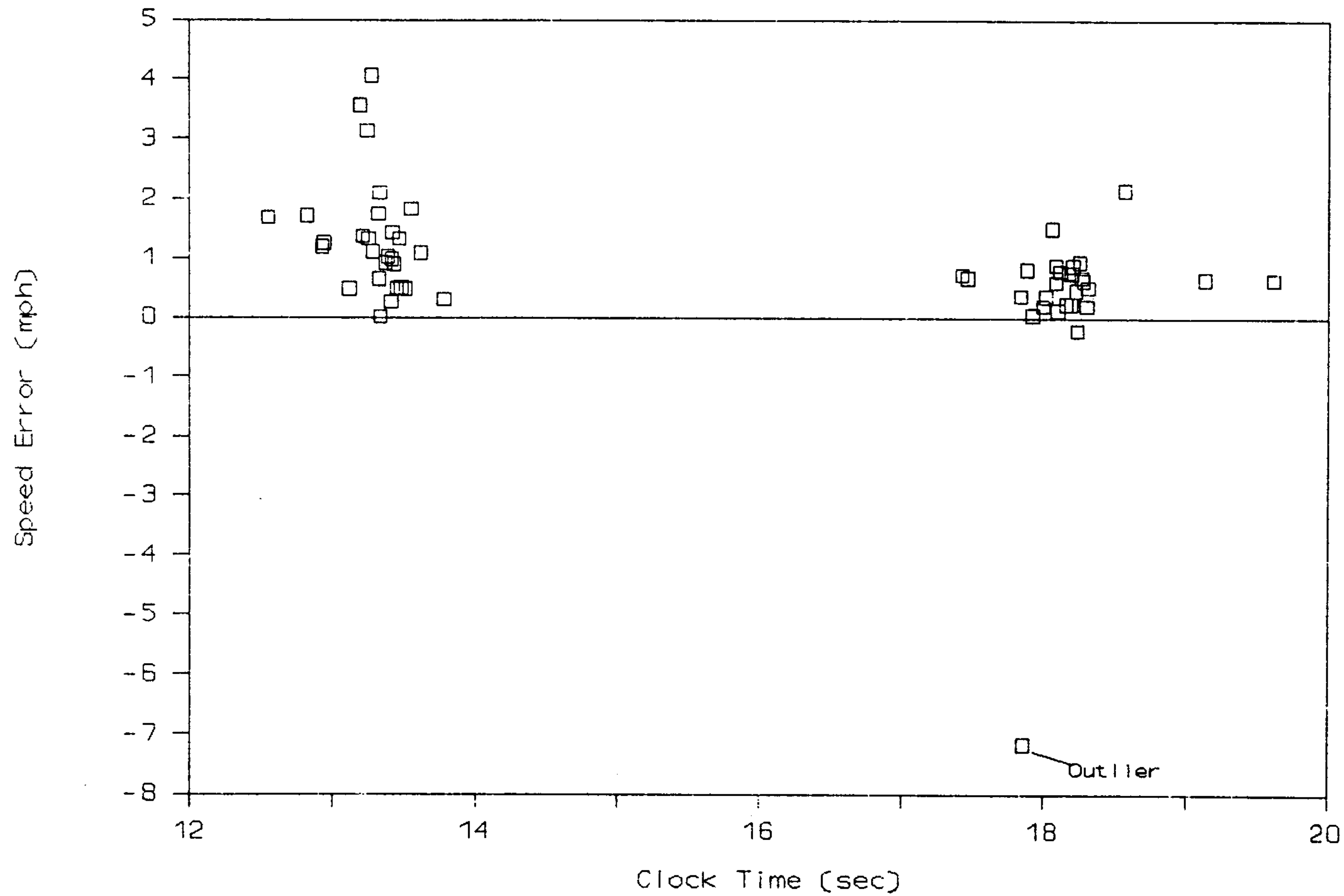


Figure 5.12 - Speed Error as a Function of Clock Duration for the Stationary Portion of the Bridge Study

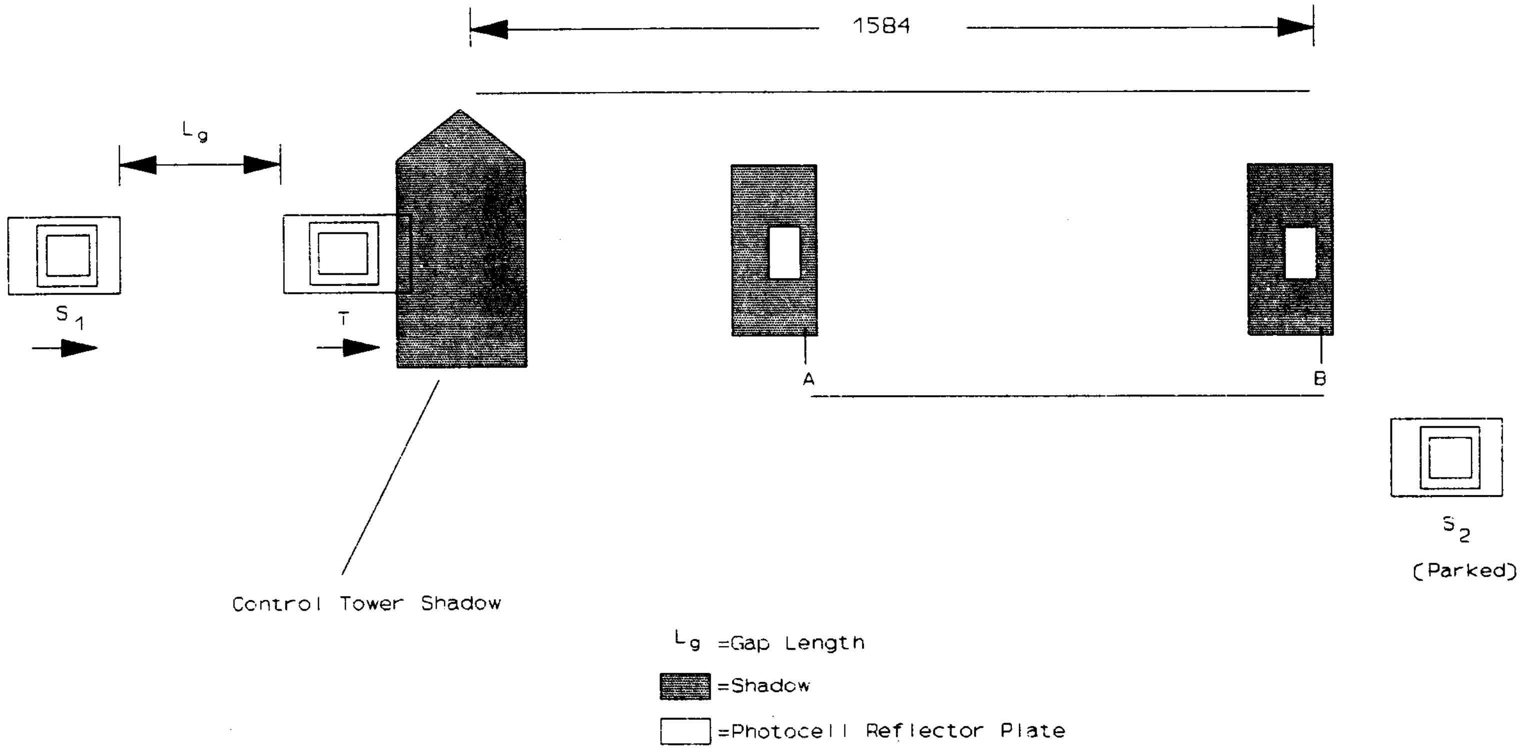


Figure 5.13 - Control Tower Shadow

There were several suggestions for improvement of this study. Widening the shadow, elevating the subject, and using a vehicle in front of the target vehicle were suggested as possible ways to produce a test condition that allows more anticipation instead of reaction.

All of the subjects thought their direct vision clocks were more accurate than the indirect vision clocks, but each subject ranked them consecutively among all the different types of clocks performed in this study. This suggests they did not think there was a large difference in the accuracy of the two methods.

Parking Study

The following variables were studied in the parking study:

Subject Number
Nominal Speed
Course Distance
Replications

Four subjects participated in this study. Each subject replicated the test conditions three times. This resulted in a total of 48 trials.

The only statistically significant variable ($p \leq 0.05$) was:

Subject Number

Only one interaction between variables was found to be nearly significant ($0.05 \leq 1.0$):

Interaction of Course Distance with Nominal Speed ($p = 0.07$)

The upper 90th percentile tolerance limit for each combination of course distance and nominal speed is plotted in Figure 5.14. The upper 90th percentile tolerance limits increased as speed increased and decreased as course length increased. The tolerance limits for the 200 foot course were 1.9 to 2.3 mph higher than those for the 1/10 mile (528 foot) course.

Speed error is plotted as a function of clock duration in Figure 5.15. As seen in this figure, there were very few clocks made in this study. This was

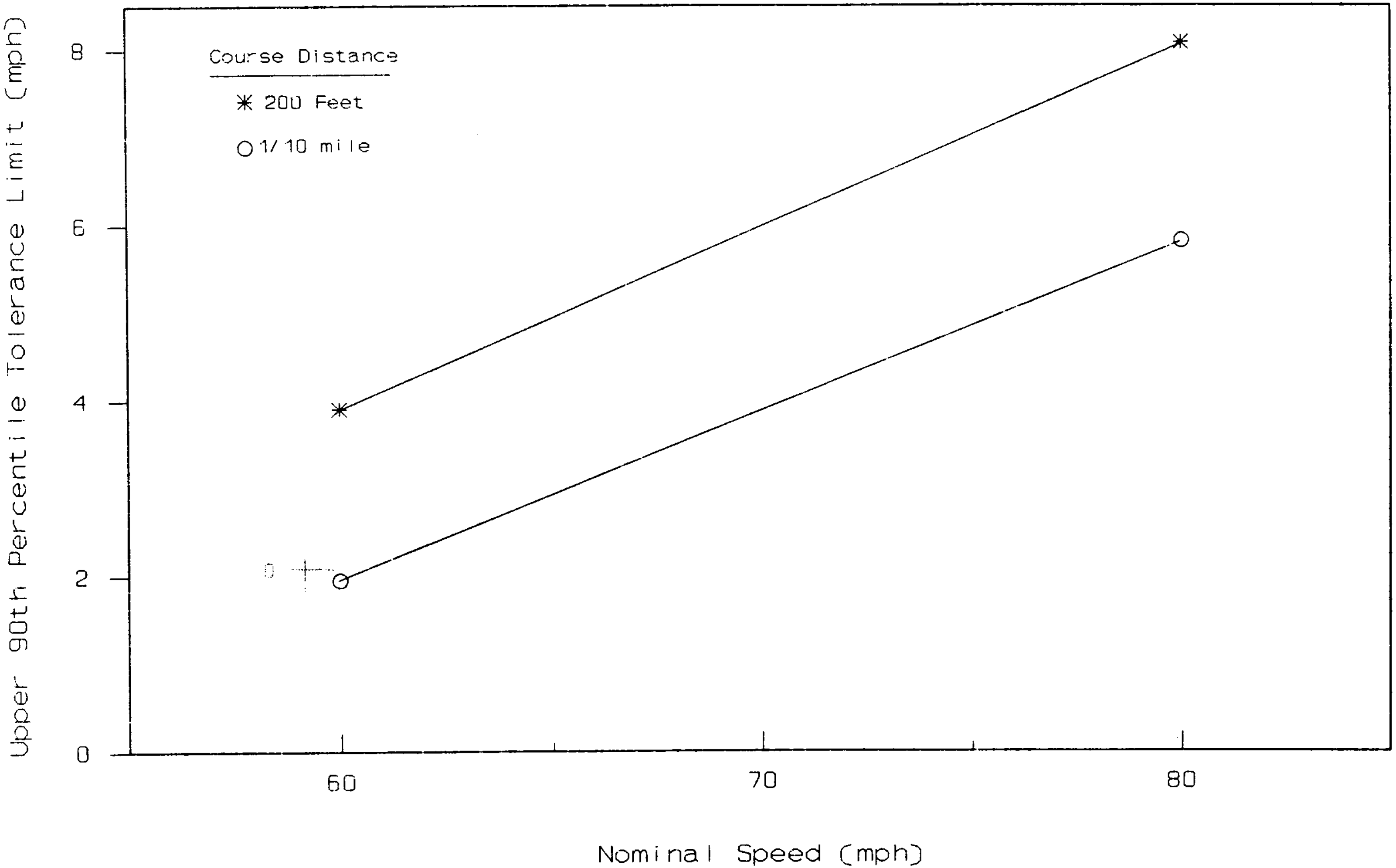


Figure 5.14 - Upper 90th Percentile Tolerance Limits for Speed Error - The Parking Study

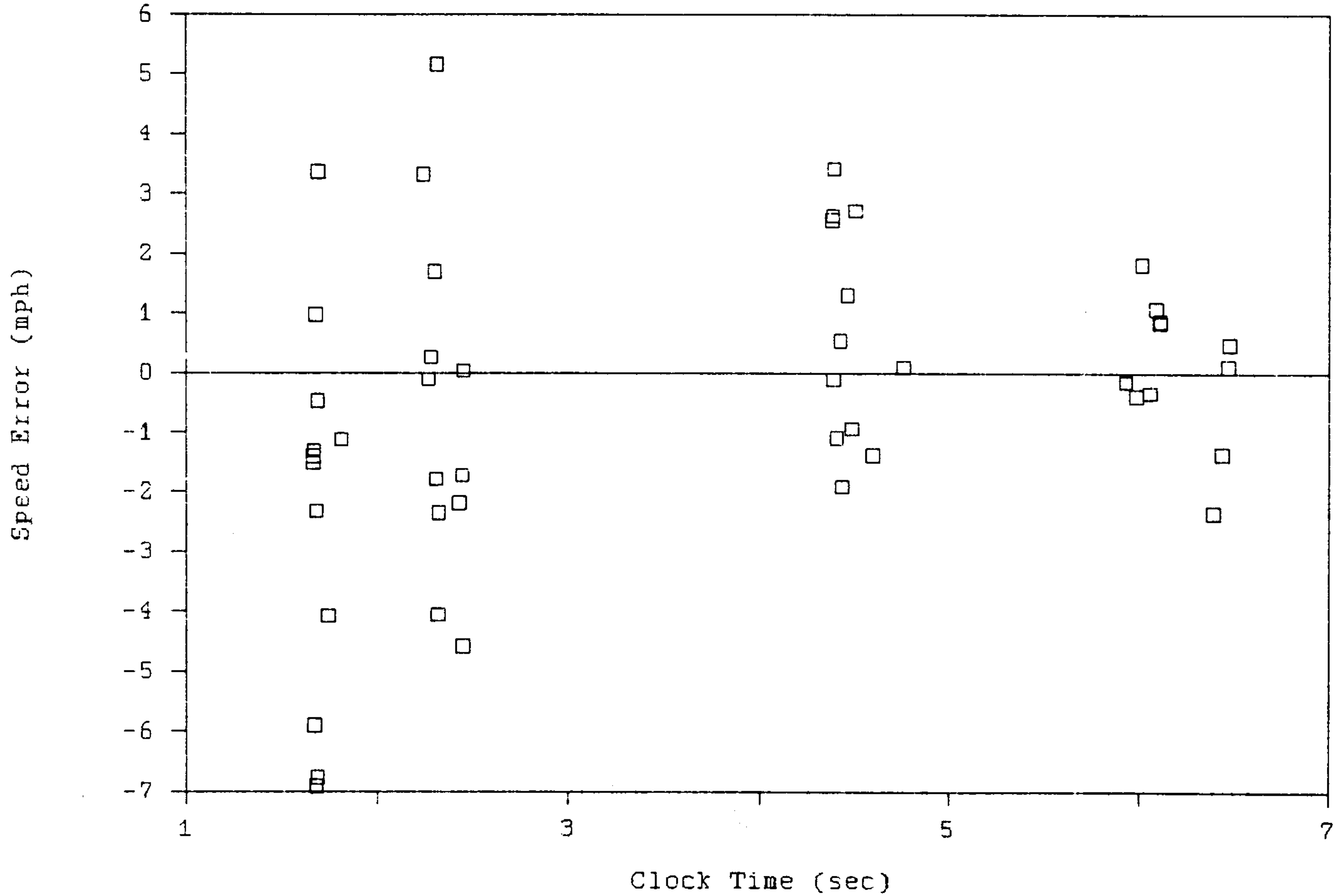


Figure 5.15 - Speed Error as a Function of Clock Duration for the Parking Study

primarily due to weather conditions. Sunny days were required to produce the bridge shadow used as a reference marker in this study. Because of the small number of trials in this study, some caution is advised when interpreting the results.

The subjects' strongest suggestion for improvement of this study was the elimination of the 200 foot clocks. They felt this distance was too short to produce an accurate clock. They also thought a larger bridge shadow would improve the accuracy of the clocks.

The subjects ranked the accuracy of the 200 foot course distance much lower than the 1/10 mile course distance.

Angular Study

The following variables were investigated in the angular study:

Group - Subjects grouped by nominal speed presentation ranges ($\pm$ 2 or $\pm$ 7 mph)
Subject Number
Replication
Viewing Distance
Elevation
Course Distance
Nominal Speed

Six subjects participated in this study. Each subject replicated the different test conditions four times. This resulted in a total of 576 trials.

The following variables and interactions between variables were found to be statistically significant ($p \leq 0.05$):

Subject Number
Viewing Distance
Course Distance
Interaction of Group with Viewing Distance
Interaction of Group with Course Distance
Interaction of Viewing Distance with Course Distance
Interaction of Course Distance with Nominal Speed
Interaction of Group with Viewing Distance with Course Distance

The following interaction between variables was found to be nearly significant ($0.05 \leq p \leq 1.0$):

Interaction of Viewing Distance with Elevation with Course Distance ($p = 0.08$)

A components of variance analysis was performed for this study. The results are presented in Figure 5.16. The differences in subjects accounted for 23 percent of the variance. This number may be artificially high due to the differences between the two nominal speed range groups (these differences are discussed further later in this section). As with the moving study, replication was not an effect. This suggests that neither learning nor fatigue occurred during the study.

Since the alignment of the pole was different for the two course distances (please see Figure 4.5), and because course distance was statistically significant by itself and in combination with other variables, a statistical analysis was performed on each course distance.

For the 528 foot course length, the following variables and interactions between variables were found to be statistically significant ($p \leq 0.05$):

Subject Number
Viewing Distance
Nominal Speed
Interaction of Group with Viewing Distance with Elevation

A components of variance analysis was performed for the 528 foot clocks and is presented in Figure 5.17. For these clocks, replication was not significant.

Although the interaction of group with viewing distance with elevation may be statistically significant, from a practical standpoint these differences were very small. The mean speed error for each combination of elevation and viewing distance for the $\pm$ 2 mph speed range group is plotted in Figure 5.18.a. The same mean speed errors for the $\pm$ 7 mph speed range group are displayed in Figure 5.18.b. There was only a .4 mph range for all of the mean speed errors for each

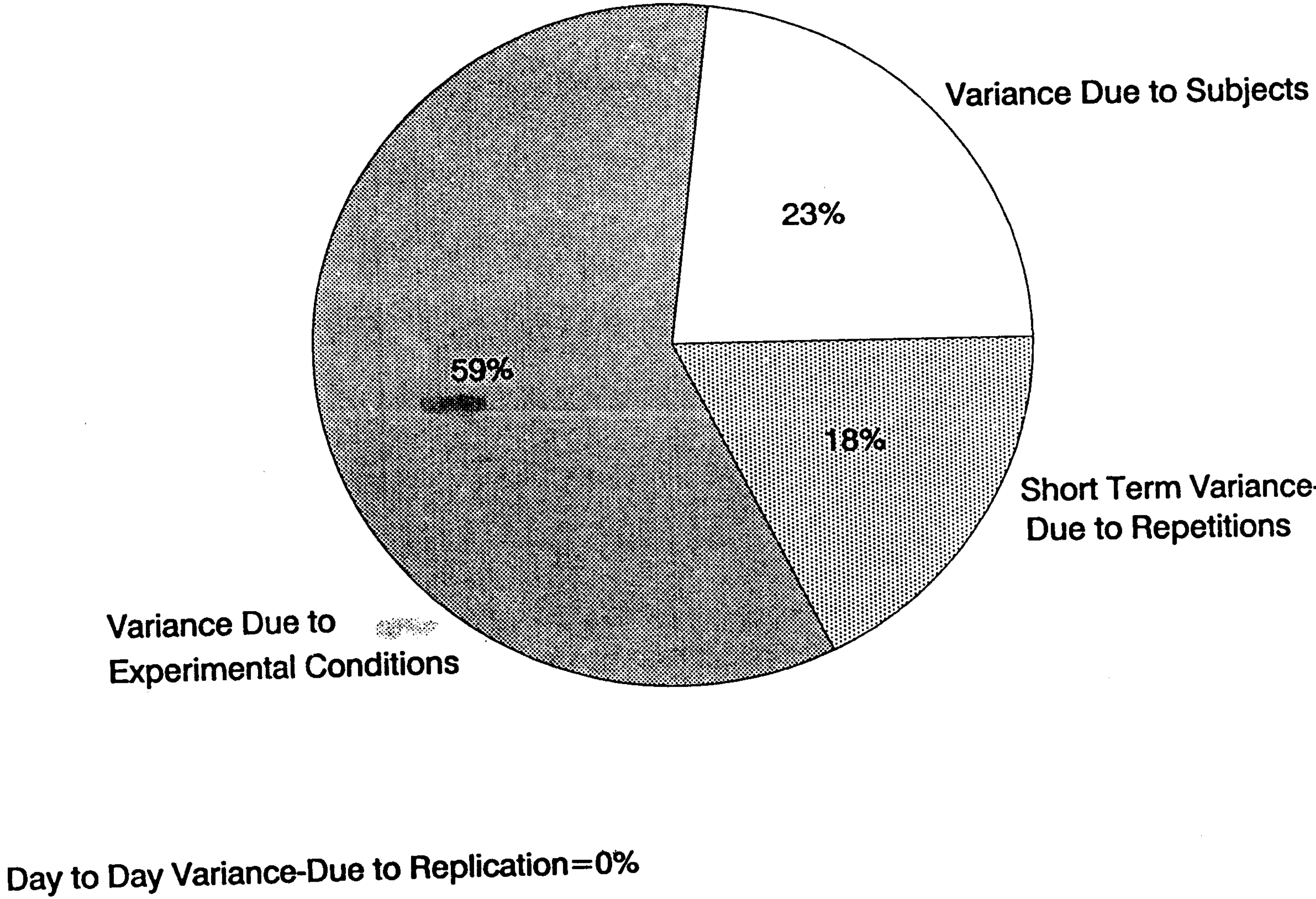


Figure 5.16 - Components of Variance for the Angular Study - Overall Study

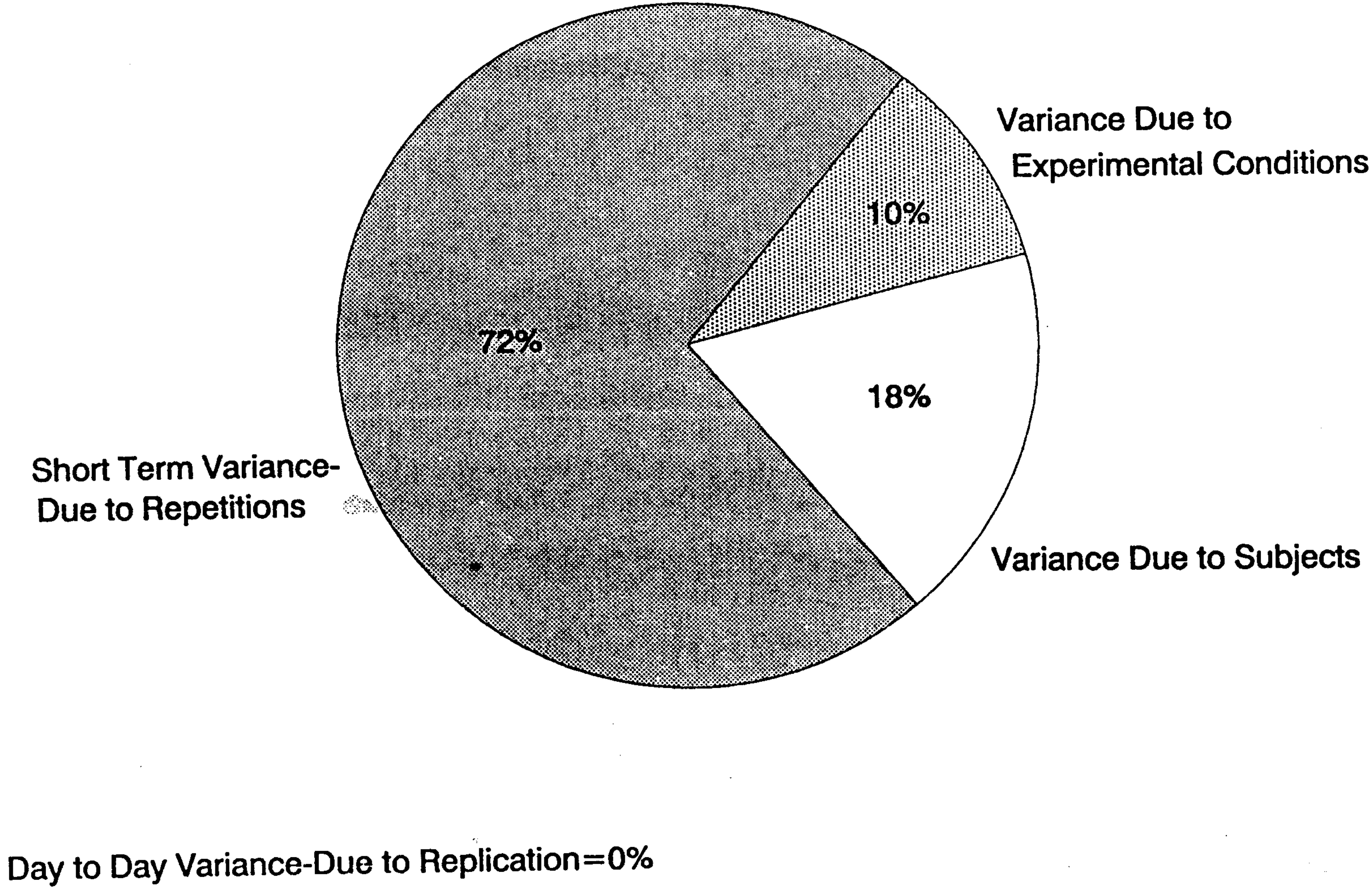


Figure 5.17 - Components of Variance for the Angular Study - 528 Foot Course Distance

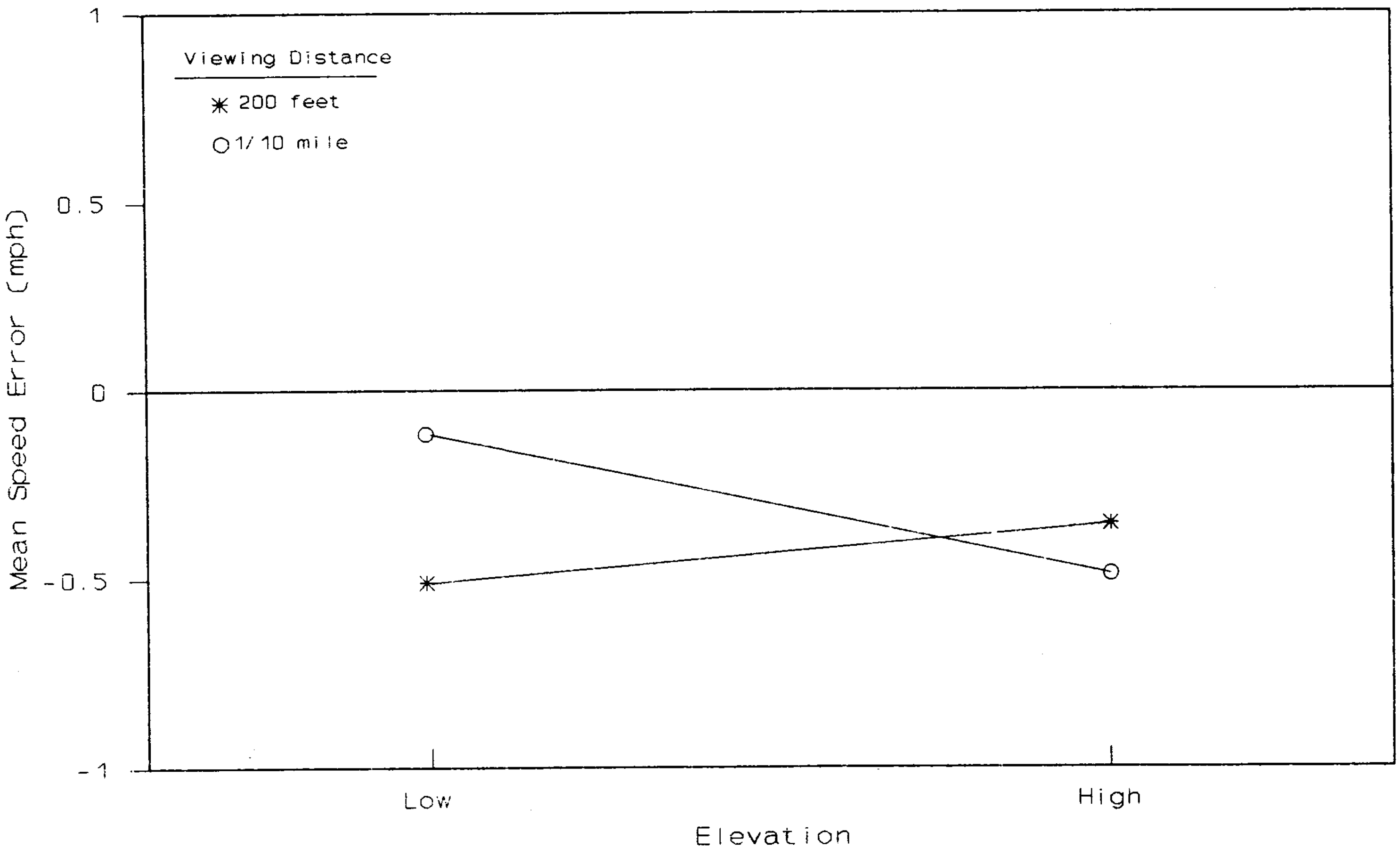


Figure 5.18.a - Mean Speed Error as a Function of Viewing Distance and Elevation for the 528 Foot Course Distance - Group 1

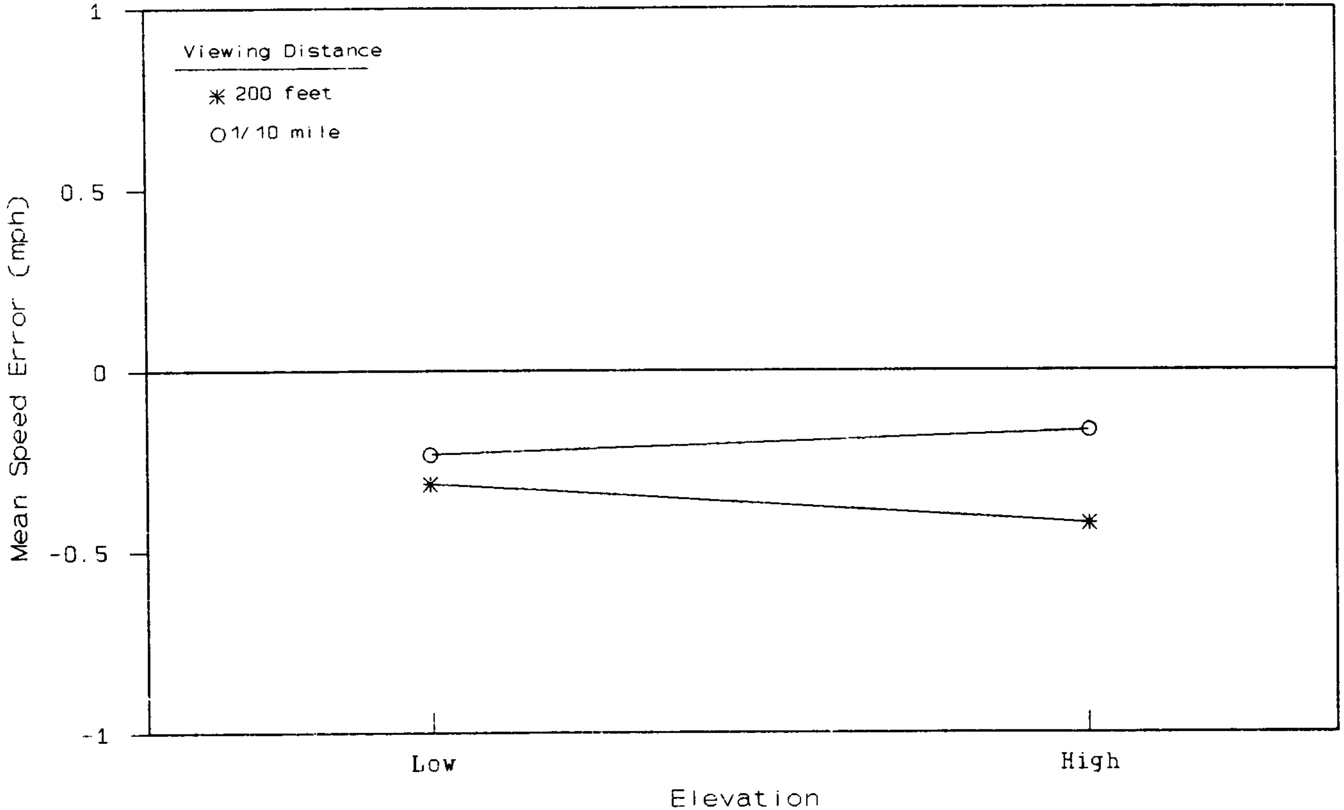


Figure 5.18.b - Mean Speed Error as a Function of Viewing Distance and Elevation for the 528 Foot Course Distance - Group 2

group x viewing distance x elevation combination (mean speed errors ranged from -0.51 to -.11 mph).

Upper 90th percentile tolerance limits for all the combinations of elevation x viewing distance x nominal speed for the 528 foot course distance are presented in Figure 5.19. These tolerance limits range from .478 to 1.419 mph. Even though viewing distance and nominal speed were statistically significant, all of the combinations of conditions produced upper 90th percentile tolerance limits that were less than 1.5 mph.

For the 200 foot course distance, the following variables and interactions between variables were found to be significant ($p \leq 0.05$):

Subject Number
Replications
Viewing Distance
Nominal Speed
Interaction of Group with Viewing Distance

The following variable was found to be nearly significant ($0.05 < p \leq 1.0$):

Group ($p = 0.09$)

The mean speed error for each group x viewing distance combination is plotted in Figure 5.20. The mean speed errors for the $\pm$ 2 mph speed range group and the $\pm$ 7 mph speed range group are significantly different. This suggests that the differences between methods of presenting nominal speed did affect the accuracy of the speed measurements for the 200 foot course distance.

A component of variance analysis was performed on the 200 foot clocks and is presented in Figure 5.21.

This portion of the angular study was the only occurrence with replication being a significant variable. As seen in Figure 5.21, replication was only 2 percent of the variance. The average speed error for each replication is plotted in Figure 5.22. The average speed was fairly constant until the fourth replication. Since subjects were concerned with the alignment of the pole for

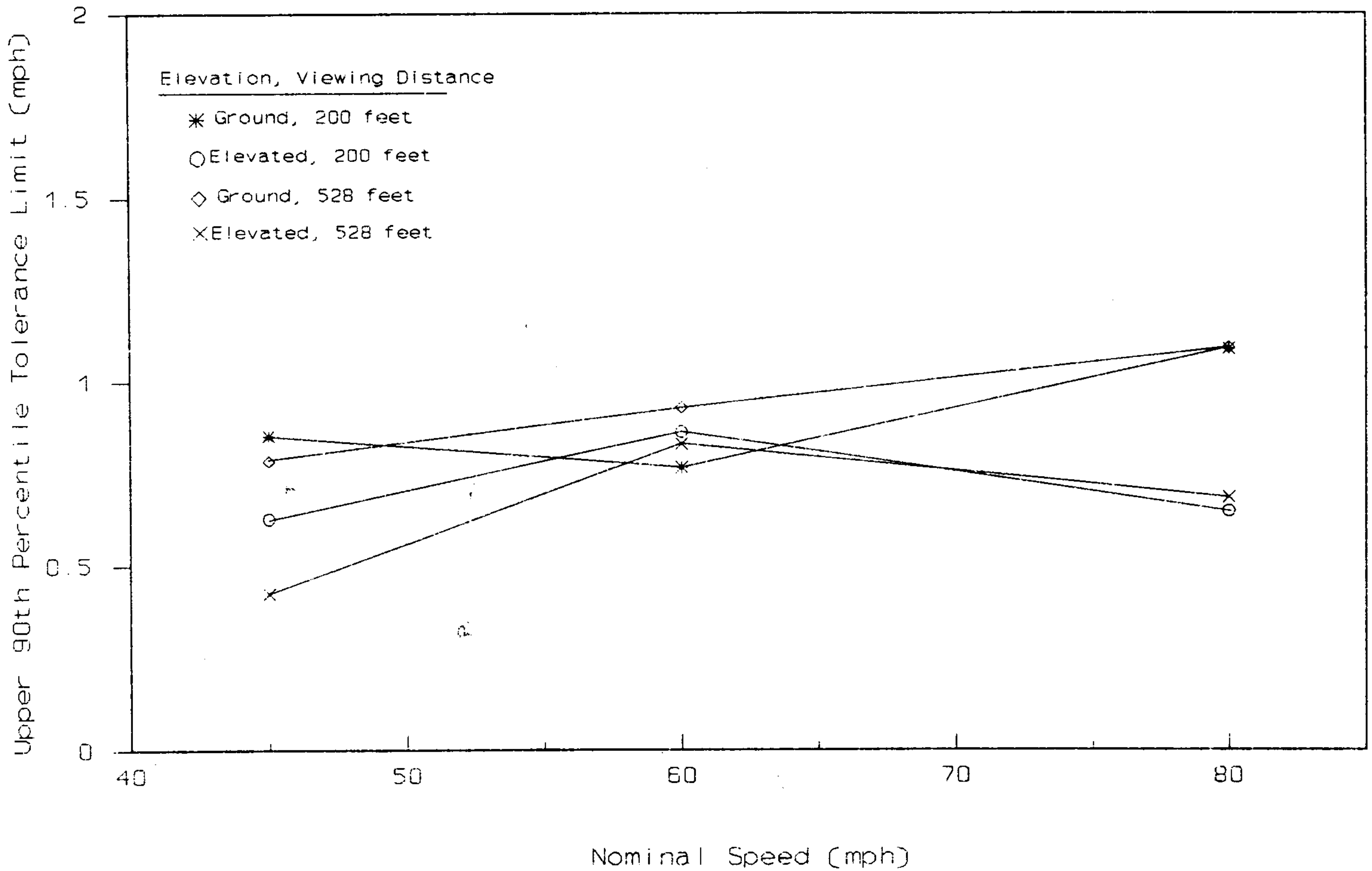


Figure 5.19 - Upper 90th Percentile Tolerance Limits for Speed Error - The Angular Study - 528 Foot Course Distance

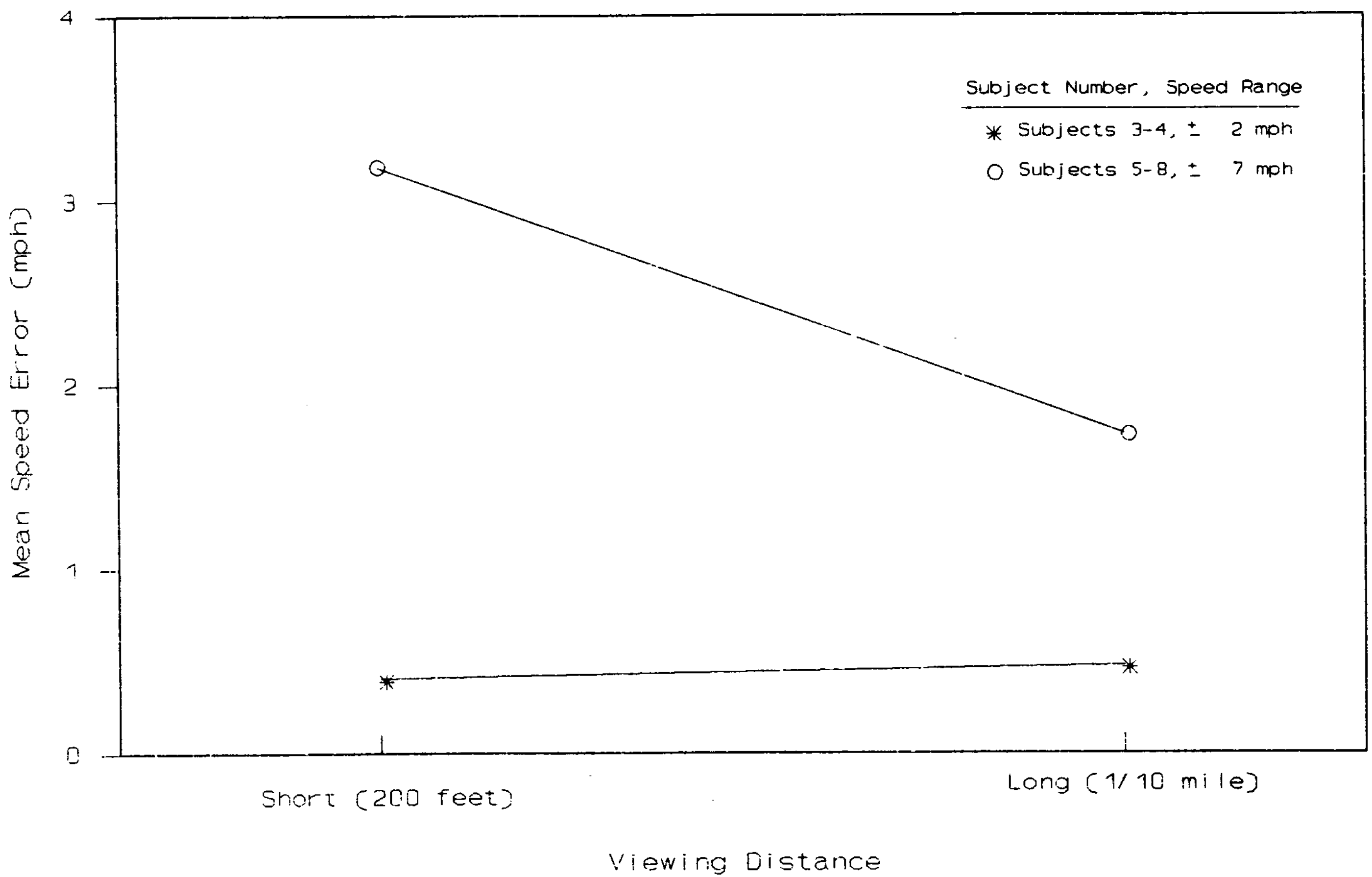


Figure 5.20 - Mean Speed Error as a Function of Viewing Distance for the 200 Foot Course Distance

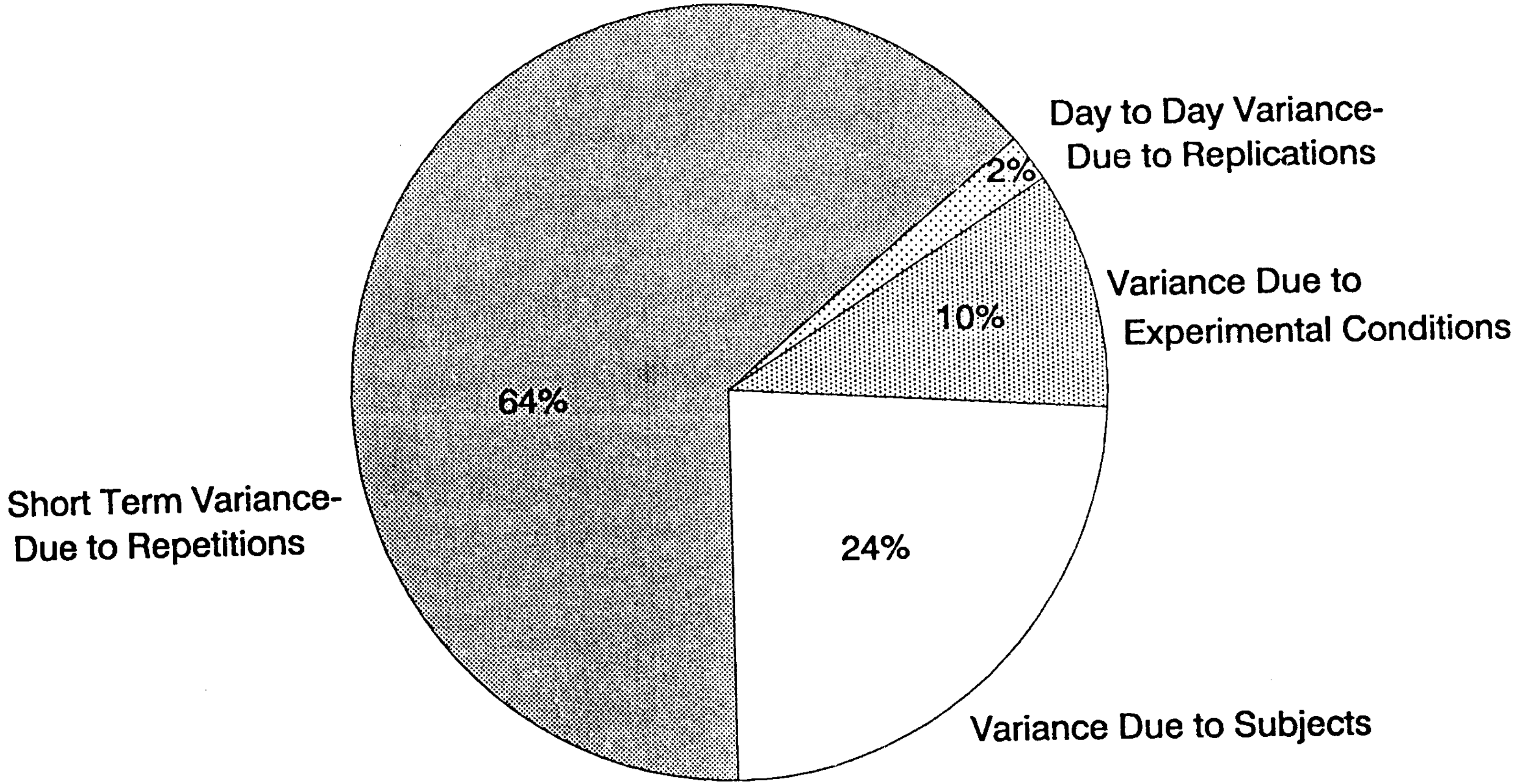


Figure 5.21 - Components of Variance for the Angular Study - 200 Foot Course Distance

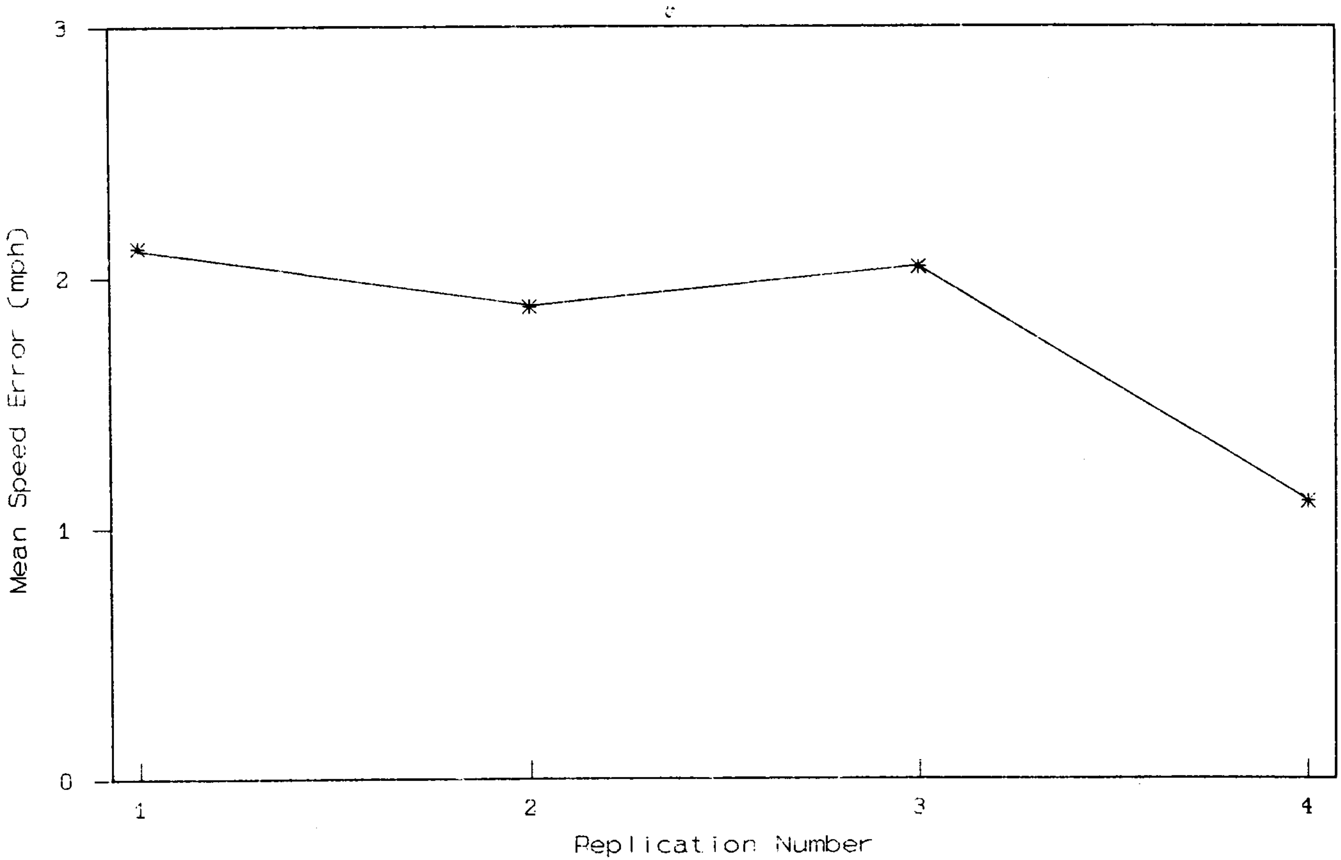


Figure 5.22 - Mean Speed Error as a Function of Replication Number for the 200 Foot Course Distance

the 200 foot clock, by the fourth replicate, they may have adjusted to compensate for the alignment problem. As seen in Figure 5.22, the average speed error did improve for the fourth replication.

Upper 90th percentile tolerance limits for all the combinations of elevation, viewing distance, and nominal speed for the 200 foot course distance are presented in Figure 5.23. The upper 90th percentile tolerance limits were lower for the longer viewing distance (528 feet). This was not surprising. The differences in the line of sight for the two viewing distances are shown in Figures 5.24.a and 5.24.b. The target vehicle covered a shorter distance when it reached the line of sight for the 200 foot viewing distance (5.24.a) than it did for the 528 foot viewing distance (5.24.b). Since this is the case, the subjects toggled the time switch off sooner for the shorter viewing distance than they did for the longer viewing distance. This resulted in higher estimated speeds for the shorter viewing distance.

Referring to Figure 5.23, at the 200 foot viewing distance, there was very little difference between the ground level and the elevated 90th percentile tolerance limits. The same was true for the 528 foot viewing distance, except at 80 mph. At 80 mph, the upper 90th percentile tolerance limit for ground level was 2.6 mph lower than it was for the elevated level.

In Figure 5.25, speed error is plotted as a function of clock duration for all of the angular clocks. The clocks above 4 seconds in length were for the 528 foot course distance and those below 4 seconds are for the 200 foot course length. All of the clocks for the 528 foot course distance had less than a + 2 mph speed error.

The subjects thought the 528 foot course distance was much more realistic than the 200 foot course distance. They also thought the longer viewing distance was more realistic than the shorter viewing distance. These same results were found when they were asked to rank their accuracy for the different conditions. They thought they were more accurate on the 528 foot course distance and were more accurate for the longer viewing distance.

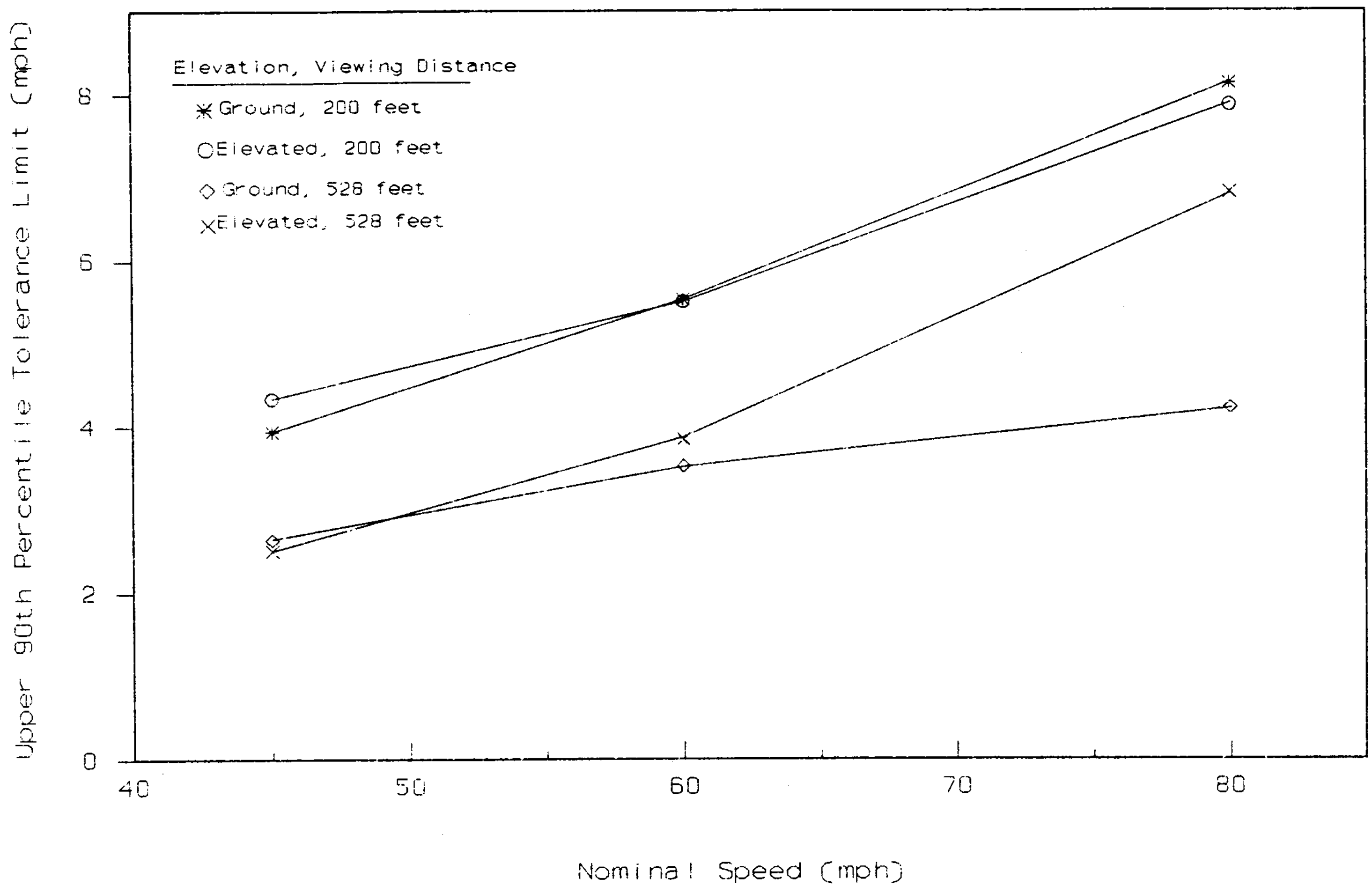
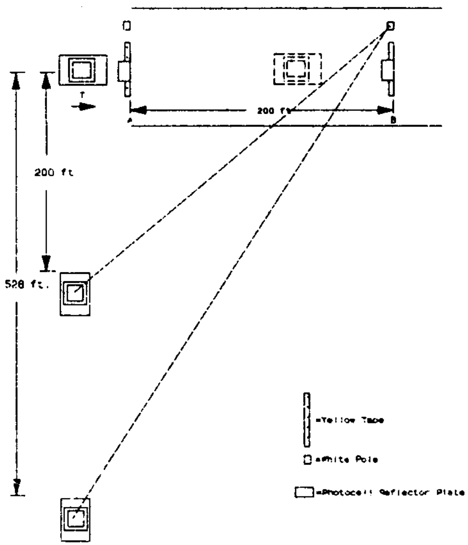
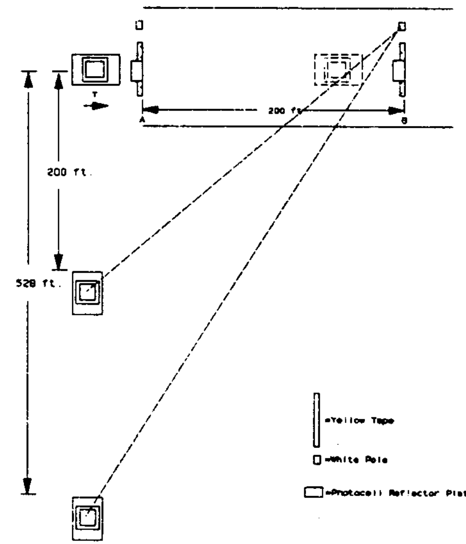


Figure 5.23 - Upper 90th Percentile Tolerance Limits for Speed Error - the Angular Study - 200 Foot Course Distance



200 Foot Viewing Distance



528 Foot Viewing Distance

Figure 5.24 - Comparison of 200 and 528 Foot Viewing Distance

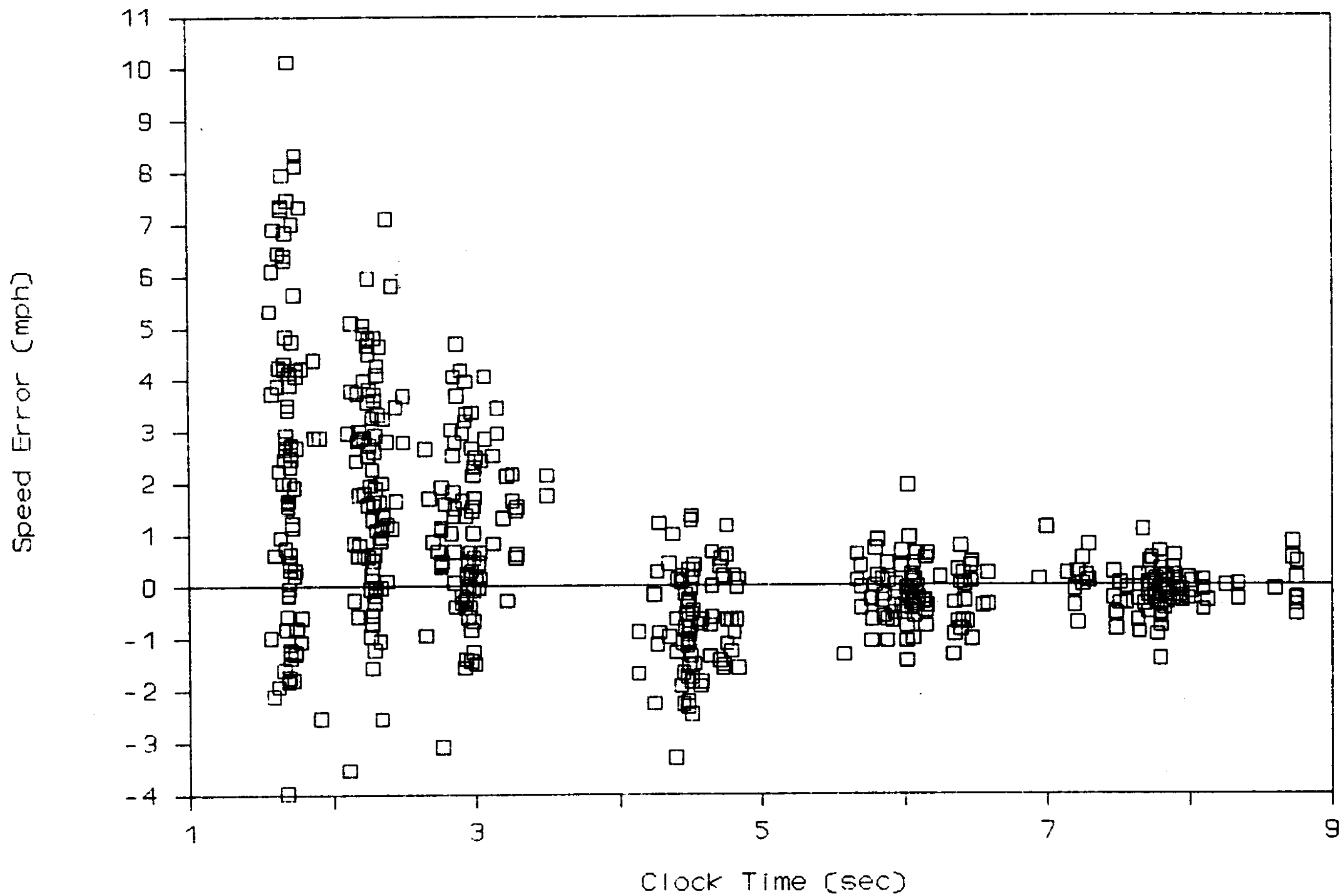


Figure 5.25 - Speed Error as a Function of Clock Duration for the Angular Study

The subjects strongest suggestions for improvement of this study was to align the reference marker for the 200 foot course distance (see Reference Marker Alignment section of Section 4.3). The subjects also thought the 200 foot course distance should be eliminated from the study.

Reference Marker Alignment Study

The following variables were examined in the reference marker alignment study:

Subjects
Nominal Speed
Replication
Alignment - Using the comparable unaligned clocks from the angular experiment

Only two subjects participated in this study. They replicated each test condition four times. This resulted in a total of 24 trials.

The following variables were found to be statistically significant ($p \leq 0.05$):

Alignment
Subject Number

The mean speed errors for both aligned and unaligned clocks are presented in Figure 5.26. Aligning the pole with the subjects line of sight resulted in mean speed errors that were very close to zero.

In Figure 5.27, speed error is plotted as a function of clock duration for the aligned clocks. These clocks ranged from ± 4 mph. The comparable unaligned clocks ranged from -1.3 to +7.4 mph.

The results of this study suggest that it is very important that the reference marker be in the subjects' line of sight. This point is made in the VASCAR manual.

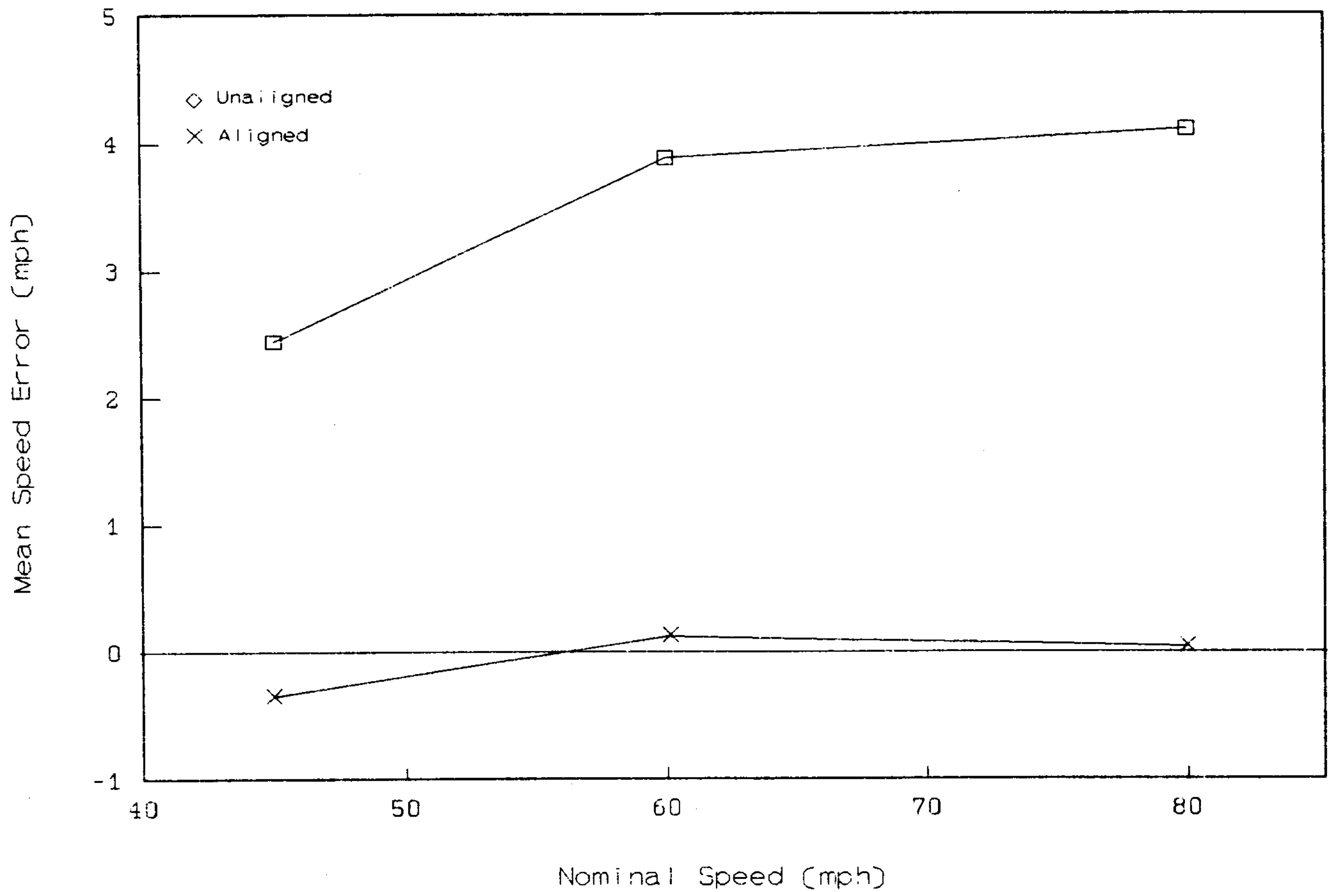


Figure 5.26 - Mean Speed Error for the Aligned and Unaligned Reference Marker

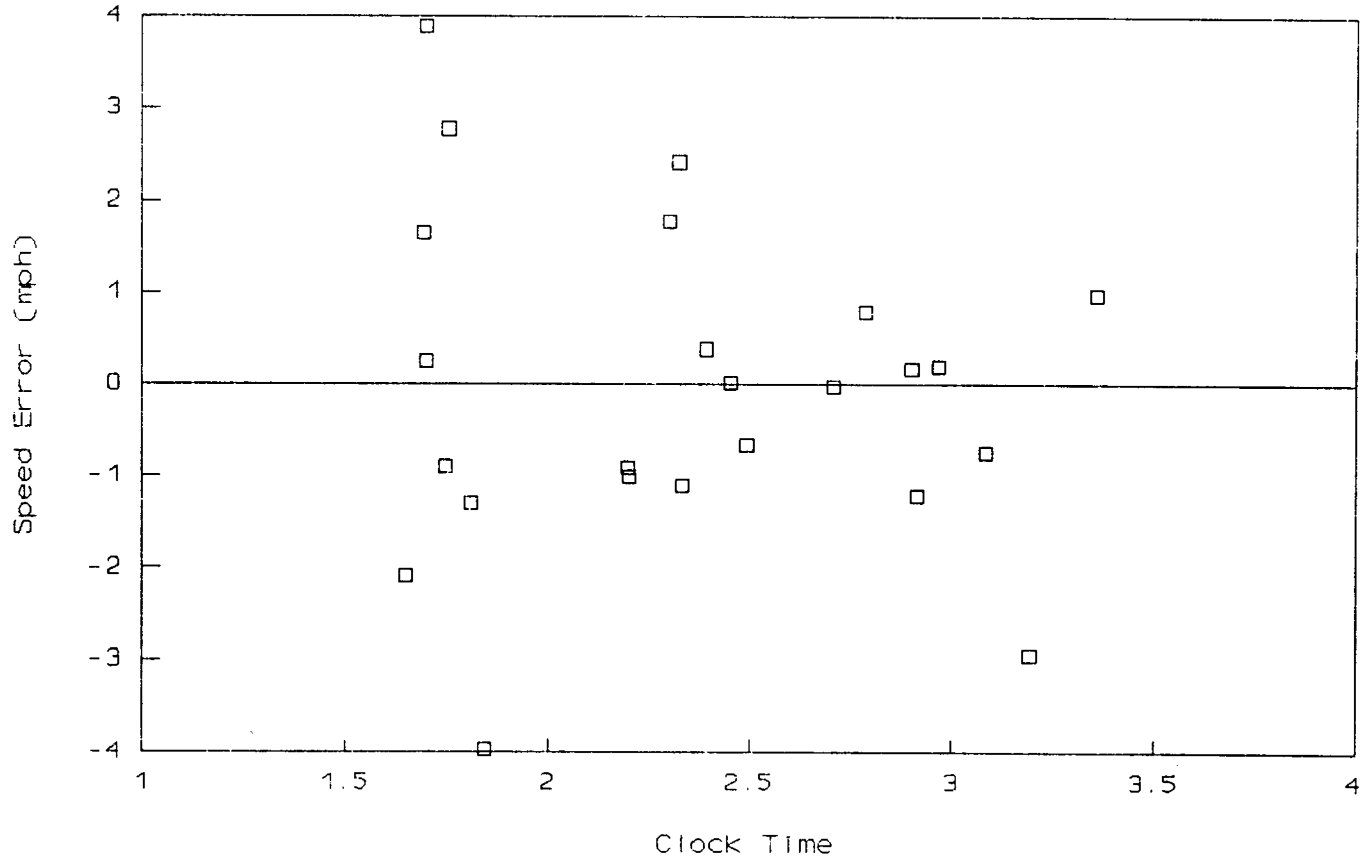


Figure 5.27 - Speed Error as a Function of Clock Duration for the Reference Marker Alignment Study

The subjects thought aligning the reference marker was more realistic, but they still thought the 200 foot course distance was not long enough.

Reference Marker Comparison

The test conditions for the 250 foot gap distance in the moving portion of the bridge study were very similar to those for the .3 mile long following clocks performed in the moving study. The only difference between the two was the type of reference marker. For the moving study the reference marker was the photocell reflector plate, for the bridge study it was the bridge shadow. An analysis was performed comparing the differences between the two types of reference markers. For this analysis, the following variables were studied:

Subjects
Nominal Speed
Reference Marker Type

None of these variables were found to be statistically significant ($p \leq 0.05$). The following variables were found to be nearly significant:

Reference Marker Type ($p = 0.051$)
Subjects ($p = 0.07$)

The mean and upper 90th percentile tolerance limits for each reference marker type are given in Table 5.7. The mean speed errors for each reference marker type were less than 1/4 mph different, and the upper 90th percentile speed errors were less than 1/2 mph different. This suggests there was no practical difference between the reference marker types.

TABLE 5.7 -- Mean and Upper 90th Percentile Tolerance Limits for Speed Error for Different Reference Marker Types

Reference Marker Type	Mean Speed Error (mph)	Upper 90th Tolerance Limit (mph)
Reflector Plate	.106	0.918
Bridge Shadow	.334	1.366

VASCAR Experience Level

Since all 8 subjects participated in the moving study, it was used to examine the effect of VASCAR experience. Four subjects had less than 1.5 years experience and the other four had 7 or more years experience. For the Following method, experience was not statistically significant. For the Approaching from the Rear method, experience was statistically significant. The mean and standard deviation for each group are presented in Table 5.8.

TABLE 5.8 -- Mean and Standard Deviation for Speed Error for the Approaching from the Rear Method - Grouped by VASCAR Experience Level

VASCAR Experience Level	Subject Numbers	Speed Error	
		Mean	Std. Dev.
< 1.5	1,4,6,7	.094	.643
≥ 7	2,3,5,8	.394	.705

From the results presented in Table 5.8, the subjects with less experience performed slightly better than those with more experience. The mean speed error for the subjects with more experience was only .3 mph higher than the mean speed error for the subjects with less experience. This would suggest little practical difference between the two experience levels.

Speed Error as a Function of Clock Time

Table 5.9 lists the mean and upper 90th percentile tolerance limits for speed error for the overall study, all of the moving clocks performed in this study (moving study, night moving, and moving portion of bridge study), and for all the stationary clocks performed in this study (stationary portion of bridge study, parking study, angular study, and reference marker alignment study). The corresponding values for percent speed error are in Table 5.10.

TABLE 5.9 -- Mean and Upper 90th Percentile Tolerance Limits for Speed Error (mph)

Portion of Study	Mean	Upper 90th Percentile
Overall	.426	3.134
Moving	.105	1.540
Stationary	.644	4.074

TABLE 5.10 -- Mean and Upper 90th Percentile Tolerance Limits for Percent Speed Error

Portion of Study	Mean	Upper 90th Percentile
Overall	.638	4.530
Moving	.164	2.230
Stationary	.959	5.886

Speed error is plotted as a function of clock time for all the moving clocks in Figure 5.28. For all of the moving clocks greater than 5 seconds in duration, the speed errors are less than + 2 mph. The mean and upper 90th percentile tolerance limits for speed error and percent speed error for the moving clocks greater than 5 seconds in duration are presented in Table 5.11

TABLE 5.11 -- Mean and Upper 90th Percentile Tolerance Limits for Moving Clocks Greater Than 5 Seconds in Duration

Dependant Variable	Mean	Upper 90th Percentile
Speed Error	.150	1.146
Percent Speed Error	.232	1.893

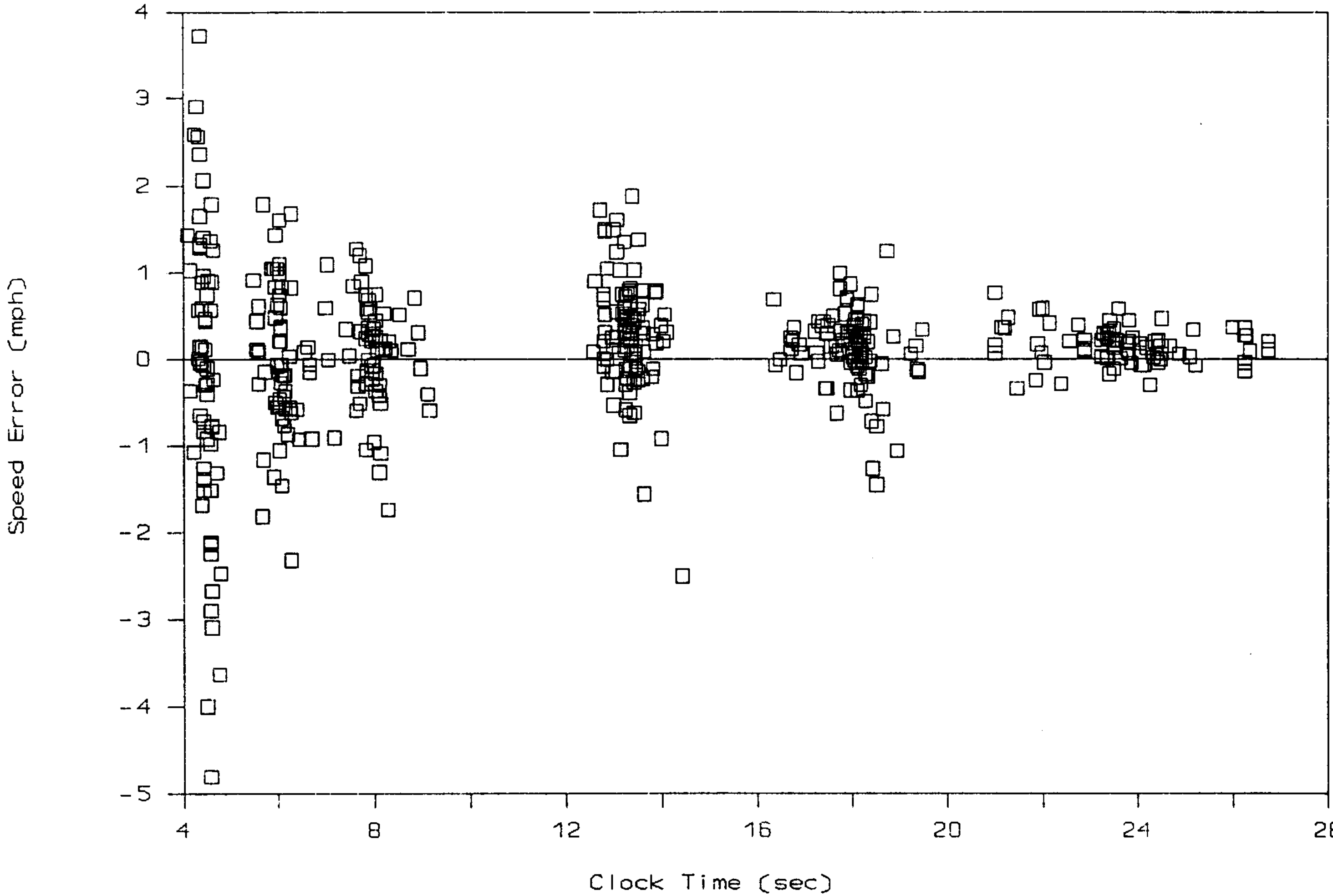


Figure 5.28 - Speed Error as a Function of Clock Duration for all Moving Clocks

Speed error is plotted as a function of clock time for all the stationary clocks in Figure 5.29. For the stationary clocks greater than 4 seconds in duration, the speed errors are less than + 4 mph. The mean and upper 90th percentile tolerance limits for speed error and percent speed error for the stationary clocks greater than or equal to 4 seconds in duration are presented in Table 5.12.

TABLE 5.12 -- Mean and Upper 90th Percentile Tolerance Limits for Stationary Clocks Greater Than or Equal to 4 Seconds in Duration

Dependant Variable	Mean	Upper 90th Percentile
Speed Error	-.072	1.567
Percent Speed Error	-.118	2.188

From the results presented in Tables 5.9 through 5.12, VASCAR-plus does not have a speed measurement accuracy of ± 1 percent, but an upper 90th percentile tolerance limit (95 percent of the values are less than or equal to this limit) of + 2 mph is achievable.

6.0 SUMMARY AND RECOMMENDATIONS

In this chapter, a summary of the findings is presented on the accuracy of VASCAR speed measurement capability and recommendations are made for VASCAR operation. These findings are based on the results of the testing and analysis documented in this report. It is very important to note that no one table or figure can stand alone. The raw data, the statistics, the laboratory environment, and the subjects' opinions of the different test conditions must all be taken into account before any conclusions can be drawn.

6.1 Summary

The results of this study show that VASCAR-plus does not have an overall speed measurement accuracy of ± 1 percent. It does appear that an upper 90th percentile tolerance limit of + 2 mph is achievable. This requires determining

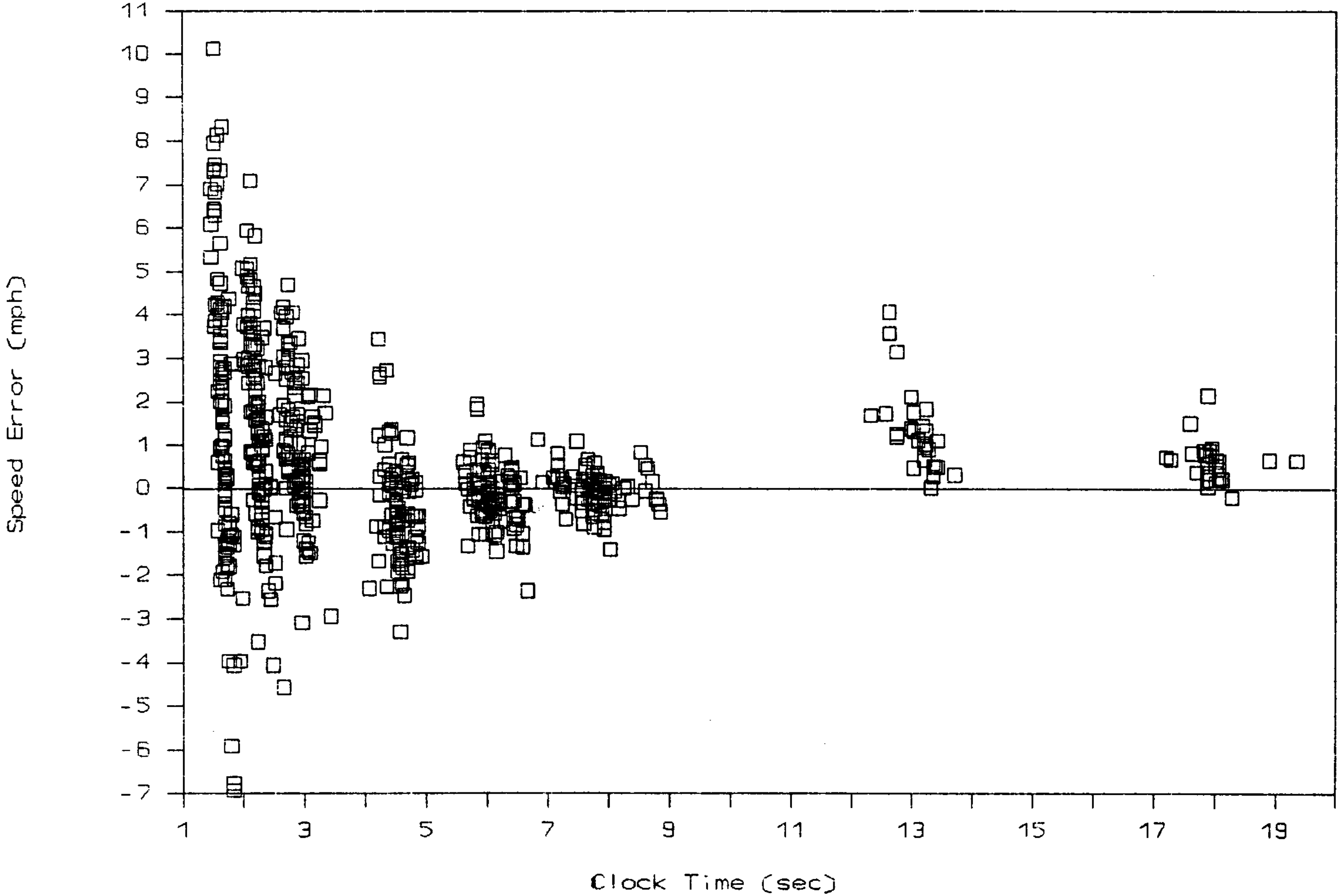


Figure 5.29 - Speed Error as a Function of Clock Duration for all Stationary Clocks

minimum distances or minimum timing durations for the different VASCAR methods. The following statements support this overall finding:

1. The VASCAR-plus timing mechanism had a lower 90th percentile tolerance limit of -0.0422 seconds. The speed error resulting from this timing error varies with course length and speed. For courses 1/10 mile or longer, the speed error is less than 1.2 mph (up to 100 mph). For course lengths greater than the mean preferred course distance (0.29-mile - from the personal interview results), the potential speed errors due to the timing mechanism are less than .5 percent.

2. The VASCAR-plus timing mechanism was always biased against the motorist, i.e., the true time was always greater than the VASCAR time, and hence the true speed was less than the VASCAR speed (this is only the timing mechanism, no human factors considered).

3. The upper 90th percentile tolerance limits for distance measurement were greater than the 6.3 inches stated in the VASCAR user manual, but they were well below .5 percent.

4. In general, the upper 90th percentile tolerance limits for speed error tended to increase as speed increased, and decrease as course distance increased.

5. For all of the moving clocks in this study, all but one combination of course distance and nominal speed produced upper 90th percentile tolerance limits lower than + 2 mph. The only combination that did not was the .1 mile course distance and the 80 mph nominal speed combination.

6. There was little practical difference between directly viewing the target vehicle and indirectly viewing the target vehicle using mirrors. There was less than a .36 mph difference between Following and Approaching from the Rear upper 90th percentile tolerance limits for every combination of course distance and nominal speed studied. There was less than a .41 mph difference between the upper 90th percentile tolerance limits for direct and indirect vision parking clocks for each nominal speed studied.

7. There were very small differences between the upper 90th percentile tolerance limits for day time and night time Following clocks (less than .35 mph).

8. As long as the officer could observe the vehicle pass the reference marker, viewing distance was not practically significant. For the moving bridge clocks, gap distance was not statistically significant. For the 528 foot angular clocks, there was little difference between the short and long viewing distances. The upper 95th percentile tolerance limits for the short and long viewing distances were less than 1/4 mph different for each combination of nominal speed and elevation.

9. Except for two cases, the upper 90th percentile tolerance limits for the two elevation levels were less than .5 mph different for each combination of nominal speed, course distance, and viewing distance.

10. It is very important that the reference markers be in the officer's line of sight (see Figures 4.5 and 4.6). For the 200 foot Angular clocks, when the pole was aligned, the mean speed errors were close to zero. When the pole was not aligned, the mean speed errors were as high as 4 mph.

11. For the 528 foot long angular clocks, all of the upper 90th percentile tolerance limits were less than + 1.5 mph.

12. Parking clocks were performed in both the parking study and the stationary portion of the bridge study. In the parking study, most of the upper 90th percentile tolerance limits were well above + 2 mph. Even for the .1 mile course distance, the upper 90th percentile tolerance limits were as high as 5.82 mph. In the stationary portion of the bridge study, all of the upper 90th percentile tolerance limits were below + 2.4 mph. The upper 90th percentile tolerance limits in the bridge study were probably lower than those in the parking study due to the longer course distance (.3 mile vs. 200 feet and .1 mile). It is important to remember that the subjects had strong opinions about how unrealistic the conditions in these two studies were. Real world Parking clocks may be more accurate and precise.

13. The amount of the speed error variance due to subject differences was dependent on the VASCAR method used. Differences between subjects accounted for only 3 percent of the variance in the moving study. This suggests that there was little difference between subjects for the moving clocks. Subject differences accounted for 23 percent of the variance in the angular study. This suggests that there were differences between subjects for angular clocks. This number may be artificially high due to the group effect (grouped by nominal speed ranges). For the 200 foot course distance, the subjects with the ± 2 mph speed range performed much differently than those subjects with the ± 7 mph speed range. Differences between subjects are not that surprising in human factors studies.

14. The group effect (nominal speed ranges) was only found to be practically significant for the 200 foot Angular clocks performed in this study. The subjects with the ± 2 mph speed range performed better than those with the ± 7 mph speed range for these clocks. There were not practical or statistical differences between groups for the 528 foot Angular clocks, or for the Moving clocks.

15. VASCAR experience was not practically significant.

16. Replication was only an effect in a portion of the angular study. Replication was not an effect in any other study. This suggests that the subjects did not learn or tire during the study. In other words, they did not improve as the study progressed. For the 200 foot clocks

in the angular study, the subjects did show a significant improvement on the fourth replication. The subjects did not think the set up for this course was appropriate. By the last day of testing they may have adjusted their technique to compensate for the experimental conditions (see Figure 5.22).

17. For all of the moving clocks greater than 5 seconds in duration, the upper 90th percentile tolerance limit for speed error was 1.146 mph (1.893 %). For all of the stationary clocks greater than 4 seconds in duration, the upper 90th percentile tolerance limit for speed error was 1.567 mph (2.188 %).

6.2 Recommendations

The following recommendations are given for VASCAR operation and for improvements of the VASCAR-plus manual.

1. When setting up a course for a stationary clock, the officer should choose a course length that will give a time duration of at least 4 seconds for the expected maximum speed. For example, in a 25 mph speed zone, an expected maximum speed might be 45 mph. A car will travel .05 miles (264 ft) in 4 seconds at 45 mph, so we are recommending that the officer use a course length of at least .05 miles. If a motorist goes through the course faster than 4 seconds, the potential speed error will increase, but it will be obvious that the motorist is well above the posted speed limit.

2. When using VASCAR-plus for moving clocks (Following and Approaching from the Rear), clock durations of at least 5 seconds should be used.

3. The VASCAR-plus manual should be revised to reflect the accuracy when it is used by human operators.

APPENDIX A

Personal Interview Form

Code Number ______________
Date ______________
Start Time ______________
Respondent ______________

Hello my name is ____________. Is __________________ there?

(Mr., Officer, etc.) ___________________. I represent the Transportation Research Center and I have been assigned as the research engineer on study sponsored by the National Highway Traffic Safety Administration dealing with speed measurement techniques used by police officers. Your department gave me your name as an officer who could help us in our study. I understand that as part of your job as an officer, that you are responsible for enforcing posted speed limits. Is this the case? (if not, end interview)

I'd like to ask you a few questions about this area of law enforcement, if I may. It will take about 20 minutes. The information that you share with me will be completely confidential. No one but our research group will see my notes. We expect to use what we learn from officer interviews to help us develop important features for some field tests of equipment that we have planned.

Is this a good time to talk or can I call you back at a specific time that would be more convenient? (set up a call back if needed) Date, time, and phone # for call back: ____

QUESTIONS

A major focus of our research is the use of VASCAR. So most of my questions deal with your experience with and opinions of VASCAR.

1. How familiar are you with VASCAR? (check off the phrase which is most descriptive of the respondent's answer)

________ Trained ________ Certified
Use: _________ Regularly (daily) ________ Often (weekly)
_________ Occasionally (monthly) _______ Infrequently (once a year)

1a. Do you currently use VASCAR or VASCAR-plus?
_________ VASCAR ________ VASCAR-plus

2. What kind of training have you had on VASCAR?

a. Nature (where and when) and amount (estimate of hours) of FORMAL IN-CLASS training:

____

b. Nature and amount of supervised training:

____

c. Nature and amount of informal training (self study):

____

2a. How many months (or years) of VASCAR experience do you have?

____

3. On a scale of 1-10, where 1=Novice and 10=Expert, what number would best reflect your VASCAR skills? ____________

4. On what type of roadway(s) do you use VASCAR?
_______freeway _______urban _______rural _______residential
_______other ____________________________

5. What percent of your overall VASCAR use has been at night? _______

6. I would like to get an idea of how often you use the different methods of operation of VASCAR. I will list some common methods. Please give me an estimate of the percentage of time you use each VASCAR method. If you do not use a method, we will give it a zero value.

Police Car Moving ________

________ a. Following the Target Vehicle

________ b. Opposite Direction

________ c. Target Vehicle Approaching from the Rear

Police Car Stationary ________

________ a. Parking

________ b. T-Intersection

________ c. Angular Clocking

6a. Is your choice of VASCAR method in any way determined by day vs. night time use? Explain.
____

7. For methods with the police car stationary, what percent of the time do you use dial a distance vs. driving in the distance? ______ Dial ______ Drive

8a. Which of the six methods described above do you have the greatest confidence in (i.e. has the best accuracy? Why? ________________________

8b. Which do you have the least confidence in (i.e. has the least accuracy)? Why? ____

9. What is the shortest course distance you typically use to make VASCAR speed measurements? _______ Feet _______ Miles

10. What is the longest course distance you typically use to make VASCAR speed measurements? _______ Feet _______ Miles

11. What is your preferred course distance? ____________

12. What is the typical maximum distance (range) from your eye to a reference point? _______ Feet _______ Miles

13. What objects do you use as stationary reference markers during the day? (could you list in order of preference)? (probe for specifics)

____

14. What objects do you use as stationary reference markers at night?

____

15. Do you use a reference marker inside your vehicle in laying out a course? (e.i. tape on window) ______________________

16. How is your choice of VASCAR method or references influenced by weather conditions? Explain. ______________________________

17. How often do you check the calibration of your VASCAR system? ________

18a. In using VASCAR, what is the speed accuracy that you believe you can achieve in typical operating conditions (± miles/hr)? ________

18b. Is this accuracy a function of course length? stream speed? VASCAR method? ______length ______speed ______method

19a. Have you ever had to go to court to defend a VASCAR based speed citation?

____

19b. If yes, how do defendants or defense attorneys attack your VASCAR speed estimates? ______________________________

20. What do you feel are the strengths of VASCAR?

____

21. What do you feel are the weaknesses of VASCAR?

____

22. Have you ever experienced a failure in VASCAR equipment operation? Explain.

____

23. Do you use Radar to establish target speeds? How often? ____________

____

24. Under what circumstances is VASCAR preferred over Radar? ____________

____

25. Under what circumstances is Radar preferred over VASCAR? ____________

____

26. It's been said that some officers prefer not to use VASCAR. Why do you think some officers avoid the use of VASCAR? ________________

____

27. Did I get all you opinions on VASCAR? ______________________

APPENDIX B

Task Analysis Results

TABLE B.1

CLOCK TARGET USING FOLLOWING MODE OF VASCAR OPERATION

Task: Clock Target Using Following Mode of VASCAR Operation

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Identify Target Vehicle	Visual acuity (required in all task elements) Visually search for potential target in traffic stream ahead of police car Estimate the target's speed	Driving skill (required in all task elements)	Decide if the potential target is likely over the posted speed limit Decide to clock the target if conditions permit	Visibility (e.g., day vs. night, adverse weather) Other vehicles in traffic stream can obscure potential targets Radio "chatter"	Similar vehicles in traffic stream; officer selects wrong vehicle	Officer makes initial speed judgements on an absolute scale and also relative to other vehicles in the traffic stream In moving modes of VASCAR operation the officer has additional information from the police car speedometer which is not available in stationary clocking modes As visibility is reduced, the distances over which VASCAR can be used are also reduced

Task: Clock Target Using Following Mode of VASCAR Operation (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Select First Reference Mark	Visually search road scene for suitable reference mark (e.g., a bridge shadow, sign post, pavement coloration change, etc.) ahead of target		Decide on the fixed object to use as the first reference mark in the course	Other vehicles can obscure objects Visibility Light levels limit use of some types of reference marks		Depending on the availability of fixed objects ahead, the second reference mark may also be selected at this time; selection of the second reference mark is discussed later
Track Target to First Reference Mark	Visually monitor target's progress toward VASCAR course Officers must allocate visual resources to three tasks: tracking the target, monitoring the position of the reference mark and driving	Estimate arrival time of target at reference mark	Decide when Time switch should be activated	Other traffic could obscure target or reference mark Radio "chatter"		Depth cues in road scene (e.g., other vehicles or fixed objects adjacent to the highway) aid in arrival time estimation On multi-lane divided highways, officers can improve their view of target and reference mark by positioning themselves in a lane adjacent to target

Task: Clock Target Using Following Mode of VASCAR Operation (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Turn Time Switch On	Obtain auditory and tactile feedback of switch activation	Push toggle switch into UP position Drive police car with left hand, while operating VASCAR with right hand Reaction time	Decide if switch was activated as target passed reference mark	Radio operation requires the same hand used for VASCAR operation	Early switch activation could lead to under-estimation of true speed Late switch activation could lead to over-estimation of true speed Distance switch could be activated instead of or in addition to Time switch	To reduce reaction time delay officers initiate switch activation just prior to arrival of the target at the reference mark
Observe Police Car's Approach to First Reference Mark	Visually monitor location of first reference mark as police car proceeds forward Officers must allocate visual resources to tracking the target, monitoring the reference mark position and driving	Estimate arrival time of police car at reference mark	Decide when Distance switch should be activated	Other traffic could obscure reference mark Radio "chatter"		Depth cues in road scene (e.g., other vehicles or fixed objects adjacent to highway) aid in arrival time estimation

Task: Clock Target Using Following Mode of VASCAR Operation (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Turn Distance Switch ON	Obtain auditory and tactile feedback of switch activation	Push toggle switch into UP position Reaction time	Decide if switch was activated as police car passed reference mark	Radio operation requires the same hand used for operating VASCAR controls	Early switch activation could lead to over-estimation of true speed Late switch activation could lead to under-estimation of true speed Time switch could be activated instead of or in addition to Distance switch	To reduce reaction time delay officers initiate switch activation just prior to the arrival of the police car at the reference mark
Select Second Reference Mark	Visually search road scene for suitable reference mark (e.g., a bridge shadow, sign post) ahead of target		Decide on the fixed object to use the second reference mark in the course	Other vehicles can obscure objects Visibility Light levels limit use of some types of reference marks		

Task: Clock Target Using Following Mode of VASCAR Operation (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Track Target Vehicle to Second Reference Mark	Visually monitor target's progress toward second reference mark Officers must allocate visual resources to tracking the target, monitoring the position of the reference mark and driving	Note if target changes lanes while in course Estimate arrival time of target at reference mark	Decide when Time switch should be activated	Other traffic could obscure target or reference mark Radio "chatter"	Lane changing by target could lead to underestimation of true speed	Depth cues aid in arrival time estimation Officers typically read the police car speedometer several times during a moving clock
Turn Time Switch OFF	Obtain auditory and tactile feedback of switch activation	Push toggle switch into DOWN position Reaction time	Decide if switch was activated as target passed the second reference mark	Radio operation requires the same hand as VASCAR operation	Early switch activation could lead to an over-estimation of true speed Late switch activation could lead to an under-estimation of true speed Distance switch could be activated instead of or in addition to Time switch	To reduce reaction time delay officers initiate switch activation prior to the arrival of the target at the reference mark

Task: Clock Target Using Following Mode of VASCAR Operation (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Observe Police Car's Approach to Second Reference Mark	Visually monitor location of second reference mark as police car proceeds through course	Estimate arrival time of police car at reference mark	Decide when Distance switch should be activated	Other traffic could obscure reference mark Radio "chatter"		Depth cues in road scene (e.g., other vehicles or fixed objects adjacent to highway) aid in arrival time estimation
Turn Distance Switch OFF	Obtain auditory and tactile feedback of switch activation	Push toggle switch into DOWN position Reaction time	Decide if switch was activated as police car passed reference mark	Radio operation requires the same hand as used for VASCAR operation	Early switch activation could lead to under-estimation of true speed Late switch activation could lead to over-estimation of true speed Time switch could be activated instead of or in addition to Distance switch	To reduce reaction time delay officers initiate switch activation just prior to the arrival of the police car at the reference mark Time switch and Distance switch activation errors at both reference marks can have offsetting effects or additive effects which increase measurement error

Task: Clock Target Using Following Mode of VASCAR Operation (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Read VASCAR Display	Read speed value displayed Viewing distance is approximately 30 inches Character height is approximately one-half inch		Displayed speed is compared with initial speed judgement made by officer and to speedometer reading(s) obtained during the clocking procedure		Error by officer in reading VASCAR display or police car speedometer Officer incorrectly recalls speedometer reading(s) from memory	
Assess Validity of Speed Measurement			Decide to accept (or reject) speed measurement based on switch activations, lane maintenance by target, speedometer reading(s) and displayed VASCAR reading			
Decide whether or not to pursue			Decide to pursue target if measured speed is greater than speed limit plus an allowance factor for motorist error	Last second requirement for officer to attend to a more critical event (e.g., accident, violent crime, other emergency)		The decision to pursue a violator depends on the measured speed, the officer's ability to safely pursue, the police department policy for issuing speeding citations and the need for the officer's services elsewhere

TABLE B.2

CLOCK TARGET APPROACHING FROM THE REAR

Task: Clock Target Approaching from the Rear

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Identify Target Vehicle	Visual acuity (required in all task elements) Visually search rear view mirror or left side mirror (plane mirrors) for potential target in traffic stream behind police car Maintain visual search ahead of police car Estimate the target's speed	Driving skill (required in all task elements)	Decide if the potential target is likely over the posted speed limit Decide to clock the target if conditions permit	Visibility (e.g., day vs. night, adverse weather) Other vehicles in traffic stream can obscure potential targets Radio "chatter" Mirror Adjustment	Similar vehicles in traffic stream; officer selects wrong vehicle	Officer makes initial speed judgements on an absolute scale and also relative to other vehicles in the traffic stream In moving modes of VASCAR operation the officer has additional information from the police car speedometer which is not available in stationary clocking modes As visibility is reduced, the distances over which VASCAR can be used are also reduced

Task: Clock Target Approaching from the Rear (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Select First Reference Mark	Visually search road scene for suitable reference mark (e.g., a bridge shadow, pavement color change, sign post, etc.) ahead of police car		Decide on the fixed object to use as the first reference mark in the course	Other vehicles can obscure objects Visibility Light levels limit the use of some types of reference marks		Depending on the availability of fixed objects ahead, the second reference mark may also be selected at this time; selection of the second reference mark is discussed later
Observe Police Car's Approach to First Reference Mark	Visually monitor location of first reference mark as police car proceeds toward course Officers must allocate visual resources to three tasks: tracking the target in the police car mirrors, monitoring the reference mark ahead and driving	Estimate arrival time of police car at reference mark	Decide when Distance switch should be activated	Other traffic could obscure reference mark Radio "chatter"		Depth cues in road scene (e.g., other vehicles or fixed objects adjacent to highway) aid in arrival time estimation

Task: Clock Target Approaching from the Rear (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Turn Distance Switch ON	Obtain auditory and tactile feedback of switch activation	Push toggle switch into UP position Drive police car with left hand, while operating VASCAR with right hand Reaction time	Decide if switch was activated as police car passed reference mark	Radio operation requires the same hand used for operating VASCAR controls	Early switch activation could lead to over-estimation of true speed Late switch activation could lead to under-estimation of true speed Time switch could be activated instead of or in addition to Distance switch	To reduce reaction time delay officers initiate switch activation just prior to the arrival of the police car at the reference mark
Track Target to First Reference Mark	Visually monitor via mirrors the target's progress toward VASCAR course Officers must allocate visual resources to tracking the target, monitoring the position of the reference mark ahead and driving	Estimate arrival time of target at reference mark	Decide when Time switch should be activated	Other traffic could obscure target or reference mark Radio "chatter"		Depth cues in road scene aid in arrival time estimation On multi-lane divided highways, officers can improve their view of target by positioning themselves in a lane adjacent to target

Task: Clock Target Approaching from the Rear (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Turn Time Switch On	Obtain auditory and tactile feedback of switch activation	Push toggle switch into UP position Reaction time	Decide if switch was activated as target passed reference mark	Radio operation requires the same hand used for VASCAR operation	Early switch activation could lead to under-estimation of true speed Late switch activation could lead to over-estimation of true speed Distance switch could be activated instead of or in addition to Time switch	To reduce reaction time delay officers initiate switch activation just prior to arrival of the target at the reference mark
Select Second Reference Mark	Visually search road scene ahead for suitable reference mark (e.g., a bridge shadow, sign post)		Decide on the fixed object to use the second reference mark in the course	Other vehicles can obscure objects Visibility Light levels limit the use of some types of reference marks		

Task: Clock Target Approaching from the Rear (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Observe Police Car's Approach to Second Reference Mark	Visually monitor location of second reference mark as police car proceeds through course	Estimate arrival time of police car at reference mark	Decide when Distance switch should be activated	Other traffic could obscure reference mark Radio "chatter"		Depth cues in road scene aid in arrival time estimation Officers typically read the police car speedometer several times during a moving clock
Turn Distance Switch OFF	Obtain auditory and tactile feedback of switch activation	Push toggle switch into DOWN position Reaction time	Decide if switch was activated as police car passed reference mark	Radio operation requires the same hand as used for VASCAR operation	Early switch activation could lead to under-estimation of true speed Late switch activation could lead to over-estimation of true speed Time switch could be activated in addition to or instead of Distance switch	To reduce reaction time delay officers initiate switch activation just prior to the arrival of the police car at the reference mark

Task: Clock Target Approaching from the Rear (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Track Target Vehicle to Second Reference Mark	Visually monitor target's progress toward second reference mark using mirrors Visual resources must be allocated to tracking the target, monitoring the reference mark and driving	Note if target changes lanes while in course Estimate arrival time of target at reference mark	Decide when Time switch should be activated	Other traffic could obscure target or reference mark Radio "chatter"	Lane changing by target could lead to underestimation of true speed	Depth cues aid in arrival time estimation Target and second reference mark are both to the rear of the police car
Turn Time Switch OFF	Obtain auditory and tactile feedback of switch activation	Push toggle switch into DOWN position Reaction time	Decide if switch was activated as target passed the second reference mark	Radio operation requires the same hand as VASCAR operation	Early switch activation could lead to an over-estimation of true speed Late switch activation could lead to an under-estimation of true speed Distance switch could be activated instead of or in addition to Time switch	To reduce reaction time delay officers initiate switch activation prior to the arrival of the target at the reference mark Time and Distance switch activation errors at both reference marks can have off-setting effects or additive effects that increase error

Task: Clock Target Approaching from the Rear (Continued)

Task Element	Sensory-Perceptual Requirements	Psycho-Motor Requirements	Cognitive Requirements	Limiting Factors	Potential Sources of Errors	Comments
Read VASCAR Display	Read speed value displayed Viewing distance is approximately 30 inches Character height is approximately one-half inch		Displayed speed is compared with initial speed judgement made by officer and to speedometer reading(s) obtained during the clocking procedure		Error by officer in reading VASCAR display or police car speedometer Officer incorrectly recalls speedometer reading(s) from memory	
Assess Validity of Speed Measurement			Decide to accept (or reject) speed measurement based on switch activations, lane maintenance by target, speedometer reading(s) and displayed VASCAR reading			
Decide whether or not to pursue			Decide to pursue target if measured speed is greater than speed limit plus an allowance factor for motorist error	Last second requirement for officer to attend to a more critical event (e.g., accident, violent crime, other emergency)		The decision to pursue a violator depends on the measured speed, the officer's ability to safely pursue, the police department policy for issuing speeding citations and the need for the officer's services elsewhere

APPENDIX C

Results of Tests Conducted with VASCAR Display Covered

Two replicates of the short viewing distance clocks of the angular study were performed by two subjects with the VASCAR LED display covered. The results of these tests were compared to the results of similar tests from the first two replicates of the angular study performed by the same subjects with the VASCAR LED display uncovered. The mean and standard deviation for speed error for each course distance are listed in Table C.1.

TABLE C.1: Mean and Standard Deviation for Speed Error For Covered and Uncovered VASCAR LED Display

Course Distance	Uncovered Display		Covered Display	
	Mean	Std. Dev.	Mean	Std. Dev.
200 ft.	0.107	1.212	1.145	2.296
1/10 mi.	-0.449	0.587	-0.582	0.663

The results presented in Table C.1 show that there was little difference between the covered and uncovered display results at 1/10 mile (528 feet), but there was a significant difference at 200 feet. This was the same result found with the group effect of the angular study. In the angular study, the effect of the nominal speed ranges ($\pm$ 2 mph and $\pm$ 7 mph) was studied. The results showed that the difference between groups was minimal for the 528 foot course distance, but it was significant for the 200 foot course distance.

Means and standard deviations for various test conditions with the 528 foot course distance are presented in Table C.2. The results presented in this table show that there were minimal differences between the results with and without the display covered for the 528 foot course distance.

TABLE C.2: Means and Standard Deviation for Various Test Conditions with the 528 Foot Course Distance

Test Condition	Uncovered Display		Covered Display	
	Mean	Std. Dev.	Mean	Std. Dev.
ground	-0.358	0.741	-0.489	0.426
elevated	-0.539	0.392	-0.674	0.889
45	-0.272	0.348	-0.330	0.588
60	-0.125	0.398	-0.470	0.517
80	-0.948	0.642	-0.944	0.771

Means and standard deviations for various test conditions with the 200 foot course distance are presented in Table C.3. The results presented in this table show there were significant difference between the results with and without the display covered for the 200 foot course distance.

TABLE C.3: Means and Standard Deviation for Various Test Conditions with the 200 Foot Course Distance

Test Condition	Uncovered Display		Covered Display	
	Mean	Std. Dev.	Mean	Std. Dev.
ground	0.229	1.439	1.965	2.468
elevated	-0.014	0.984	0.324	1.862
45	0.078	1.255	1.052	1.395
60	0.079	1.424	1.452	2.326
80	0.165	1.105	0.930	3.130

It is important to note that officers in the real world do not have their displays covered. The results of the task analysis showed that officers compare their initial speed assessment to their VASCAR clock. Using this assessment, and other information, the officers then decide whether or not they have a valid clock.

APPENDIX D

Order of Trials

ORDER OF TRIALS FOR MOVING STUDY

SUBJECTS A AND B

DAY 1

Trial Number	Course Distance	VASCAR Method		Target Speed
		Subject A	Subject B	
1	0.3 mile	Leading	Following	60
2	0.3 mile	Following	Leading	45
3	0.3 mile	Following	Leading	60
4	0.3 mile	Leading	Following	80
5	0.3 mile	Following	Leading	80
6	0.3 mile	Leading	Following	45
7	0.1 mile	Following	Leading	45
8	0.1 mile	Following	Leading	60
9	0.1 mile	Following	Leading	80
10	0.1 mile	Leading	Following	80
11	0.1 mile	Leading	Following	60
12	0.1 mile	Leading	Following	45

ORDER OF TRIALS FOR BRIDGE SESSION

SUBJECTS A AND B

DAY 1

		Subject A		Subject B	
Trial Number	Target Speed	VASCAR Method	Gap/Viewing Method	VASCAR Method	Gap/Viewing Method
1	60	Parking	Direct	Following	250 ft
2	80	Parking	Indirect	Following	1/8 mile
3	60	Parking	Indirect	Following	1/8 mile
4	80	Following	250 ft	Parking	Indirect
5	80	Following	1/8 mile	Parking	Direct
6	60	Following	1/8 mile	Parking	Direct
7	60	Following	250 ft	Parking	Indirect
8	80	Parking	Direct	Following	250 ft

Gap/Viewing Method - Gap distance if a following clock; visual method if parking clock

ORDER OF TRIALS FOR ANGULAR SESSION

SUBJECTS A AND B

DAY 1

Trial Number	Subject A	Subject B	Course Distance	Target Speed
	Elev., Viewing Dis.	Elev., Viewing Dis.		
1	Elevated, 200 ft.	Ground, 200 ft.	1/10 mile	60
2	Elevated, 200 ft.	Ground, 200 ft.	1/10 mile	45
3	Elevated, 200 ft.	Ground, 200 ft.	1/10 mile	80
4	Elevated, 200 ft.	Ground, 200 ft.	200 ft.	80
5	Elevated, 200 ft.	Ground, 200 ft.	200 ft.	45
6	Elevated, 200 ft.	Ground, 200 ft.	200 ft.	60
7	Ground, 200 ft.	Elevated, 200 ft.	1/10 mile	45
8	Ground, 200 ft.	Elevated, 200 ft.	1/10 mile	60
9	Ground, 200 ft.	Elevated, 200 ft.	1/10 mile	80
10	Ground, 200 ft.	Elevated, 200 ft.	200 ft.	60
11	Ground, 200 ft.	Elevated, 200 ft.	200 ft.	45
12	Ground, 200 ft.	Elevated, 200 ft.	200 ft.	80
13	Ground, 528 ft.	Elevated, 528 ft.	1/10 mile	45
14	Ground, 528 ft.	Elevated, 528 ft.	1/10 mile	80
15	Ground, 528 ft.	Elevated, 528 ft.	1/10 mile	60
16	Ground, 528 ft.	Elevated, 528 ft.	200 ft.	45
17	Ground, 528 ft.	Elevated, 528 ft.	200 ft.	60
18	Ground, 528 ft.	Elevated, 528 ft.	200 ft.	80
19	Elevated, 528 ft.	Ground, 528 ft.	200 ft.	80
20	Elevated, 528 ft.	Ground, 528 ft.	200 ft.	60
21	Elevated, 528 ft.	Ground, 528 ft.	200 ft.	45
22	Elevated, 528 ft.	Ground, 528 ft.	1/10 mile	45
23	Elevated, 528 ft.	Ground, 528 ft.	1/10 mile	60
24	Elevated, 528 ft.	Ground, 528 ft.	1/10 mile	80

ORDER OF TRIALS FOR NIGHT MOVING STUDY

SUBJECTS A

DAY 1

Trial Number	Target Speed
1	45
2	60
3	60
4	80
5	45
6	80

ORDER OF TRIALS FOR PARKING STUDY

SUBJECTS A AND B

DAY 1

Trial Number	Subject A Course Distance	Subject B Course Distance	Target Speed
1	200 ft.	1/10 mile	60
2	200 ft.	1/10 mile	80
3	1/10 mile	200 ft.	80
4	1/10 mile	200 ft.	60

ORDER OF TRIALS FOR REFERENCE MARKER ALIGNMENT STUDY

SUBJECT A

DAY 1

Trial Number	Target Speed
1	60
2	45
3	80

APPENDIX E

Testing Procedure and Protocol Statement

Testing Procedure and Protocol

The Transportation Research Center (TRC) has been contracted by the National Highway Traffic Safety Administration to conduct a study to assess the speed measurement ability of VASCAR under various test conditions including Following, Approaching from the Rear, Angular, and Parking methods. In order to properly test VASCAR, it is very important that professionally trained and certified VASCAR users are a part of this study. The results of this testing may be used to refine or revise the VASCAR manual.

The testing of VASCAR will be performed at TRC test facilities. Other TRC testing will be conducted in close proximity to the testing you will be involved in. All of the personnel involved in testing will be in communication with the control tower and each other using hand held radios. The control tower will give warning if there is any testing being conducted that will interfere with the testing that you will be involved with. Proper protocol involved with the different testing areas will be thoroughly explained before testing begins.

If at any time during the study you do not wish to continue to complete the testing, you have the right to terminate your involvement in the study.

Some of the testing to be conducted will be at higher speeds (85 mph maximum). It is important that you are aware that there is some risk involved in testing at high speeds. This risk is minimized by having professional drivers involved in the testing conducted at the TRC.

As stated above, you will be performing Following, Approaching from the Rear, Angular, and Parking methods. If at any time you feel that you have an unacceptable clock (a clock you would not take when out on routine patrol), just mention that you have a bad clock, and the test will be repeated.

The true vehicle speed will be measured using a photocell. The speed from your clock will be compared to this true vehicle speed. During the course of testing we will not be able to provide you with information concerning the accuracy of your clocks. This information can be provided after testing has been completed.

The results of this testing will be kept confidential. The test results will be reported, but your name will never be associated with the data. The data will be labeled as Officer A, Officer B, etc.. You will be given a copy of your data 3 weeks following completion of this testing. These results will be sent directly to you. Your superior officers will not be given copies of individual results unless you chose to share the results provided to you. We will send you a copy of the final report when it is available. This report will contain a more thorough analysis of your results.

Finally, you should know how important your contribution is to this study. Without the dedication of professionals like yourself, this research would not be completed.

I have read and understand the explanation of the testing procedure and protocol. I also understand that I can terminate my involvement in this study at any time.

Signature ______________________________

APPENDIX F

Determination of Accuracy of Photocell Measurement System

As stated in section 4.4, the target vehicle true speed was measured using a SUNX-RS-120H photocell, an RTI-815 analog acquisition board, and onboard computer. Several tests were run to determine the accuracy of this system. A Nicolet oscilloscope, triggered by electronic trip switches, was used as the standard. The trip switches were placed next to the photocell reflector plates. The Nicolet's timing resolution was set at 1 msec. The target vehicle covered a 100 foot course at nominal speeds of 45 and 80 mph. Both the Nicolet and the photocell system measured the time for the target vehicle to cover the 100 foot course. The results are presented in Table F.1.

Table F.1: Comparison of Photocell System and Nicolet Time Measurements

Trial Number	Photocell Time	Nicolet Time	Time Error
1	0.880	0.880	0.0
2	0.881	0.881	0.0
3	0.874	0.874	0.0
4	0.877	0.877	0.0
5	0.880	0.880	0.0
6	0.879	0.879	0.0
7	1.506	1.506	0.0
8	1.408	1.408	0.0

As seen in Table F.1, the photocell system and the Nicolet oscilloscope gave the same exact times.

APPENDIX G

Debriefing Guide and Results

1. **Did you encounter any problems during the experiment? (explain)**

   Had trouble with eye during one day of the testing - probably would not have run VASCAR on that day if on patrol.
   Shadow of guard shack interfered with bridge study.
   200 foot clocks - too short (n=3)
   Stationary bridge clock - no anticipation time for the far shadow.
   Reflective plates were not enough of a reference mark.
   Had some trouble getting use to car. (did not use own vehicle)
   Odometer module went out.

2. **On the scale below, please indicate how realistic you feel the conditions used in our study were.**

   1 2 3 4 5

   |---------|---------|---------|---------|

Test Condition	Subject Number 1	2	3	4	5	6	7	8	Mean
Overall study	3	3	3	3	4	3	4	3	3.25
Moving									
Following .1 mile	4	4	2	3	5	4	5	3.5	3.81
Following .3 mile	4	4	5	5	5	5	5	3.5	4.56
Leading .1 mile	4	4	2	2	5	4	5	5	3.88
Leading .3 mile	4	4	5	3	5	5	5	5	4.5
Angular									
Ele. C.D. V.D.									
G S S			1	1	1	1	1	4.5	1.58
G L S			4	2	2	2	5	4	3.17
G S L			1	1	1	3	1	4	1.83
G L L			5	3	4	4	5	4.5	4.25
E S S			1	1	1	1	1	4.5	1.58
E L S			5	2	2	2	5	4.5	3.42
E S L			1	1	1	3	1	4.5	1.92
E L L			5	2	4	5	5	4.5	4.25
Parking									
200 Feet			1	1	1	2			1.25
1/10 mile			1	3	4	3			2.75
Bridge									
Following									
Short Gap	1	1	5	5	5	2			3.17
Long Gap	1	1	5	5	4	5			3.50
Parking									
Direct Viewing	1	1	2	3	2	2			1.83
Indirect Viewing	1	1	2	2	2	3			1.83
Night Moving			5	5	5	5	5	5	5.00

3. **What parts of the study were not realistic? (probe for specific situations)**

Much of the information gathered from this question is embedded in the table for question 2. From the table, the officers in general felt the 200 foot course distance clocks were not realistic. They felt it was too short. They also did not think the parking portion of the bridge study was realistic. They did not think the bridge shadow was wide enough. They said they were reacting to the bridge shadow instead of anticipating it.

Other comments:

Competing against photocell - little more stressful than the real world; the competition could make you better or worse depending on the individual.

Following clock harder than leading clock - couldn't anticipate the plate.

Angular clocking 200 foot distance - should align post with line of sight of officer.

4. **If you were to re-design this study, what would you change to improve it?**

Make scaffolding higher and wider for bridge shadow.
Have a car leading target car in bridge study so you can anticipate when the target vehicle is coming through bridge.
Parked portion of moving-stationary study - Place bridge shadows so you could see both shadows, maybe elevate officer.
Lighter colored car would help with bridge shadow.
Moving study - seams in road as reference markers instead of reflector plate and cone.
Do longer clocks in moving study - half mile clocks would be better.
Better reference markers in angular study; white posts were hard to see when you're on the ground.
Minimum clocks should be .1 mile.
Better visibility for first bridge shadow on long clocks.
Do some testing on the highway - more realistic marks.
In the moving study, use more definite references other than reflector plates.
Have officers use their own equipment.
Get rid of short clocks.
More night testing - can use long stationary clocks at night.
Put tape all the way across the lane so the following clocks are more anticipation instead of reaction.
White posts were hard to see when the sun was bright, a different color may have been better.

5. **For those runs you asked to repeat, what was the usual reason you needed to repeat them?**

Missing clock - knew I missed clock (n=5)
Time measurement was either early or late; distance measurements were almost always good. (n=2)
You know if you've hit the marks right or not.
Forgot to redial distance.
Used wrong marker - didn't activate switch at right marker.

6a. **Under what conditions in this study did you have the most confidence in your clocks?**

6b. **How about the least confidence?**

Each subject was asked to rank the confidence level of their clocks

Subjects 1 and 2 participated in the moving and the moving-stationary studies.

	Subject 1	Subject 2
Moving		
Following	1	1
Leading	2	2
Moving-Stationary		
Following		
Short Gap	3	3
Long Gap	4	4
Parking		
Direct Vision	5	5
Indirect Vision	6	6

Subjects 3, 4, 5, and 6 participated in the moving, moving-stationary, angular, and parking studies.

	Subject 3	Subject 4	Subject 5	Subject 6
Moving				
Following				
.1 mile	5	5	5	9
.3 mile	1	3	1	1
Leading				
.1 mile	6	6	6	10
.3 mile	4	4	2	2
Moving-Stationary				
Following				
Short Gap	2	1	3	5
Long Gap	3	2	11	6
Parking				
Direct Vision	12	8	17	7
Indirect Vision	13	9	18	8
Angular				
Ele. C.D. V.D.				
G S S	17	18	15	18
G L S	10	13	9	15
G S L	16	17	13	16
G L L	9	12	7	12
E S S	15	15	16	17
E L S	8	11	10	11
E S L	14	14	14	14
E L L	7	10	8	3
Parking				
200 Feet	18	16	12	13
1/10 mile	11	7	4	4

Subjects 7 and 8 participated in the moving, angular, and 200 foot aligned post studies.

			Subject 7	Subject 8
Moving				
Following				
.1 mile			6	4
.3 mile			5	3
Leading				
.1 mile			8	2
.3 mile			7	1
Angular				
Ele.	C.D.	V.D.		
G	S	S	13	13
G	L	S	4	8
G	S	L	11	11
G	L	L	2	7
E	S	S	10	10
E	L	S	3	6
E	S	L	9	9
E	L	L	1	5
200 foot aligned post			12	12

7. **What reference markers were you using in each aspect of the stationary study?**

200 feet, ground level
post at start, plate at end
white posts (n=5)
200 feet, elevated
post at start, plate at end
yellow tape
plates (n=2)
white posts (n=2)

528 feet, ground level
white posts (n=6)
528 feet, elevated
white posts (n=4)
plates (n=2)

8. **Do you have any other comments?**

The tests given were harder than the real world
If officer makes good clocks under these conditions, then the clocks made in real world will be good clocks.
Situations presented force you to be sharper-keener.
In real world situations I give the violator the benefit of the doubt by shutting their time off a little late.

APPENDIX H

Subject Information

TABLE H.1: Selected Biographic and Anthropometric Characteristics

Characteristic	Subject Number 1	2	3	4	5	6	7	8
Age	39	50	39	25	40	29	26	36
Years On Force	11.5	27	16	3	10	1	5	10
Years Experience Clocking Vehicles	11.5	27	16	3	9	1	5	7
Years Experience With VASCAR	1.42	11	15	.83	7	.5	1	7
Corrected Visual Acuity	20/10	20/13	20/15	20/15	20/13	20/13	20/15	20/13
Corrective Lenses	yes	yes	yes	no	yes	no	no	no
Purpose of Lenses	Reading	Reading	Stigma.	-	Reading	-	-	-
Seated Eye Height			49	49.75	46.5	47.25	46.75	48.5

TABLE H.2: Percentage Use and Typical Course Distances for VASCAR Methods

Method	Subject 1		Subject 2	
	Percent Use	Course Dis.	Percent Use	Course Dis.
Following Target Vehicle	2.375	300ft-.25mile	37.5	.1 - .3 mile
Opposite Direction	.025	300 - 500 ft	-	-
Approaching from Rear	2.375	300ft-.25mile	12.5	.1 mile
Parking	95.0	99 - 300 ft	50.0	200 - 300 ft
T-Intersection	-	-	-	-
Angular Clocking	-	-	-	-

Method	Subject 3		Subject 4	
	Percent Use	Course Dis.	Percent Use	Course Dis.
Following Target Vehicle	90.0	1 - 3 miles	85.0	$\geq$ 1 mile
Opposite Direction	-	-	-	-
Approaching from Rear	10.0	1 - 3 miles	15.0	$\geq$ 1 mile
Parking	-	-	-	-
T-Intersection	-	-	-	-
Angular Clocking	-	-	-	-

Method	Subject 5		Subject 6	
	Percent Use	Course Dis.	Percent Use	Course Dis.
Following Target Vehicle	22.5	.2 - .4 mile	45.0	.1 - 2 miles
Opposite Direction	.25	.2 mile	2.5	.1 mile
Approaching from Rear	2.25	.3 mile	2.5	.1 - .5 mile
Parking	7.5	.1 mile	2.5	.1 - .2 mile
T-Intersection	-	-	2.5	.1 - .2 mile
Angular Clocking	67.5	.1 - .3 mile	45.0	.1 - .2 mile

Method	Subject 7		Subject 8	
	Percent Use	Course Dis.	Percent Use	Course Dis.
Following Target Vehicle	29.7	$\geq$ .9 mile	72.0	$\geq$ 1 mile
Opposite Direction	.3	.2 mile	4.5	.25 mile
Approaching from Rear	-	-	13.5	.25 mile
Parking	-	-	2.5	.1 mile
T-Intersection	-	-	-	-
Angular Clocking	70.0	.2217 mile	7.5	.1 mile

APPENDIX I

Raw Data and Statistical Results

Several statistical terms are used to present the results. The following definitions will aid in understanding the results:

Mean - the mean is nothing more than the average; the arithmetic sum of all values, divided by the total number of values in the data set:

$$Mean = \overline{x} = \frac{1}{n}\sum_{i=1}^{c} x_i \tag{I.1}$$

Variance - is a measure of the variability of the data set:

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{c} (x_i-\overline{x})^2 \tag{I.2}$$

Standard Deviation - the square root of the variance; it is also a measure of the variability of the data set.

Type I Error - falsely concluding that something is an effect (the alternative hypothesis) when it is not.

p - the probability of committing a Type I error; $p \leq 0.05$ is used to determine if a variable is a statistically significant effect.

Mean Square Error - MSE; a measure of the unexplained error

$$MSE = \frac{Unexplained\ Variation}{n-2} \tag{I.3}$$

Two Sided Upper 90th Percentile Tolerance Limit with a 95 Percent Confidence - 95 percent of the population is below this limit; to calculate a tolerance limit, two conditions must be met.

1. All assignable causes of variability must be detected and eliminated so the remaining variability may be considered random.

2. Certain assumptions must be made concerning the nature of the statistical population under study - for this study a normal distribution is assumed.

$$Upper\ 95\%\ T.L = Mean + K \times \sqrt{MSE} \tag{I.4}$$

K is dependant on the number of samples (n)

Observed Upper Nth Percentile - N percent of the data in the sample is equal to or less than this value; if the Nth percentile is not an exact sample point, then the value is linearly interpolated between the data points immediately below and immediately above the Nth percentile.

For more thorough statistical definitions see [1]

1 Ostle, Bernard, Statistics in Research, 2nd Edition, The Iowa State University Press, 1963.

TABLE I.1 -- Raw Data for VASCAR Timing Mechanism Study

VASCAR Unit	Nicolet Time	VASCAR Time	VASCAR Calculated Time	Time Error
1	1.521	1.51	1.512	-0.009
1	1.296	1.26	1.26	-0.036
1	0.99	0.97	0.972	-0.018
1	0.91	0.9	0.9	-0.01
1	2.01	1.98	1.98	-0.03
1	2.662	2.66	2.664	0.002
1	3.108	3.09	3.096	-0.012
1	3.082	3.06	3.06	-0.022
1	2.696	2.66	2.664	-0.032
1	3.223	3.2	3.204	-0.019
1	2.586	2.55	2.556	-0.03
1	2.881	2.84	2.844	-0.037
1	1.405	1.36	1.368	-0.037
1	1.671	1.65	1.656	-0.015
1	1.118	1.11	1.116	-0.002
1	1.346	1.33	1.332	-0.014
1	1.137	1.11	1.116	-0.021
1	2.412	2.37	2.376	-0.036
1	3.484	3.45	3.456	-0.028
1	2.436	2.41	2.412	-0.024
1	1.689	1.65	1.656	-0.033
1	2.599	2.59	2.592	-0.007
1	2.807	2.77	2.772	-0.035
1	2.072	2.05	2.052	-0.02
1	1.679	1.65	1.656	-0.023
1	2.134	2.12	2.124	-0.01
1	1.984	1.94	1.944	-0.04
1	1.936	1.9	1.908	-0.028
1	2.532	2.52	2.52	-0.012
1	0.882	0.86	0.864	-0.018
1	1.386	1.36	1.368	-0.018
1	1.709	1.69	1.692	-0.017
1	2.098	2.08	2.088	-0.01
1	3.444	3.42	3.42	-0.024
1	2.18	2.16	2.16	-0.02
1	1.919	1.9	1.908	-0.011
1	1.451	1.44	1.44	-0.011
1	1.332	1.29	1.296	-0.036
1	2.806	2.77	2.772	-0.034

TABLE I.1 -- Raw Data for VASCAR Timing Mechanism Study (Continued)

VASCAR Unit	Nicolet Time	VASCAR Time	VASCAR Calculated Time	Time Error
1	2.251	2.23	2.232	-0.019
1	2.523	2.48	2.484	-0.039
1	3.843	3.81	3.816	-0.027
1	3.539	3.52	3.528	-0.011
1	3.48	3.45	3.456	-0.024
1	2.083	2.05	2.052	-0.031
1	3.829	3.81	3.816	-0.013
1	3.617	3.6	3.6	-0.017
1	1.161	1.15	1.152	-0.009
1	1.739	1.72	1.728	-0.011
1	2.911	2.88	2.88	-0.031
1	2.231	2.19	2.196	-0.035
1	2.487	2.44	2.448	-0.039
1	1.535	1.51	1.512	-0.023
1	0.999	0.97	0.972	-0.027
1	2.748	2.73	2.736	-0.012
1	3.302	3.27	3.276	-0.026
1	3.641	3.6	3.6	-0.041
1	2.503	2.48	2.484	-0.019
2	1.521	1.51	1.512	-0.009
2	1.296	1.29	1.296	-2.2E-16
2	0.99	0.97	0.972	-0.018
2	0.91	0.9	0.9	-0.01
2	2.01	1.98	1.98	-0.03
2	2.662	2.66	2.664	0.002
2	3.108	3.09	3.096	-0.012
2	3.082	3.06	3.06	-0.022
2	2.696	2.66	2.664	-0.032
2	3.223	3.2	3.204	-0.019
2	2.586	2.55	2.556	-0.03
2	2.881	2.84	2.844	-0.037
2	1.405	1.36	1.368	-0.037
2	1.671	1.65	1.656	-0.015
2	1.118	1.08	1.08	-0.038
2	1.346	1.33	1.332	-0.014
2	1.137	1.11	1.116	-0.021
2	2.412	2.37	2.376	-0.036
2	3.484	3.45	3.456	-0.028
2	2.436	2.41	2.412	-0.024
2	1.689	1.65	1.656	-0.033
2	2.599	2.59	2.592	-0.007

TABLE I.1 -- Raw Data for VASCAR Timing Mechanism Study (Continued)

VASCAR Unit	Nicolet Time	VASCAR Time	VASCAR Calculated Time	Time Error
2	2.807	2.77	2.772	-0.035
2	2.072	2.05	2.052	-0.02
2	1.679	1.65	1.656	-0.023
2	2.134	2.12	2.124	-0.01
2	1.984	1.94	1.944	-0.04
2	1.936	1.9	1.908	-0.028
2	2.532	2.52	2.52	-0.012
2	0.882	0.86	0.864	-0.018
2	1.386	1.36	1.368	-0.018
2	1.709	1.69	1.692	-0.017
2	2.098	2.08	2.088	-0.01
2	3.444	3.42	3.42	-0.024
2	2.18	2.16	2.16	-0.02
2	1.919	1.9	1.908	-0.011
2	1.451	1.44	1.44	-0.011
2	1.332	1.29	1.296	-0.036
2	2.806	2.77	2.772	-0.034
2	2.251	2.23	2.232	-0.019
2	2.523	2.48	2.484	-0.039
2	3.843	3.81	3.816	-0.027
2	3.539	3.52	3.528	-0.011
2	3.48	3.45	3.456	-0.024
2	2.083	2.05	2.052	-0.031
2	3.829	3.81	3.816	-0.013
2	3.617	3.6	3.6	-0.017
2	1.161	1.15	1.152	-0.009
2	1.739	1.72	1.728	-0.011
2	2.911	2.88	2.88	-0.031
2	2.231	2.19	2.196	-0.035
2	2.487	2.44	2.448	-0.039
2	1.535	1.51	1.512	-0.023
2	0.999	0.97	0.972	-0.027
2	2.748	2.73	2.736	-0.012
2	3.302	3.27	3.276	-0.026
2	3.641	3.6	3.6	-0.041
2	2.503	2.48	2.484	-0.019

TABLE I.2 -- Raw Data for the Distance Measurement Study

Subject Number	True Distance	True Dist Recoded	VASCAR Distance	Distance Error	% Distance Error
1	0.5	3	0.5	0	0
1	0.5	3	0.5	0	0
1	0.5	3	0.5002	0.0002	0.04
1	0.5	3	0.5001	0.0001	0.02
1	0.1	2	0.1	0	0
1	0.1	2	0.1001	0.0001	0.1
1	0.1	2	0.1	0	0
1	0.1	2	0.1001	0.0001	0.1
1	0.037878	1	0.0379	0.000021	0.056
1	0.037878	1	0.0378	-0.00007	-0.208
1	0.037878	1	0.0379	0.000021	0.056
1	0.037878	1	0.0379	0.000021	0.056
2	0.5	3	0.5001	0.0001	0.02
2	0.5	3	0.5001	0.0001	0.02
2	0.5	3	0.5	0	0
2	0.5	3	0.5002	0.0002	0.04
2	0.1	2	0.1	0	0
2	0.1	2	0.1	0	0
2	0.1	2	0.1	0	0
2	0.1	2	0.1001	0.0001	0.1
2	0.037878	1	0.0378	-0.00007	-0.208
2	0.037878	1	0.0378	-0.00007	-0.208
2	0.037878	1	0.0379	0.000021	0.056
2	0.037878	1	0.0378	-0.00007	-0.208
3	0.5	3	0.4998	-0.0002	-0.04
3	0.5	3	0.4998	-0.0002	-0.04
3	0.5	3	0.5001	0.0001	0.02
3	0.5	3	0.5002	0.0002	0.04
3	0.1	2	0.1	0	0
3	0.1	2	0.1001	0.0001	0.1
3	0.1	2	0.0999	-0.0001	-0.1
3	0.1	2	0.1	0	0
3	0.037878	1	0.0379	0.000021	0.056
3	0.037878	1	0.0379	0.000021	0.056
3	0.037878	1	0.038	0.000121	0.32
3	0.037878	1	0.0379	0.000021	0.056

TABLE I.2 -- Raw Data for the Distance Measurement Study (Continued)

Subject Number	True Distance	True Dist Recoded	VASCAR Distance	Distance Error	% Distance Error
4	0.5	3	0.5	0	0
4	0.5	3	0.5	0	0
4	0.5	3	0.5001	0.0001	0.02
4	0.5	3	0.5001	0.0001	0.02
4	0.1	2	0.1	0	0
4	0.1	2	0.1	0	0
4	0.1	2	0.1001	0.0001	0.1
4	0.1	2	0.1	0	0
4	0.037878	1	0.0379	0.000021	0.056
4	0.037878	1	0.0378	-0.00007	-0.208
4	0.037878	1	0.0379	0.000021	0.056
4	0.037878	1	0.0379	0.000021	0.056
5	0.5	3	0.4999	-0.0001	-0.02
5	0.5	3	0.5001	0.0001	0.02
5	0.5	3	0.5002	0.0002	0.04
5	0.5	3	0.5003	0.0003	0.06
5	0.1	2	0.1	0	0
5	0.1	2	0.1	0	0
5	0.1	2	0.1	0	0
5	0.1	2	0.1	0	0
5	0.037878	1	0.0378	-0.00007	-0.208
5	0.037878	1	0.0379	0.000021	0.056
5	0.037878	1	0.0378	-0.00007	-0.208
5	0.037878	1	0.0378	-0.00007	-0.208
6	0.5	3	0.4999	-0.0001	-0.02
6	0.5	3	0.5001	0.0001	0.02
6	0.5	3	0.5002	0.0002	0.04
6	0.5	3	0.5002	0.0002	0.04
6	0.1	2	0.0999	-0.0001	-0.1
6	0.1	2	0.1001	0.0001	0.1
6	0.1	2	0.1	0	0
6	0.1	2	0.1001	0.0001	0.1
6	0.037878	1	0.0378	-0.00007	-0.208
6	0.037878	1	0.0378	-0.00007	-0.208
6	0.037878	1	0.0379	0.000021	0.056
6	0.037878	1	0.0379	0.000021	0.056

TABLE I.3 -- Summary of Speed Measurement Experiments

		S1	S2	S3	S4	S5	S6	S7	S8	All Subjects Combined	Upper 90% Tolerance Limit	Observed 95%-tile	Observed 99%-tile
Moving	N	48	48	48	48	48	48	48	48	384			
	Mean	-0.291	0.377	0.092	0.183	0.206	0.014	-0.137	0.054	0.062			
	SD	0.966	0.744	0.924	0.680	0.891	0.694	0.914	0.987	0.872	1.471	1.271	2.396
Moving-Following Method	N	24	24	24	24	24	24	24	24	192			
	Mean	-0.657	0.431	-0.253	0.217	-0.077	-0.036	-0.362	-0.218	-0.119			
	SD	1.033	0.839	0.952	0.789	0.993	0.715	1.166	1.133	0.991	1.550	0.943	2.407
Moving-Leading Method	N	24	24	24	24	24	24	24	24	192			
	Mean	0.076	0.324	0.437	0.148	0.488	0.064	0.087	0.326	0.244			
	SD	0.749	0.649	0.768	0.566	0.685	0.684	0.598	0.742	0.690	1.291	1.418	2.106
Night Moving	N			6	6	6	6	6	6	36			
	Mean			0.148	0.060	0.691	0.392	0.553	0.149	0.332			
	SD			0.297	0.451	0.681	0.232	0.679	0.206	0.493	1.046	1.450	1.824
Bridge-Moving	N	8	8	12	12	8	8			56			
	Mean	0.257	0.594	0.233	-0.004	0.198	0.367			0.251			
	SD	1.012	0.389	0.304	0.605	0.553	0.615			0.602	1.308	1.296	1.544
Bridge-Stationary	N	8	8	12	11	8	8			55			
	Mean	2.238	0.816	0.467	0.753	0.965	0.948			0.975			
	SD	1.271	0.421	0.324	2.363	0.506	0.442			0.830	1.673	2.396	3.791
Park	N			12	12	12	12			48			
	Mean			1.471	-0.859	-2.072	-0.565			-0.506			
	SD			2.816	2.145	2.100	2.027			2.566	1.996	3.350	4.334
Angular	N			96	96	96	96	96	96	576			
	Mean			-0.089	0.163	0.372	1.667	0.524	1.791	0.738			
	SD			0.972	1.417	2.107	2.494	1.621	2.137	1.992	3.906	4.650	7.332
Align	N							12	12	24			
	Mean							-0.572	0.447	-0.063			
	SD							1.601	1.877	1.784	3.999	2.698	2.877
Entire Study	N									1180			
	Mean									0.426			
	SD									1.646	NA	3.708	6.439

TABLE I.4 -- Moving Summary Statistics

VASCAR Method	Course Distance	Nominal Speed	N	Mean	Upper 90% Limit	Observed 95%-tile	Observed 99%-tile	MSE	Variance	K
Overall			384	0.062	1.471	1.271	2.396	0.6469	0.760	1.752
Following			192	-0.119	1.550	0.943	2.407	0.8577	0.983	1.802
Approach from Rear			192	0.244	1.291	1.418	2.106	0.3382	0.476	1.802
Following	0.1		96	-0.309	2.139	1.143	2.943	1.6957	1.696	1.880
Following	0.3		96	0.070	0.985	0.581	0.908	0.2371	0.207	1.880
App. Rear	0.1		96	0.236	1.596	1.678	2.566	0.5232	0.808	1.880
App. Rear	0.3		96	0.251	0.730	0.796	1.358	0.0648	0.148	1.880
Following	0.1	45	32	-0.067	1.113	0.725	0.974	0.3096	0.403	2.120
App. Rear	0.1	45	32	0.222	1.334	1.135	1.249	0.2751	0.294	2.120
Following	0.1	60	32	0.079	1.470	1.069	1.493	0.4302	0.543	2.120
App. Rear	0.1	60	32	-0.077	1.789	1.504	1.728	0.7751	0.838	2.120
Following	0.1	80	32	-0.939	3.138	2.584	3.183	3.6987	3.627	2.120
App. Rear	0.1	80	32	0.464	2.787	2.267	2.581	1.2010	1.132	2.120
Following	0.3	45	32	0.124	0.543	0.358	0.664	0.0269	0.039	2.120
App. Rear	0.3	45	32	0.209	0.669	0.575	0.586	0.0293	0.047	2.120
Following	0.3	60	32	0.095	0.592	0.473	0.577	0.0549	0.080	2.120
App. Rear	0.3	60	32	0.141	0.890	0.699	0.783	0.1249	0.143	2.120
Following	0.3	80	32	-0.071	1.632	0.813	0.988	0.6451	0.505	2.120
App. Rear	0.3	80	32	0.404	1.427	1.169	1.467	0.2329	0.225	2.120

Moving Study (all conditions combined)

A. Variables

Course Distance
Nominal Speed
VASCAR Method
  Subject Number
  Groups
Replication

B. Significant Effects ($p \leq 0.05$)

Subject Number - see summary of experiment

Course Distance

Course Distance	Mean Error
.1	-.04
.3	.16

VASCAR Method

VASCAR Method	Mean Error
Following	.12
Leading	.24

Course Distance x Method

Course Distance	Mean Error	
	Following	Approach from Rear
.1	-.31	.24
.3	.07	.25

Nominal Speed x Method

Nominal Speed	Mean Error	
	Following	Approach from Rear
45	.03	.22
60	.09	.03
80	-.47	.48

Course Distance x Speed x Method - see Moving Summary Statistics on previous page

Moving Study - Analysis by Method

A. Significant Effects for Following Method ($p \leq 0.05$)

Course Distance
Nominal Speed
Subject Number
Course Distance x Nominal Speed

Course Distance	Mean Speed Error		
	45	60	80
.1	-.07	.08	-.94
.3	.12	.09	-.01

B. Significant Effects for Leading Method ($p \leq 0.05$)

Nominal Speed

The following list of definitions explain the title headings found in the raw data listings:

SubNum - Subject Number

SessNum - Session Number, the number given to each study (i.e., moving, bridge, etc.)

RepNum - Replicate Number

Repeat# - Repeat Number, used only in bridge study, subjects 1 and 2 made repeats instead of replicates

TrialNo - Trial Number

CrsDist - Course Distance

CrsDistR- Course Distance Recoded, represents the course distance - used for statistical analysis

RefType - Reference Type

VMethod - VASCAR Method, used in moving study, 1 = following, 2 = Approaching from the Rear

NomSpd - Nominal Speed, represents the desired speed for statistical analysis

DsrdSpd - Desired Speed in mph

NoAttemp- Number of Attempts necessary to complete an acceptable clock - acceptability based on subject's assessment of the accuracy of his clock

TrueTime- True Time, measured by photocell system

TrueSpd - True Speed, calculated using known distance and true time

VASspeed- VASCAR displayed speed

VAStime - VASCAR time

VASdist - VASCAR Distance

VehGap - Vehicle Gap, distance between target vehicle and police cruiser

VehGapR - Vehicle Gap Recoded, used for statistical analysis

VisMode - Visual Mode, method of viewing target vehicle, direct and indirect (mirrors)

VisModeR- Visual Mode Recoded, used for statistical analysis

Elevatn - Elevation, subject elevation, used in angular study, 1 = ground, 2 = elevated

ViewDist- Viewing Distance, used in angular study, 1 = 200 feet, 2 = 528 feet

TABLE I.5 -- Raw Data for Moving Study

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	VMethod	NomSpd	DesrdSpd	NoAttempts	TrueTime	TrueSpd	VASspeed	VAStime	VASdist
1	1	1	1	0.1	1	1	1	2	60	2	6.158	58.461	57.9	6.22	0.1002
1	1	1	2	0.1	1	1	2	1	45	1	8.018	44.899	45.1	7.95	0.0997
1	1	1	3	0.1	1	1	2	2	60	1	6.111	58.910	59.5	6.04	0.0999
1	1	1	4	0.1	1	1	1	1	45	1	7.873	45.726	45.6	7.84	0.0995
1	1	1	5	0.1	1	1	2	3	80	1	4.478	80.393	81.3	4.53	0.1024
1	1	1	6	0.1	1	1	1	3	80	1	4.423	81.393	78.3	4.6	0.1002
1	1	1	7	0.3	2	1	1	3	80	1	13.286	81.289	80.9	13.32	0.2994
1	1	1	8	0.3	2	1	2	1	45	1	24.445	44.181	44.4	24.44	0.3016
1	1	1	9	0.3	2	1	1	2	60	1	18.469	58.476	57.9	18.64	0.3004
1	1	1	10	0.3	2	1	2	2	60	1	18.263	59.136	59.2	18.21	0.2999
1	1	1	11	0.3	2	1	1	1	45	1	24.637	43.837	43.9	24.51	0.299
1	1	1	12	0.3	2	1	2	3	80	1	13.632	79.225	79	13.6	0.2988
1	1	2	1	0.3	2	1	1	1	45	1	23.743	45.487	45.7	23.58	0.2997
1	1	2	2	0.3	2	1	1	3	80	1	13.527	79.840	80	13.46	0.2994
1	1	2	3	0.3	2	1	1	2	60	1	18.28	59.081	59.1	18.28	0.3006
1	1	2	4	0.3	2	1	2	3	80	1	13.465	80.208	81	13.32	0.2999
1	1	2	5	0.3	2	1	2	1	45	1	24.524	44.038	44	24.44	0.2991
1	1	2	6	0.3	2	1	2	2	60	1	18.146	59.517	59.7	18.07	0.2998
1	1	2	7	0.1	1	1	1	1	45	1	7.85	45.860	44.9	7.99	0.0996
1	1	2	8	0.1	1	1	2	3	80	1	4.477	80.411	81.3	4.39	0.0992
1	1	2	9	0.1	1	1	1	2	60	1	6.022	59.781	59.1	6.08	0.0998
1	1	2	10	0.1	1	1	2	2	60	1	6.092	59.094	58.9	6.12	0.1001
1	1	2	11	0.1	1	1	2	1	45	1	7.938	45.351	45.9	7.88	0.1005
1	1	2	12	0.1	1	1	1	3	80	1	4.428	81.301	78.4	4.57	0.0096
1	1	3	1	0.3	2	1	1	1	45	1	23.657	45.652	46.1	23.42	0.3005
1	1	3	2	0.3	2	1	1	2	60	1	18.156	59.484	59	18.28	0.2999
1	1	3	3	0.3	2	1	2	2	60	1	18.185	59.390	59.5	18.07	0.299
1	1	3	4	0.3	2	1	2	1	45	1	23.646	45.674	46	23.4	0.2995
1	1	3	5	0.3	2	1	2	3	80	1	13.419	80.483	80.4	13.35	0.2985
1	1	3	6	0.3	2	1	1	3	80	1	13.304	81.179	81.5	13.21	0.2991
1	1	3	7	0.1	1	1	2	2	60	1	6.125	58.776	58.6	6.15	0.1002
1	1	3	8	0.1	1	1	2	3	80	1	4.449	80.917	79.4	4.57	0.1008
1	1	3	9	0.1	1	1	1	3	80	1	4.457	80.772	78.1	4.6	0.1
1	1	3	10	0.1	1	1	1	1	45	1	7.993	45.039	43.3	8.28	0.0996
1	1	3	11	0.1	1	1	1	2	60	1	6.096	59.055	57.6	6.08	0.0974
1	1	3	12	0.1	1	1	2	1	45	1	8.05	44.720	44.3	8.1	0.0997
1	1	4	1	0.1	1	1	1	1	45	1	7.894	45.604	44.3	8.1	0.0998
1	1	4	2	0.1	1	1	1	3	80	1	4.484	80.285	80	4.5	0.1001
1	1	4	3	0.1	1	1	2	2	60	1	6.028	59.721	57.4	6.26	0.1
1	1	4	4	0.1	1	1	2	1	45	1	7.877	45.703	46.9	7.7	0.1005
1	1	4	5	0.1	1	1	1	2	60	1	6.053	59.475	59.4	6.04	0.0998
1	1	4	6	0.1	1	1	2	3	80	1	4.457	80.772	80.7	4.42	0.0993
1	1	4	7	0.3	2	1	2	3	80	1	13.317	81.099	81.7	13.21	0.3
1	1	4	8	0.3	2	1	1	3	80	1	13.341	80.953	81.2	13.28	0.2997
1	1	4	9	0.3	2	1	1	2	60	1	18.392	58.721	58.7	18.36	0.2996
1	1	4	10	0.3	2	1	1	1	45	1	24.148	44.724	44.8	24.04	0.2997
1	1	4	11	0.3	2	1	2	1	45	1	24.178	44.669	44.6	24.12	0.2994
1	1	4	12	0.3	2	1	2	2	60	1	18.337	58.897	59.2	18.25	0.3005

TABLE I.5 -- Raw Data for Moving Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	VMethod	NomSpd	DesrdSpd	NoAttempts	TrueTime	TrueSpd	VASspeed	VAStime	VASdist
2	1	1	1	0.1	1	1	2	2	60	1	6.141	58.622	58	6.26	0.101
2	1	1	2	0.1	1	1	1	1	45	1	8.018	44.899	44.6	8.1	0.1003
2	1	1	3	0.1	1	1	1	2	60	1	6.111	58.910	59.9	6.01	0.1001
2	1	1	4	0.1	1	1	2	1	45	1	7.873	45.726	47	7.63	0.0998
2	1	1	5	0.1	1	1	1	3	80	2	4.466	80.609	81.9	4.35	0.0991
2	1	1	6	0.1	1	1	2	3	80	2	4.494	80.107	80	4.5	0.1
2	1	1	7	0.3	2	1	2	3	80	2	13.452	80.285	81.1	13.35	0.301
2	1	1	8	0.3	2	1	1	1	45	1	24.445	44.181	44.2	24.33	0.2989
2	1	1	9	0.3	2	1	2	2	60	1	18.469	58.476	58.9	18.36	0.3005
2	1	1	10	0.3	2	1	1	2	60	2	18.461	58.502	58.7	18.32	0.2991
2	1	1	11	0.3	2	1	2	1	45	1	24.637	43.837	44.3	24.51	0.302
2	1	1	12	0.3	2	1	1	3	80	1	13.632	79.225	79.8	13.53	0.3002
2	1	2	1	0.3	2	1	2	1	45	1	23.743	45.487	45.5	23.65	0.2994
2	1	2	2	0.3	2	1	2	3	80	1	13.527	79.840	79.7	13.5	0.2989
2	1	2	3	0.3	2	1	2	2	60	1	18.28	59.081	59.1	18.21	0.2992
2	1	2	4	0.3	2	1	1	3	80	1	13.465	80.208	80.5	13.35	0.2987
2	1	2	5	0.3	2	1	1	1	45	1	24.524	44.038	44.1	24.4	0.2995
2	1	2	6	0.3	2	1	1	2	60	1	18.146	59.517	59.5	18.03	0.2984
2	1	2	7	0.1	1	1	2	1	45	1	7.85	45.860	46.1	7.81	0.1
2	1	2	8	0.1	1	1	1	3	80	1	4.477	80.411	81	4.39	0.0988
2	1	2	9	0.1	1	1	2	2	60	1	6.022	59.781	59.7	5.97	0.0991
2	1	2	10	0.1	1	1	1	2	60	1	6.092	59.094	59.3	6.01	0.099
2	1	2	11	0.1	1	1	1	1	45	1	7.938	45.351	46.1	7.81	0.1001
2	1	2	12	0.1	1	1	2	3	80	1	4.477	80.411	80	4.5	0.1
2	1	3	1	0.3	2	1	2	1	45	1	23.657	45.652	46	23.5	0.3005
2	1	3	2	0.3	2	1	2	2	60	1	18.156	59.484	59.7	18.07	0.2998
2	1	3	3	0.3	2	1	1	2	60	1	18.185	59.390	59.3	18.1	0.2986
2	1	3	4	0.3	2	1	1	1	45	1	23.646	45.674	45.9	23.47	0.2998
2	1	3	5	0.3	2	1	1	3	80	1	13.419	80.483	80.7	13.35	0.2997
2	1	3	6	0.3	2	1	2	3	80	1	13.304	81.179	81.7	13.17	0.2991
2	1	3	7	0.1	1	1	1	2	60	1	6.125	58.776	58.6	6.08	0.099
2	1	3	8	0.1	1	1	1	3	80	2	4.4	81.818	81.1	4.42	0.998
2	1	3	9	0.1	1	1	2	3	80	2	4.446	80.972	81.4	4.46	0.1009
2	1	3	10	0.1	1	1	2	1	45	1	7.993	45.039	44.8	7.95	0.0991
2	1	3	11	0.1	1	1	2	2	60	1	6.096	59.055	59.4	6.04	0.0999
2	1	3	12	0.1	1	1	1	1	45	1	8.05	44.720	45.8	7.81	0.0995
2	1	4	1	0.1	1	1	2	1	45	1	7.894	45.604	46.5	7.74	0.1
2	1	4	2	0.1	1	1	2	3	80	2	4.448	80.935	83.5	4.32	0.1002
2	1	4	3	0.1	1	1	1	2	60	1	6.028	59.721	60.2	5.94	0.0993
2	1	4	4	0.1	1	1	1	1	45	1	7.877	45.703	45.7	7.88	0.1001
2	1	4	5	0.1	1	1	2	2	60	1	6.053	59.475	59.2	6.04	0.0994
2	1	4	6	0.1	1	1	1	3	80	1	4.457	80.772	84.5	4.35	0.1022
2	1	4	7	0.3	2	1	1	3	80	1	13.317	81.099	81.5	13.24	0.3001
2	1	4	8	0.3	2	1	2	3	80	1	13.341	80.953	81.7	13.17	0.2993
2	1	4	9	0.3	2	1	2	2	60	2	18.201	59.337	59.5	18.14	0.3003
2	1	4	10	0.3	2	1	2	1	45	1	24.148	44.724	44.9	24.04	0.3004
2	1	4	11	0.3	2	1	1	1	45	1	24.178	44.669	44.6	24.08	0.2989
2	1	4	12	0.3	2	1	1	2	60	1	18.337	58.897	59.5	18.1	0.2996

TABLE I.5 -- Raw Data for Moving Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	VMethod	NomSpd	DesrdSpd	NoAttempts	TrueTime	TrueSpd	VASspeed	VAStime	VASdist
3	1	1	1	0.1	1	1	2	1	45	1	7.932	45.386	44.3	8.13	0.1001
3	1	1	2	0.1	1	1	2	3	80	1	4.519	79.664	78.9	4.6	0.101
3	1	1	3	0.1	1	1	2	2	60	1	6.053	59.475	58.9	6.15	0.1008
3	1	1	4	0.1	1	1	1	1	45	1	8.006	44.966	44.8	8.02	0.0999
3	1	1	5	0.1	1	1	1	3	80	1	4.532	79.435	75.8	4.75	0.1001
3	1	1	6	0.1	1	1	1	2	60	1	6.085	59.162	59.9	6.01	0.0995
3	1	1	7	0.3	2	1	2	3	80	1	13.265	81.417	81.3	13.24	0.2994
3	1	1	8	0.3	2	1	2	2	60	1	18.198	59.347	59.3	18.21	0.3003
3	1	1	9	0.3	2	1	1	1	45	2	23.924	45.143	45.2	23.83	0.2997
3	1	1	10	0.3	2	1	1	2	60	1	18.349	58.859	59.1	18.25	0.3
3	1	1	11	0.3	2	1	1	3	80	1	13.509	79.947	80	13.46	0.2994
3	1	1	12	0.3	2	1	2	1	45	1	24.488	44.103	44.1	24.48	0.3003
3	1	2	1	0.3	2	1	1	3	80	1	13.354	80.875	81.4	13.24	0.2998
3	1	2	2	0.3	2	1	2	3	80	1	13.425	80.447	81.8	13.21	0.3003
3	1	2	3	0.3	2	1	1	1	45	1	23.542	45.875	46	23.5	0.3007
3	1	2	4	0.3	2	1	2	2	60	1	18.095	59.685	60.4	17.89	0.3004
3	1	2	5	0.3	2	1	2	1	45	1	23.469	46.018	46.3	23.36	0.3011
3	1	2	6	0.3	2	1	1	2	60	1	18.168	59.445	59.5	18.14	0.3002
3	1	2	7	0.1	1	1	1	1	45	1	7.894	45.604	45.9	7.88	0.1006
3	1	2	8	0.1	1	1	1	2	60	1	5.994	60.060	59.6	6.01	0.0996
3	1	2	9	0.1	1	1	2	3	80	1	4.448	80.935	81.4	4.46	0.101
3	1	2	10	0.1	1	1	2	2	60	1	6.044	59.563	60.4	5.94	0.996
3	1	2	11	0.1	1	1	1	3	80	2	4.489	80.196	79.9	4.46	0.991
3	1	2	12	0.1	1	1	2	1	45	1	7.907	45.529	45.9	7.88	0.1007
3	1	3	1	0.1	1	1	2	3	80	2	4.487	80.232	82.3	4.42	0.1013
3	1	3	2	0.1	1	1	2	1	45	1	7.97	45.169	44.8	8.02	0.1001
3	1	3	3	0.1	1	1	1	2	60	1	6.068	59.328	58.9	6.12	0.1002
3	1	3	4	0.1	1	1	2	2	60	1	6.123	58.795	60.4	6.01	0.101
3	1	3	5	0.1	1	1	1	1	45	1	8.069	44.615	44.1	8.13	0.0998
3	1	3	6	0.1	1	1	1	3	80	1	4.47	80.537	78.4	4.57	0.0996
3	1	3	7	0.3	2	1	1	1	45	1	23.839	45.304	45.4	23.79	0.3001
3	1	3	8	0.3	2	1	2	1	45	1	23.936	45.120	45.7	23.61	0.2998
3	1	3	9	0.3	2	1	1	3	80	2	13.423	80.459	78.9	13.64	0.2992
3	1	3	10	0.3	2	1	1	2	60	1	18.152	59.498	59.2	18.18	0.2993
3	1	3	11	0.3	2	1	2	3	80	2	13.324	81.057	81.2	13.28	0.2999
3	1	3	12	0.3	2	1	2	2	60	1	18.202	59.334	59.7	18.07	0.2999
3	1	4	1	0.1	1	1	2	1	45	1	7.909	45.518	46.1	7.84	0.1005
3	1	4	2	0.1	1	1	1	1	45	2	8.045	44.748	45	8.02	0.1003
3	1	4	3	0.1	1	1	2	2	60	1	6.044	59.563	61	5.94	0.1006
3	1	4	4	0.1	1	1	1	3	80	1	4.451	80.881	81	4.46	0.1005
3	1	4	5	0.1	1	1	1	2	60	2	6.062	59.386	59.6	6.04	0.1002
3	1	4	6	0.1	1	1	2	3	80	2	4.478	80.393	81.8	4.42	0.1006
3	1	4	7	0.3	2	1	2	3	80	1	13.477	80.137	80.9	13.35	0.3002
3	1	4	8	0.3	2	1	1	2	60	1	18.177	59.416	59.8	18.03	0.2997
3	1	4	9	0.3	2	1	2	2	60	1	18.065	59.784	60.1	17.96	0.3003
3	1	4	10	0.3	2	1	2	1	45	2	23.669	45.629	45.8	23.54	0.2995
3	1	4	11	0.3	2	1	1	3	80	1	13.441	80.351	80.4	13.42	0.3001
3	1	4	12	0.3	2	1	1	1	45	2	23.336	46.280	46.5	23.25	0.3005

TABLE I.5 -- Raw Data for Moving Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	VMethod	NomSpd	DesrdSpd	NoAttempts	TrueTime	TrueSpd	VASspeed	VAStime	VASdist
4	1	1	1	0.1	1	1	1	1	45	2	8.128	44.291	44.4	8.06	0.0995
4	1	1	2	0.1	1	1	1	3	80	1	4.519	79.664	80.4	4.5	0.1005
4	1	1	3	0.1	1	1	1	2	60	1	6.053	59.475	60.1	5.97	0.0998
4	1	1	4	0.1	1	1	2	1	45	1	8.006	44.966	44.9	7.99	0.0998
4	1	1	5	0.1	1	1	2	3	80	1	4.532	79.435	80	4.57	0.1017
4	1	1	6	0.1	1	1	2	2	60	1	6.085	59.162	58.3	6.19	0.1003
4	1	1	7	0.3	2	1	1	3	80	1	13.265	81.417	81.9	13.21	0.3007
4	1	1	8	0.3	2	1	1	2	60	1	18.198	59.347	59.4	18.14	0.2998
4	1	1	9	0.3	2	1	2	1	45	2	23.924	45.143	45.1	23.86	0.2993
4	1	1	10	0.3	2	1	2	2	60	1	18.349	58.859	57.8	18.93	0.3045
4	1	1	11	0.3	2	1	2	3	80	1	13.509	79.947	79.7	13.5	0.2991
4	1	1	12	0.3	2	1	1	1	45	1	24.488	44.103	44.3	24.37	0.3004
4	1	2	1	0.3	2	1	2	3	80	1	13.354	80.875	81.6	13.24	0.3004
4	1	2	2	0.3	2	1	1	3	80	1	13.425	80.447	81.2	13.28	0.2998
4	1	2	3	0.3	2	1	2	1	45	1	23.542	45.875	46.1	23.4	0.2999
4	1	2	4	0.3	2	1	1	2	60	1	18.095	59.685	59.8	18	0.299
4	1	2	5	0.3	2	1	1	1	45	1	23.469	46.018	46.3	23.29	0.2999
4	1	2	6	0.3	2	1	2	2	60	1	18.168	59.445	59.9	18.07	0.3009
4	1	2	7	0.1	1	1	2	1	45	2	8.013	44.927	45.2	7.95	0.0999
4	1	2	8	0.1	1	1	2	2	60	1	5.994	60.060	60	5.97	0.0996
4	1	2	9	0.1	1	1	1	3	80	1	4.448	80.935	83.3	4.35	0.1008
4	1	2	10	0.1	1	1	1	2	60	1	6.044	59.563	59.5	6.08	0.1005
4	1	2	11	0.1	1	1	2	3	80	1	4.398	81.855	81.8	4.39	0.0999
4	1	2	12	0.1	1	1	1	1	45	1	7.907	45.529	45.4	7.95	0.1003
4	1	3	1	0.1	1	1	1	3	80	1	4.46	80.717	79.8	4.5	0.0997
4	1	3	2	0.1	1	1	1	1	45	1	7.97	45.169	45.1	7.95	0.0997
4	1	3	3	0.1	1	1	2	2	60	1	6.068	59.328	59.7	6.04	0.1003
4	1	3	4	0.1	1	1	1	2	60	1	6.123	58.795	59.9	6.01	0.1001
4	1	3	5	0.1	1	1	2	1	45	1	8.069	44.615	45.2	7.92	0.0994
4	1	3	6	0.1	1	1	2	3	80	1	4.47	80.537	81.5	4.42	0.1003
4	1	3	7	0.3	2	1	2	1	45	1	23.839	45.304	45.5	23.83	0.3014
4	1	3	8	0.3	2	1	1	1	45	1	23.936	45.120	45.3	23.79	0.2995
4	1	3	9	0.3	2	1	2	3	80	1	13.37	80.778	81.1	13.32	0.3
4	1	3	10	0.3	2	1	2	2	60	2	18.182	59.399	59.6	18.1	0.3001
4	1	3	11	0.3	2	1	1	3	80	1	13.324	81.057	81.5	13.21	0.2992
4	1	3	12	0.3	2	1	1	2	60	2	18.202	59.334	59.6	18.07	0.2992
4	1	4	1	0.1	1	1	1	1	45	1	7.909	45.518	46.2	7.88	0.1013
4	1	4	2	0.1	1	1	2	1	45	1	8.117	44.351	45.1	8.02	0.1007
4	1	4	3	0.1	1	1	1	2	60	1	6.044	59.563	59.5	6.04	0.1
4	1	4	4	0.1	1	1	2	3	80	1	4.451	80.881	82.2	4.35	0.0995
4	1	4	5	0.1	1	1	2	2	60	1	5.995	60.050	59.5	5.97	0.0988
4	1	4	6	0.1	1	1	1	3	80	1	4.431	81.246	79	4.57	0.1003
4	1	4	7	0.3	2	1	1	3	80	1	13.477	80.137	80.1	13.46	0.2997
4	1	4	8	0.3	2	1	2	2	60	1	18.177	59.416	58.7	18.39	0.2999
4	1	4	9	0.3	2	1	1	2	60	1	18.065	59.784	60	17.96	0.2997
4	1	4	10	0.3	2	1	1	1	45	1	24.287	44.468	44.6	24.19	0.2997
4	1	4	11	0.3	2	1	2	3	80	1	13.441	80.351	80.6	13.35	0.2993
4	1	4	12	0.3	2	1	2	1	45	2	23.336	46.280	46.3	23.25	0.2995

TABLE I.5 -- Raw Data for Moving Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	VMethod	NomSpd	DesrdSpd	NoAttempts	TrueTime	TrueSpd	VASspeed	VAStime	VASdist
5	1	1	1	0.1	1	1	1	1	45	1	8.999	40.004	39.6	9.1	0.1002
5	1	1	2	0.1	1	1	2	2	60	1	5.768	62.413	64.2	5.68	0.1014
5	1	1	3	0.1	1	1	2	3	80	1	4.705	76.514	78.3	4.6	0.1002
5	1	1	4	0.1	1	1	1	3	80	2	4.407	81.688	84.6	4.28	0.1007
5	1	1	5	0.1	1	1	1	2	60	1	6.672	53.957	53.8	6.66	0.0995
5	1	1	6	0.1	1	1	2	1	45	1	9.002	39.991	39.4	9.14	0.1001
5	1	1	7	0.3	2	1	1	2	60	2	18.411	58.661	59.1	18.25	0.2998
5	1	1	8	0.3	2	1	1	1	45	1	25.19	42.874	42.8	25.2	0.2997
5	1	1	9	0.3	2	1	2	2	60	1	16.78	64.362	64.2	16.81	0.3002
5	1	1	10	0.3	2	1	2	1	45	1	26.869	40.195	40.4	26.74	0.3003
5	1	1	11	0.3	2	1	1	3	80	1	13.248	81.522	81.3	13.28	0.3
5	1	1	12	0.3	2	1	2	3	80	1	13.221	81.688	81.3	13.32	0.3011
5	1	2	1	0.3	2	1	1	1	45	2	22.028	49.029	49.1	21.96	0.2999
5	1	2	2	0.3	2	1	1	2	60	1	17.273	62.525	62.5	17.28	0.3001
5	1	2	3	0.3	2	1	1	3	80	1	13.968	77.320	76.4	14	0.2974
5	1	2	4	0.3	2	1	2	1	45	1	22.217	48.611	49.2	21.99	0.3007
5	1	2	5	0.3	2	1	2	3	80	1	13.624	79.272	79.9	13.6	0.3021
5	1	2	6	0.3	2	1	2	2	60	1	16.825	64.190	64.4	16.74	0.2998
5	1	2	7	0.1	1	1	2	2	60	1	6.603	54.521	53.6	6.69	0.0998
5	1	2	8	0.1	1	1	2	1	45	1	8.677	41.489	41.6	8.71	0.1007
5	1	2	9	0.1	1	1	1	3	80	2	4.641	77.569	75.1	4.78	0.0999
5	1	2	10	0.1	1	1	2	3	80	1	4.32	83.333	83.9	4.32	0.1007
5	1	2	11	0.1	1	1	1	2	60	2	6.055	59.455	60.5	5.97	0.1005
5	1	2	12	0.1	1	1	1	1	45	1	7.641	47.114	46.8	7.66	0.0998
5	1	3	1	0.3	2	1	1	1	45	2	22.069	48.937	48.9	22.03	0.2997
5	1	3	2	0.3	2	1	2	2	60	1	17.915	60.285	61.1	17.74	0.3015
5	1	3	3	0.3	2	1	1	3	80	1	13.035	82.854	83	12.99	0.2996
5	1	3	4	0.3	2	1	1	2	60	1	17.457	61.866	62.3	17.38	0.3009
5	1	3	5	0.3	2	1	2	3	80	1	12.874	83.890	84.4	12.81	0.3006
5	1	3	6	0.3	2	1	2	1	45	1	24.134	44.750	45.2	23.83	0.2997
5	1	3	7	0.1	1	1	1	3	80	1	4.395	81.911	79.8	4.57	0.1014
5	1	3	8	0.1	1	1	2	3	80	1	4.202	85.673	86.7	4.14	0.0997
5	1	3	9	0.1	1	1	1	1	45	1	9.002	39.991	40.3	8.92	0.1
5	1	3	10	0.1	1	1	2	2	60	1	5.985	60.150	61.2	5.86	0.0997
5	1	3	11	0.1	1	1	1	2	60	1	5.591	64.389	65	5.58	0.1008
5	1	3	12	0.1	1	1	2	1	45	1	7.491	48.058	48.1	7.48	0.1001
5	1	4	1	0.1	1	1	1	1	45	1	7.794	46.189	45.9	7.81	0.0997
5	1	4	2	0.1	1	1	2	2	60	1	6.21	57.971	58	6.22	0.1004
5	1	4	3	0.1	1	1	1	2	60	1	5.955	60.453	59.9	6.01	0.1001
5	1	4	4	0.1	1	1	1	3	80	1	4.655	77.336	77.1	4.64	0.0995
5	1	4	5	0.1	1	1	2	1	45	1	7.668	46.948	47.8	7.56	0.1005
5	1	4	6	0.1	1	1	2	3	80	1	4.377	82.248	83.9	4.35	0.1015
5	1	4	7	0.3	2	1	2	3	80	1	13.739	78.608	79.4	13.64	0.3011
5	1	4	8	0.3	2	1	1	1	45	1	21.369	50.541	50.2	21.45	0.2997
5	1	4	9	0.3	2	1	1	3	80	1	13.844	78.012	78.3	13.82	0.3007
5	1	4	10	0.3	2	1	2	1	45	1	22.927	47.106	47.5	22.75	0.3003
5	1	4	11	0.3	2	1	1	2	60	1	17.72	60.948	61	17.67	0.2995
5	1	4	12	0.3	2	1	2	2	60	1	17.499	61.718	62	17.46	0.3008

TABLE I.5 -- Raw Data for Moving Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	VMethod	NomSpd	DesrdSpd	NoAttempts	TrueTime	TrueSpd	VASspeed	VAStime	VASdist
6	1	1	1	0.1	1	1	2	1	45	1	8.999	40.004	39.9	8.96	0.0994
6	1	1	2	0.1	1	1	1	2	60	2	5.765	62.446	62.3	5.72	0.0991
6	1	1	3	0.1	1	1	1	3	80	1	4.705	76.514	75.2	4.71	0.0986
6	1	1	4	0.1	1	1	2	3	80	1	4.391	81.986	80.6	4.42	0.0992
6	1	1	5	0.1	1	1	2	2	60	1	6.672	53.957	54.1	6.62	0.0997
6	1	1	6	0.1	1	1	1	1	45	1	9.002	39.991	40.3	8.92	0.1
6	1	1	7	0.3	2	1	2	2	60	1	18.603	58.055	58	18.61	0.3001
6	1	1	8	0.3	2	1	2	1	45	1	25.19	42.874	42.9	25.09	0.2997
6	1	1	9	0.3	2	1	1	2	60	1	16.78	64.362	64.6	16.7	0.2998
6	1	1	10	0.3	2	1	1	1	45	1	26.869	40.195	40.3	26.74	0.2998
6	1	1	11	0.3	2	1	2	3	80	1	13.248	81.522	81.6	13.1	0.2971
6	1	1	12	0.3	2	1	1	3	80	1	13.221	81.688	81.1	13.24	0.2986
6	1	2	1	0.3	2	1	2	1	45	2	22.028	49.029	49.2	21.88	0.2994
6	1	2	2	0.3	2	1	2	2	60	1	17.273	62.525	62.6	17.24	0.3003
6	1	2	3	0.3	2	1	2	3	80	1	13.968	77.320	77.5	13.89	0.2993
6	1	2	4	0.3	2	1	1	1	45	2	22.738	47.498	47.7	22.57	0.2995
6	1	2	5	0.3	2	1	1	3	80	1	13.624	79.272	80.3	13.42	0.2996
6	1	2	6	0.3	2	1	1	2	60	1	16.825	64.190	64.3	16.7	0.2987
6	1	2	7	0.1	1	1	1	2	60	1	6.603	54.521	54.6	6.55	0.0994
6	1	2	8	0.1	1	1	1	1	45	1	8.677	41.489	42	8.53	0.0995
6	1	2	9	0.1	1	1	2	3	80	1	4.645	77.503	78.4	4.6	0.1004
6	1	2	10	0.1	1	1	1	3	80	2	4.359	82.588	80.9	4.39	0.0987
6	1	2	11	0.1	1	1	2	2	60	1	6.034	59.662	58.9	6.12	0.1001
6	1	2	12	0.1	1	1	2	1	45	1	7.641	47.114	46.6	7.7	0.0998
6	1	3	1	0.3	2	1	2	1	45	1	22.209	48.629	49.2	21.92	0.3001
6	1	3	2	0.3	2	1	1	2	60	2	18.037	59.877	60.4	17.85	0.3
6	1	3	3	0.3	2	1	2	3	80	1	13.035	82.854	83.9	12.85	0.2998
6	1	3	4	0.3	2	1	2	2	60	1	17.457	61.866	62.3	17.28	0.2992
6	1	3	5	0.3	2	1	1	3	80	1	12.874	83.890	84.1	12.78	0.2988
6	1	3	6	0.3	2	1	1	1	45	1	24.134	44.750	45	23.9	0.299
6	1	3	7	0.1	1	1	1	3	80	1	4.395	81.911	80.4	4.42	0.0989
6	1	3	8	0.1	1	1	2	3	80	1	4.202	85.673	84.6	4.21	0.099
6	1	3	9	0.1	1	1	1	1	45	1	9.002	39.991	40.7	8.85	0.1001
6	1	3	10	0.1	1	1	2	2	60	1	5.985	60.150	59.1	6.01	0.0988
6	1	3	11	0.1	1	1	1	2	60	1	5.591	64.389	65.3	5.47	0.0993
6	1	3	12	0.1	1	1	2	1	45	1	7.491	48.058	48.4	7.41	0.0998
6	1	4	1	0.1	1	1	2	1	45	1	7.794	46.189	45.9	7.84	0.1002
6	1	4	2	0.1	1	1	1	2	60	1	6.21	57.971	58	6.22	0.1003
6	1	4	3	0.1	1	1	2	2	60	1	5.955	60.453	61.5	5.9	0.1008
6	1	4	4	0.1	1	1	2	3	80	1	4.655	77.336	78.7	4.57	0.1
6	1	4	5	0.1	1	1	1	1	45	1	7.668	46.948	45.9	7.81	0.0996
6	1	4	6	0.1	1	1	1	3	80	1	4.377	82.248	82.2	4.35	0.0994
6	1	4	7	0.3	2	1	1	3	80	1	13.739	78.608	78.4	13.78	0.3004
6	1	4	8	0.3	2	1	2	1	45	1	21.369	50.541	50.9	21.2	0.3002
6	1	4	9	0.3	2	1	2	3	80	1	13.844	78.012	77.9	13.82	0.2994
6	1	4	10	0.3	2	1	1	1	45	1	22.927	47.106	47.2	22.89	0.3005
6	1	4	11	0.3	2	1	2	2	60	1	17.72	60.948	61.1	17.64	0.2998
6	1	4	12	0.3	2	1	1	2	60	1	17.499	61.718	62.1	17.35	0.2995

TABLE I.5 -- Raw Data for Moving Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	VMethod	NomSpd	DesrdSpd	NoAttempts	TrueTime	TrueSpd	VASspeed	VAStime	VASdist
7	1	1	1	0.1	1	1	1	1	45	3	8.281	43.473	43.6	8.24	0.0999
7	1	1	2	0.1	1	1	1	3	80	1	4.425	81.356	80.1	4.42	0.0985
7	1	1	3	0.1	1	1	1	2	60	1	6.659	54.062	54.2	6.62	0.0999
7	1	1	4	0.1	1	1	2	3	80	4	4.357	82.626	82.6	4.35	0.1
7	1	1	5	0.1	1	1	2	1	45	1	8.392	42.898	43.1	8.31	0.0997
7	1	1	6	0.1	1	1	2	2	60	1	5.6	64.286	64	5.58	0.0993
7	1	1	7	0.3	2	1	2	2	60	1	18.048	59.840	59.8	17.96	0.2987
7	1	1	8	0.3	2	1	1	3	80	1	14.175	76.190	76.4	14.04	0.2982
7	1	1	9	0.3	2	1	1	1	45	1	23.477	46.002	46.3	23.29	0.3001
7	1	1	10	0.3	2	1	2	1	45	1	24.859	43.445	43.5	24.87	0.3006
7	1	1	11	0.3	2	1	2	3	80	2	12.858	83.994	84	12.78	0.2983
7	1	1	12	0.3	2	1	1	2	60	1	19.408	55.647	55.8	19.33	0.2997
7	1	2	1	0.3	2	1	2	3	80	1	13.084	82.544	82.4	12.96	0.2969
7	1	2	2	0.3	2	1	2	2	60	2	19.417	55.621	55.5	19.36	0.299
7	1	2	3	0.3	2	1	2	1	45	1	26.253	41.138	41	26.24	0.2992
7	1	2	4	0.3	2	1	1	3	80	1	12.827	84.197	85.1	12.6	0.2981
7	1	2	5	0.3	2	1	1	2	60	1	17.793	60.698	60.8	17.71	0.2994
7	1	2	6	0.3	2	1	1	1	45	1	23.038	46.879	47	22.89	0.2991
7	1	2	7	0.1	1	1	2	2	60	1	5.829	61.760	60.4	5.9	0.0992
7	1	2	8	0.1	1	1	2	1	45	1	8.116	44.357	44.8	8.02	0.1
7	1	2	9	0.1	1	1	1	1	45	1	7.142	50.406	49.5	7.16	0.0985
7	1	2	10	0.1	1	1	1	3	80	1	4.722	76.239	75.4	4.75	0.0996
7	1	2	11	0.1	1	1	2	3	80	2	4.387	82.061	82.2	4.39	0.1002
7	1	2	12	0.1	1	1	1	2	60	1	5.589	64.412	62.6	5.65	0.0984
7	1	3	1	0.3	2	1	2	2	60	1	18.039	59.870	60.2	17.92	0.2998
7	1	3	2	0.3	2	1	1	1	45	1	26.454	40.826	41.1	26.28	0.3004
7	1	3	3	0.3	2	1	1	3	80	2	14.006	77.110	74.6	14.43	0.2991
7	1	3	4	0.3	2	1	2	3	80	1	12.889	83.792	84.1	12.81	0.2994
7	1	3	5	0.3	2	1	2	1	45	1	21.288	50.733	51.1	21.13	0.3002
7	1	3	6	0.3	2	1	1	2	60	1	16.893	63.932	64.3	16.77	0.2997
7	1	3	7	0.1	1	1	1	1	45	1	7.779	46.278	46.6	7.7	0.0998
7	1	3	8	0.1	1	1	1	2	60	1	6.157	58.470	59.3	6.08	0.1002
7	1	3	9	0.1	1	1	1	3	80	1	4.377	82.248	81.6	4.35	0.0987
7	1	3	10	0.1	1	1	2	3	80	1	4.599	78.278	77.3	4.57	0.0982
7	1	3	11	0.1	1	1	2	2	60	1	6.449	55.823	54.9	6.44	0.0983
7	1	3	12	0.1	1	1	2	1	45	1	8.241	43.684	43.8	8.17	0.0994
7	1	4	1	0.3	2	1	2	3	80	1	14.096	76.617	77.4	13.89	0.2988
7	1	4	2	0.3	2	1	1	3	80	1	13.101	82.436	82.3	13.03	0.2981
7	1	4	3	0.3	2	1	2	1	45	1	22.322	48.383	48.8	22.14	0.3001
7	1	4	4	0.3	2	1	1	2	60	1	17.409	62.037	61.7	17.46	0.2992
7	1	4	5	0.3	2	1	2	2	60	1	16.536	65.312	66	16.34	0.3
7	1	4	6	0.3	2	1	1	1	45	1	21.079	51.236	51.3	20.98	0.2996
7	1	4	7	0.1	1	1	1	3	80	1	4.348	82.797	78.8	4.5	0.0986
7	1	4	8	0.1	1	1	2	3	80	1	4.178	86.166	87.6	4.1	0.0998
7	1	4	9	0.1	1	1	2	2	60	1	6.341	56.773	57.6	6.26	0.1002
7	1	4	10	0.1	1	1	1	2	60	1	5.611	64.160	64.6	5.54	0.0995
7	1	4	11	0.1	1	1	1	1	45	1	7.661	46.991	46.4	7.63	0.0985
7	1	4	12	0.1	1	1	2	1	45	1	7.1	50.704	50.7	7.05	0.0994

TABLE I.5 -- Raw Data for Moving Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	VMethod	NomSpd	DesrdSpd	NoAttempts	TrueTime	TrueSpd	VASspeed	VAStime	VASdist
8	1	1	1	0.1	1	1	2	1	45	3	8.281	43.473	44	8.2	0.1003
8	1	1	2	0.1	1	1	2	3	80	2	4.395	81.911	84.5	4.24	0.0997
8	1	1	3	0.1	1	1	2	2	60	1	6.659	54.062	54	6.66	0.0999
8	1	1	4	0.1	1	1	1	3	80	1	4.374	82.305	77.5	4.57	0.0984
8	1	1	5	0.1	1	1	1	1	45	1	8.392	42.898	43	8.35	0.0998
8	1	1	6	0.1	1	1	1	2	60	1	5.6	64.286	64.4	5.54	0.0992
8	1	1	7	0.3	2	1	1	2	60	2	18.048	59.840	60.1	17.96	0.2999
8	1	1	8	0.3	2	1	2	3	80	1	14.175	76.190	76.7	14.07	0.3002
8	1	1	9	0.3	2	1	2	1	45	2	24.161	44.700	44.4	24.26	0.2994
8	1	1	10	0.3	2	1	1	1	45	1	24.859	43.445	43.6	24.66	0.2993
8	1	1	11	0.3	2	1	1	3	80	2	12.858	83.994	83.7	12.85	0.2989
8	1	1	12	0.3	2	1	2	2	60	1	19.408	55.647	55.5	19.4	0.2996
8	1	2	1	0.3	2	1	1	3	80	1	13.084	82.544	81.5	13.14	0.2976
8	1	2	2	0.3	2	1	1	2	60	1	19.27	56.046	56.1	19.22	0.2999
8	1	2	3	0.3	2	1	1	1	45	1	26.253	41.138	41.1	26.24	0.3001
8	1	2	4	0.3	2	1	2	3	80	2	12.995	83.109	84.6	12.81	0.3013
8	1	2	5	0.3	2	1	2	2	60	1	17.793	60.698	61.2	17.6	0.2994
8	1	2	6	0.3	2	1	2	1	45	1	23.038	46.879	47.1	22.89	0.2999
8	1	2	7	0.1	1	1	1	2	60	2	5.844	61.602	61.1	5.94	0.1009
8	1	2	8	0.1	1	1	1	1	45	1	8.116	44.357	44.7	7.99	0.0994
8	1	2	9	0.1	1	1	2	1	45	1	7.142	50.406	51.5	7.02	0.1006
8	1	2	10	0.1	1	1	2	3	80	1	4.722	76.239	77.5	4.64	0.1
8	1	2	11	0.1	1	1	1	3	80	1	4.378	82.229	81.4	4.42	0.1002
8	1	2	12	0.1	1	1	2	2	60	1	5.589	64.412	64.5	5.58	0.1001
8	1	3	1	0.3	2	1	1	2	60	1	18.039	59.870	59.5	18.1	0.2996
8	1	3	2	0.3	2	1	2	1	45	1	26.454	40.826	41.1	26.24	0.3
8	1	3	3	0.3	2	1	2	3	80	1	14.001	77.137	77.9	13.86	0.3002
8	1	3	4	0.3	2	1	1	3	80	2	12.887	83.805	83.8	12.85	0.2993
8	1	3	5	0.3	2	1	1	1	45	1	21.288	50.733	51.5	20.98	0.3006
8	1	3	6	0.3	2	1	2	2	60	1	16.893	63.932	64.1	16.88	0.3008
8	1	3	7	0.1	1	1	2	1	45	1	7.779	46.278	46.6	7.74	0.1002
8	1	3	8	0.1	1	1	2	2	60	1	6.157	58.470	58.1	6.15	0.0995
8	1	3	9	0.1	1	1	2	3	80	1	4.377	82.248	82.4	4.35	0.0998
8	1	3	10	0.1	1	1	1	3	80	1	4.599	78.278	77.5	4.6	0.0992
8	1	3	11	0.1	1	1	1	2	60	1	6.449	55.823	57.5	6.26	0.1002
8	1	3	12	0.1	1	1	1	1	45	1	8.241	43.684	43.9	8.13	0.0992
8	1	4	1	0.3	2	1	1	3	80	1	14.096	76.617	77	14	0.2995
8	1	4	2	0.3	2	1	2	3	80	1	13.101	82.436	82.7	13.06	0.3004
8	1	4	3	0.3	2	1	1	1	45	1	22.322	48.383	48.1	22.39	0.2995
8	1	4	4	0.3	2	1	2	2	60	1	17.409	62.037	61.7	17.42	0.2986
8	1	4	5	0.3	2	1	1	2	60	1	16.536	65.312	65.3	16.48	0.2993
8	1	4	6	0.3	2	1	2	1	45	1	21.079	51.236	51.4	20.98	0.3001
8	1	4	7	0.1	1	1	2	3	80	1	4.348	82.797	82.8	4.32	0.0993
8	1	4	8	0.1	1	1	1	3	80	1	4.178	86.166	85.8	4.14	0.0987
8	1	4	9	0.1	1	1	1	2	60	1	6.341	56.773	56.2	6.37	0.0995
8	1	4	10	0.1	1	1	2	2	60	1	5.611	64.160	63	5.68	0.0995
8	1	4	11	0.1	1	1	2	1	45	1	7.661	46.991	46.8	7.66	0.0998
8	1	4	12	0.1	1	1	1	1	45	1	7.1	50.704	51.3	6.98	0.0995

TABLE I.6 -- Night Moving Summary Statistics

VASCAR Method	Course Distance	Nominal Speed	N	Mean	Upper 90% Limit	Observed 95%-tile	Observed 99%-tile	MSE	Variance	K
Night Moving - Overall			36	0.322	1.046	1.450	1.824	0.1176	0.243	2.082
Following	0.3	45	12	0.128	0.477	0.412	0.466	0.0173	0.055	2.655
Following	0.3	60	12	0.120	1.020	0.391	0.397	0.1148	0.102	2.655
Following	0.3	80	12	0.748	1.994	1.784	1.862	0.2204	0.331	2.655

Similar Day Clocks - Subjects, Distance, Speeds

VASCAR Method	Course Distance	Nominal Speed	N	Mean	Upper 90% Limit	Observed 95%-tile	Observed 99%-tile	MSE	Variance	K
Day Moving - Overall			72	0.059	0.987	0.696	0.953	0.2325	0.248	1.924
Following	0.3	45	24	0.122	0.584	0.295	0.655	0.0432	0.044	2.225
Following	0.3	60	24	0.142	0.676	0.438	0.503	0.0575	0.057	2.225
Following	0.3	80	24	-0.085	1.793	0.874	0.998	0.7121	0.632	2.225

Nighttime Moving Study

A. Variables

Subject Number
Nominal Speed
Light Condition

B. Significant Effects ($p \leq 0.05$)

Light Condition

Light Condition	Mean Error
Day	.059
Night	.275

Light Condition x Nominal Speed

Light Condition	Mean Speed Error		
	45	60	80
Day	.122	.142	-.085
Night	-.044	.120	.748

C. Nearly Significant Effects

Nominal Speed ($p = .07$)

Nominal Speed	Mean Error
45	.066
60	.134
80	.193

TABLE I.7 -- Raw Data for the Night Moving Study

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	VMethod	NomSpd	DesrdSpd	NoAttempts	TrueTime	TrueSpd	VASspeed	VAStime	VASdist
3	4	1	4	0.3	1	4	1	1	45	1	22.39	48.236	46	23.4	0.2995
3	4	1	1	0.3	1	4	1	1	45	1	23.419	46.116	46	23.5	0.3006
3	4	1	6	0.3	1	4	1	2	60	1	18.314	58.971	59.1	18.18	0.2988
3	4	1	3	0.3	1	4	1	2	60	1	18.194	59.360	59.4	18.18	0.2999
3	4	1	2	0.3	1	4	1	3	80	2	13.45	80.297	80.8	13.35	0.2997
3	4	1	5	0.3	1	4	1	3	80	1	13.586	79.494	80	13.5	0.3002
4	4	1	6	0.3	1	4	1	1	45	1	23.393	46.168	46.2	23.25	0.2984
4	4	1	3	0.3	1	4	1	1	45	1	23.432	46.091	46.1	23.36	0.2992
4	4	1	2	0.3	1	4	1	2	60	1	18.355	58.840	59.1	18.25	0.2998
4	4	1	4	0.3	1	4	1	2	60	1	18.218	59.282	58.5	18.5	0.3009
4	4	1	5	0.3	1	4	1	3	80	1	13.51	79.941	80.4	13.42	0.3
4	4	1	1	0.3	1	4	1	3	80	1	13.43	80.417	80.8	13.39	0.3008
5	4	1	6	0.3	1	4	1	1	45	1	26.256	41.133	41.5	25.99	0.2999
5	4	1	1	0.3	1	4	1	1	45	1	26.443	40.843	41.2	26.24	0.3003
5	4	1	5	0.3	1	4	1	2	60	1	19.034	56.741	57	18.86	0.2991
5	4	1	2	0.3	1	4	1	2	60	1	16.972	63.634	63.7	16.92	0.2997
5	4	1	4	0.3	1	4	1	3	80	1	13.015	82.981	84.7	12.7	0.299
5	4	1	3	0.3	1	4	1	3	80	1	13.789	78.323	79.7	13.53	0.2999
6	4	1	4	0.3	1	4	1	1	45	1	26.466	40.807	40.9	26.35	0.2996
6	4	1	2	0.3	1	4	1	1	45	1	23.552	45.856	46.1	23.36	0.2995
6	4	1	1	0.3	1	4	1	2	60	1	18.398	58.702	59.1	18.21	0.2992
6	4	1	3	0.3	1	4	1	2	60	1	17.313	62.381	62.7	17.2	0.2997
6	4	1	5	0.3	1	4	1	3	80	2	12.911	83.650	84.4	12.78	0.2996
6	4	1	6	0.3	1	4	1	3	80	1	13.146	82.154	82.7	13.06	0.3005
7	4	1	5	0.3	1	4	1	1	45	1	21.591	50.021	50.5	21.27	0.2987
7	4	1	1	0.3	1	4	1	1	45	1	25.435	42.461	42.8	25.16	0.2997
7	4	1	6	0.3	1	4	1	2	60	1	16.394	65.878	65.8	16.38	0.2993
7	4	1	3	0.3	1	4	1	2	60	1	17.672	61.114	61.5	17.49	0.2989
7	4	1	2	0.3	1	4	1	3	80	1	13.79	78.318	80.2	13.39	0.2987
7	4	1	4	0.3	1	4	1	3	80	1	14.212	75.992	76.3	14.11	0.2994
8	4	1	3	0.3	1	4	1	1	45	1	21.841	49.448	49.2	21.85	0.2992
8	4	1	4	0.3	1	4	1	1	45	1	25.089	43.047	43.2	24.49	0.2994
8	4	1	1	0.3	1	4	1	2	60	1	17.573	61.458	61.6	17.56	0.3007
8	4	1	6	0.3	1	4	1	2	60	1	17.618	61.301	61.6	17.49	0.2995
8	4	1	2	0.3	1	4	1	3	80	1	13.723	78.700	79	13.64	0.2996
8	4	1	5	0.3	1	4	1	3	80	2	13.051	82.752	83	12.96	0.2991

TABLE I.8 -- Bridge - Moving Portion Summary Statistics

VASCAR Method	Nominal Speed	Vehicle Gap	N	Mean	Upper 90% Limit	Observed 95%-tile	Observed 99%-tile	MSE	Variance	K
Bridge Moving - Overall			56	0.251	1.308	1.296	1.544	0.2874	0.362	1.972
Following	60	both	28	0.158	1.353	0.942	1.179	0.3046	0.349	2.165
Following	80	both	28	0.344	1.469	1.486	1.577	0.2702	0.371	2.165
Following	60	short	14	0.265	1.354	0.902	0.976	0.1854	0.392	2.529
Following	60	long	14	0.051	1.697	0.899	1.180	0.4237	0.372	2.529
Following	80	short	14	0.404	1.932	1.315	1.457	0.3651	0.262	2.529
Following	80	long	14	0.285	1.344	1.516	1.591	0.1753	0.500	2.529

Bridge Study - Moving Portion

A. Variables

Subject Number
Nominal Speed
Vehicle Gap

B. Significant Effects ($p \leq 0.05$)

Subject x Nominal Speed

Subject Number	Mean Error 60 mph	Mean Error 80 mph
1	-.412	.925
2	.662	.525
3	.203	.262
4	-.074	.066
5	.040	.356
6	.096	.637

C. Nearly Significant Effects

Subject x Vehicle Gap $p = 0.09$

TABLE I.9 -- Raw Data for the Moving Portion of the Bridge Study

SubNum	Sessnum	RepNum	Repeat#	TrialNo	crsdist	CrsDistr	VehGap	VehGapR	RefType	NomSpd	DesrdSpd	NoAttempt	TrueTime	Truespd	VASspeed	VAStime	VASdist
1	2	1	1	1	0.3	2	1/8 mile	2	2	2	80	1	13.119	82.323	83.8	12.81	0.2986
1	2	1	2	1	0.3	2	1/8 mile	2	2	2	80	1	13.256	81.473	82.5	13.14	0.3012
1	2	1	1	4	0.3	2	1/8 mile	2	2	1	60	1	18.305	59.000	58.8	18.32	0.2997
1	2	1	2	4	0.3	2	1/8 mile	2	2	1	60	1	18.311	58.981	59	18.28	0.2997
1	2	1	1	6	0.3	2	250 feet	1	2	1	60	1	18.197	59.350	57.9	18.5	0.2977
1	2	1	2	6	0.3	2	250 feet	1	2	1	60	1	18.116	59.616	59.6	18.07	0.2996
1	2	1	1	7	0.3	2	250 feet	1	2	2	80	1	13.285	81.295	81	13.24	0.2981
1	2	1	2	7	0.3	2	250 feet	1	2	2	80	1	13.234	81.608	83.1	12.99	0.3003
2	2	1	1	2	0.3	2	1/8 mile	2	2	1	60	1	18.573	58.149	58.9	18.39	0.301
2	2	1	2	2	0.3	2	1/8 mile	2	2	1	60	1	18.174	59.426	59.7	18.07	0.2997
2	2	1	1	3	0.3	2	250 feet	1	2	2	80	1	13.242	81.559	82.8	13.06	0.3006
2	2	1	2	3	0.3	2	250 feet	1	2	2	80	1	13.333	81.002	81.3	13.21	0.2985
2	2	1	1	5	0.3	2	1/8 mile	2	2	2	80	1	13.278	81.338	81.8	13.21	0.3003
2	2	1	2	5	0.3	2	1/8 mile	2	2	2	80	2	13.235	81.602	81.7	13.21	0.3000
2	2	1	1	8	0.3	2	250 feet	1	2	1	60	1	18.283	59.071	59.7	18.1	0.3006
2	2	1	2	8	0.3	2	250 feet	1	2	1	60	1	18.089	59.705	60.7	17.74	0.2993
3	2	1	1	1	0.3	2	1/8 mile	2	2	2	80	2	13.448	80.309	80.2	13.46	0.3001
3	2	1	1	3	0.3	2	250 feet	1	2	1	60	1	18.086	59.715	60.4	17.89	0.3003
3	2	1	1	4	0.3	2	250 feet	1	2	2	80	1	13.422	80.465	80.7	13.39	0.3003
3	2	1	1	8	0.3	2	1/8 mile	2	2	1	60	1	18.238	59.217	59.7	18.1	0.3003
3	2	2	1	1	0.3	2	250 feet	1	2	1	60	1	17.86	60.470	60.8	17.74	0.3001
3	2	2	1	3	0.3	2	1/8 mile	2	2	1	60	1	18.242	59.204	59.1	18.14	0.2982
3	2	2	1	5	0.3	2	250 feet	1	2	2	80	1	13.471	80.172	80.4	13.35	0.2985
3	2	2	1	6	0.3	2	1/8 mile	2	2	2	80	1	13.385	80.687	80.9	13.35	0.3001
3	2	3	1	2	0.3	2	1/8 mile	2	2	1	60	1	17.923	60.258	59.9	17.96	0.2991
3	2	3	1	4	0.3	2	1/8 mile	2	2	2	80	1	13.555	79.675	80.1	13.42	0.2990
3	2	3	1	6	0.3	2	250 feet	1	2	2	80	1	13.514	79.917	80.5	13.35	0.2989
3	2	3	1	7	0.3	2	250 feet	1	2	1	60	2	18.147	59.514	59.7	18.07	0.2998

TABLE I.9 -- Raw Data for the Moving Portion of the Bridge Study (Continued)

SubNum	Sessnum	RepNum	Repeat#	TrialNo	crsdist	CrsDistr	VehGap	VehGapR	RefType	NomSpd	DesrdSpd	NoAttempt	TrueTime	Truespd	VASspeed	VAStime	VASdist
4	2	1	1	2	0.3	2	1/8 mile	2	2	2	80	1	13.43	80.417	79.8	13.42	0.2979
4	2	1	1	5	0.3	2	250 feet	1	2	2	80	1	13.387	80.675	81.3	13.35	0.3017
4	2	1	1	6	0.3	2	1/8 mile	2	2	1	60	1	18.101	59.665	58.4	18.43	0.2993
4	2	1	1	7	0.3	2	250 feet	1	2	1	60	1	18.019	59.937	60.8	17.96	0.3035
4	2	2	1	2	0.3	2	250 feet	1	2	2	80	1	13.371	80.772	80.5	13.42	0.3003
4	2	2	1	4	0.3	2	1/8 mile	2	2	2	80	1	13.325	81.051	80.4	13.32	0.2977
4	2	2	1	7	0.3	2	250 feet	1	2	1	60	1	18.229	59.246	59.5	18.1	0.2993
4	2	2	1	8	0.3	2	1/8 mile	2	2	1	60	1	18.099	59.672	59.7	18	0.2986
4	2	3	1	1	0.3	2	1/8 mile	2	2	1	60	1	17.885	60.386	60.6	17.78	0.2997
4	2	3	1	3	0.3	2	1/8 mile	2	2	2	80	1	13.484	80.095	80.1	13.46	0.2996
4	2	3	1	5	0.3	2	250 feet	1	2	1	60	1	18	60.000	60.3	17.89	0.3000
4	2	3	1	8	0.3	2	250 feet	1	2	2	80	1	13.41	80.537	81	13.28	0.2991
5	2	1	1	3	0.3	2	1/8 mile	2	2	2	80	1	12.944	83.436	82.9	12.99	0.2995
5	2	1	1	5	0.3	2	250 feet	1	2	1	60	1	18.268	59.120	59.4	18.18	0.3001
5	2	1	1	6	0.3	2	1/8 mile	2	2	1	60	1	18.281	59.078	58.9	18.28	0.2992
5	2	1	1	8	0.3	2	250 feet	1	2	2	80	1	12.829	84.184	84.1	12.78	0.2987
5	2	2	1	1	0.3	2	250 feet	1	2	2	80	1	12.933	83.507	84.2	12.78	0.2991
5	2	2	1	2	0.3	2	250 feet	1	2	1	60	1	17.843	60.528	60.6	17.78	0.2994
5	2	2	1	5	0.3	2	1/8 mile	2	2	2	80	1	13.617	79.313	79.4	13.64	0.3011
5	2	2	1	8	0.3	2	1/8 mile	2	2	1	60	1	19.132	56.450	57.7	18.72	0.3004
6	2	1	1	1	0.3	2	250 feet	1	2	2	80	1	13.664	79.040	79.4	13.6	0.3003
6	2	1	1	2	0.3	2	250 feet	1	2	1	60	2	19.615	55.060	55.4	19.47	0.3000
6	2	1	1	4	0.3	2	1/8 mile	2	2	1	60	1	17.485	61.767	62.2	17.38	0.3004
6	2	1	1	7	0.3	2	1/8 mile	2	2	2	80	2	13.368	80.790	82.4	13.06	0.2991
6	2	2	1	3	0.3	2	250 feet	1	2	1	60	1	18.256	59.159	59.4	18.18	0.3001
6	2	2	1	4	0.3	2	1/8 mile	2	2	1	60	1	17.468	61.827	61.2	17.67	0.3005
6	2	2	1	6	0.3	2	250 feet	1	2	2	80	1	12.556	86.015	86.1	12.56	0.3005
6	2	2	1	7	0.3	2	1/8 mile	2	2	2	80	1	13.415	80.507	81	13.28	0.2991

TABLE I.10 -- Bridge - Stationary Portion Summary Statistics

VASCAR Method	Nominal Speed	Visual Method	N	Mean	Upper 90% Limit	Observed 95%-tile	Observed 99%-tile	MSE	Variance	K
Bridge	Stationary-All		55	0.975	1.673	2.396	3.791	0.1246	0.691	1.976
Parking	60	Direct	14	0.521	1.308	1.109	1.429	0.0969	0.184	2.529
Parking	60	Indirect	13	0.717	1.713	1.259	1.973	0.1481	0.224	2.587
Parking	80	Direct	14	1.288	2.094	3.715	3.993	0.1017	1.419	2.529
Parking	80	Indirect	14	1.355	2.349	2.406	2.994	0.1545	0.494	2.529

Bridge Study - Stationary Portion

A. Variables

Subject Number
Visual Mode
Nominal Speed

B. Significant Effects

Subject Number - see summary of experiment

Nominal Speed

Nominal Speed	Mean Error
60	.616
80	1.322

Subject Number x Visual Mode

Subject Number x Nominal Speed

Subject Number x Visual Mode x Nominal Speed

TABLE I.11 -- Raw Data for the Stationary Portion of the Bridge Study

SubNum	Sessnum	RepNum	Repeat#	TrialNo	CrsDist	CrsDistR	VisMode	VisModeR	RefType	NomSpd	DesrdSpd	NoRepeat	TrueTime	Truespd	VASspeed	VAStime
1	2	1	1	2	0.3	2	Indirect	2	2	1	60	1	18.573	58.149	60.3	17.89
1	2	1	2	2	0.3	2	Indirect	2	2	1	60	1	18.174	59.426	60.2	17.92
1	2	1	1	3	0.3	2	Indirect	2	2	2	80	1	13.242	81.559	84.7	12.74
1	2	1	2	3	0.3	2	Indirect	2	2	2	80	1	13.333	81.002	83.1	12.99
1	2	1	1	5	0.3	2	Direct	1	2	2	80	1	13.278	81.338	85.4	12.63
1	2	1	2	5	0.3	2	Direct	1	2	2	80	1	13.198	81.831	85.4	12.63
1	2	1	1	8	0.3	2	Direct	1	2	1	60	2	18.089	59.705	60.3	17.89
1	2	1	2	8	0.3	2	Direct	1	2	1	60	1	18.063	59.791	61.3	17.6
2	2	1	1	1	0.3	2	Direct	1	2	2	80	1	13.119	82.323	82.8	13.03
2	2	1	2	1	0.3	2	Direct	1	2	2	80	1	13.256	81.473	82.8	13.03
2	2	1	1	4	0.3	2	Direct	1	2	1	60	1	18.305	59.000	59.2	18.14
2	2	1	2	4	0.3	2	Direct	1	2	1	60	1	18.311	58.981	59.5	18.03
2	2	1	1	6	0.3	2	Indirect	2	2	1	60	1	18.197	59.350	60.1	17.96
2	2	1	2	6	0.3	2	Indirect	2	2	1	60	1	18.116	59.616	60.4	17.85
2	2	1	1	7	0.3	2	Indirect	2	2	2	80	1	13.285	81.295	82.4	13.1
2	2	1	2	7	0.3	2	Indirect	2	2	2	80	3	13.214	81.731	83.1	12.99
3	2	1	1	2	0.3	2	Direct	1	2	2	80	1	13.411	80.531	80.8	13.35
3	2	1	1	5	0.3	2	Indirect	2	2	2	80	1	13.387	80.675	81.7	13.21
3	2	1	1	6	0.3	2	Indirect	2	2	1	60	1	18.101	59.665	59.8	18.03
3	2	1	1	7	0.3	2	Direct	1	2	1	60	1	18.019	59.937	60.3	17.89
3	2	2	1	2	0.3	2	Indirect	2	2	2	80	1	13.371	80.772	81.7	13.21
3	2	2	1	4	0.3	2	Direct	1	2	2	80	1	13.325	81.051	81.7	13.21
3	2	2	1	7	0.3	2	Indirect	2	2	1	60	1	18.229	59.246	59.7	18.07
3	2	2	1	8	0.3	2	Direct	1	2	1	60	3	18.194	59.360	59.6	18.1
3	2	3	1	1	0.3	2	Direct	1	2	1	60	1	17.885	60.386	61.2	17.64
3	2	3	1	3	0.3	2	Indirect	2	2	2	80	1	13.484	80.095	80.6	13.39
3	2	3	1	5	0.3	2	Indirect	2	2	1	60	1	18	60.000	60.2	17.92
3	2	3	1	8	0.3	2	Direct	1	2	2	80	1	13.337	80.978	81	13.32

TABLE I.11 -- Raw Data for the Stationary Portion of the Bridge Study (Continued)

SubNum	Sessnum	RepNum	Repeat#	TrialNo	CrsDist	CrsDistR	VisMode	VisModeR	RefType	NomSpd	DesrdSpd	NoRepeat	TrueTime	Truespd	VASspeed	VAStime
4	2	1	1	1	0.3	2	Direct	1	2	2	80	2	13.448	80.309	80.8	13.35
4	2	1	1	3	0.3	2	Indirect	2	2	1	60	1	18.086	59.715	60.6	17.82
4	2	1	1	4	0.3	2	Indirect	2	2	2	80	1	13.422	80.465	81.9	13.17
4	2	1	1	8	0.3	2	Direct	1	2	1	60	1	18.238	59.217	59	18.28
4	2	2	1	1	0.3	2	Indirect	2	2	1	60	1	17.86	60.470	53.3	20.23
4	2	2	1	3	0.3	2	Direct	1	2	1	60	2	18.161	59.468	59.7	18.07
4	2	2	1	5	0.3	2	Indirect	2	2	2	80	1	13.471	80.172	81.5	13.24
4	2	2	1	6	0.3	2	Direct	1	2	2	80	3	13.433	80.399	81.3	13.28
4	2	3	1	2	0.3	2	Direct	1	2	1	60	1	17.923	60.258	60.3	17.89
4	2	3	1	4	0.3	2	Indirect	2	2	2	80	1	13.555	79.675	81.5	13.24
4	2	3	1	6	0.3	2	Direct	1	2	2	80	1	13.514	79.917	80.4	13.42
4	2	3	1	7	0.3	2	Indirect	2	2	1	60	1	18.207	59.318	60.2	17.92
5	2	1	1	1	0.3	2	Indirect	2	2	2	80	2	13.778	78.386	78.7	13.71
5	2	1	1	2	0.3	2	Indirect	2	2	1	60	1	19.615	55.060	55.7	19.36
5	2	1	1	4	0.3	2	Direct	1	2	1	60	1	17.428	61.969	62.7	17.2
5	2	1	1	7	0.3	2	Direct	1	2	2	80	1	13.324	81.057	82.8	13.03
5	2	2	1	3	0.3	2	Direct	1	2	1	60	2	18.256	59.159	60.1	17.96
5	2	2	1	4	0.3	2	Indirect	2	2	1	60	1	17.468	61.827	62.5	17.28
5	2	2	1	6	0.3	2	Direct	1	2	2	80	2	12.556	86.015	87.7	12.31
5	2	2	1	7	0.3	2	Indirect	2	2	2	80	1	13.415	80.507	81.5	13.24
6	2	1	1	3	0.3	2	Direct	1	2	2	80	1	12.944	83.436	84.7	12.74
6	2	1	1	5	0.3	2	Direct	1	2	1	60	1	18.268	59.120	59.8	18.03
6	2	1	1	6	0.3	2	Indirect	2	2	1	60	1	18.281	59.078	59.7	18.07
6	2	1	1	8	0.3	2	Indirect	2	2	2	80	1	12.829	84.184	85.9	12.56
6	2	2	1	1	0.3	2	Indirect	2	2	2	80	1	12.933	83.507	84.7	12.74
6	2	2	1	2	0.3	2	Indirect	2	2	1	60	2	17.843	60.528	60.9	17.71
6	2	2	1	5	0.3	2	Direct	1	2	2	80	1	13.617	79.313	80.4	13.42
6	2	2	1	8	0.3	2	Direct	1	2	1	60	1	19.132	56.450	57.1	18.9

TABLE I.12 -- Park - Summary Statistics

VASCAR Method	Course Distance	Nominal Speed	N	Mean	Upper 90% Limit	Observed 95%-tile	Observed 99%-tile	MSE	Variance	K
Parked - Overall			48	-0.506	1.996	3.350	4.334	1.5554	6.583	2.006
Parked	200 ft		24	-1.403	4.229	3.358	4.739	6.4079	9.454	2.225
Parked	528 ft		24	0.391	3.875	2.706	3.264	2.4516	2.318	2.225
Parked	200 ft	60	12	-0.522	3.909	4.061	4.947	2.7859	8.296	2.655
Parked	200 ft	80	12	-2.285	8.076	1.939	3.083	15.2304	9.777	2.655
Parked	528 ft	60	12	0.123	1.955	1.378	1.740	0.4761	1.131	2.655
Parked	528 ft	80	12	0.659	5.821	3.008	3.350	3.7801	3.379	2.655

Parked Study

A. Variables

Subject Number
Replications
Course Distance
Nominal Speed

B. Significant Effects ($p \leq 0.05$)

Subject Number - see summary of experiment

C. Nearly Significant Effects

Course Distance x Nominal Speed ($p = .07$)

TABLE I.13 -- Raw Data for the Park Study

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
3	5	1	1	200	1	5	1	60	1	2.24	60.877	64.2	2.12
3	5	1	2	200	1	5	2	80	1	1.677	81.314	82.3	1.65
3	5	1	3	528	2	5	2	80	2	4.507	79.876	82.6	4.35
3	5	1	4	528	2	5	1	60	1	6.089	59.123	60.2	5.97
3	5	2	1	200	1	5	1	60	2	2.296	59.392	61.1	2.23
3	5	2	2	200	1	5	2	80	3	1.687	80.832	84.2	1.62
3	5	2	3	528	2	5	2	80	1	4.392	81.967	85.4	4.21
3	5	2	4	528	2	5	1	60	1	6.109	58.929	59.8	6.01
3	5	3	1	528	2	5	2	80	2	4.487	80.232	79.3	4.53
3	5	3	2	528	2	5	1	60	1	6.013	59.870	61.7	5.83
3	5	3	3	200	1	5	2	80	2	1.669	81.704	75.8	1.8
3	5	3	4	200	1	5	1	60	2	2.31	59.032	64.2	2.12
4	5	1	1	528	2	5	1	60	1	5.926	60.749	60.6	5.94
4	5	1	2	528	2	5	2	80	1	4.425	81.356	81.9	4.39
4	5	1	3	200	1	5	2	80	1	1.682	81.072	74.3	1.83
4	5	1	4	200	1	5	1	60	1	2.304	59.186	57.4	2.37
4	5	2	1	528	2	5	1	60	1	6.107	58.949	59.8	6.01
4	5	2	2	528	2	5	2	80	1	4.39	82.005	81.9	4.39
4	5	2	3	200	1	5	2	80	1	1.665	81.900	80.6	1.69
4	5	2	4	200	1	5	1	60	1	2.317	58.854	56.5	2.41
4	5	3	1	200	1	5	2	80	1	1.682	81.072	80.6	1.69
4	5	3	2	200	1	5	1	60	1	2.279	59.835	60.1	2.26
4	5	3	3	528	2	5	2	80	1	4.467	80.591	81.9	4.39
4	5	3	4	528	2	5	1	60	2	6.057	59.435	59.1	6.08
5	5	1	1	528	2	5	1	60	1	5.982	60.181	59.8	6.01
5	5	1	2	528	2	5	2	80	1	4.407	81.688	80.6	4.46
5	5	1	3	200	1	5	2	80	1	1.679	81.217	74.3	1.83
5	5	1	4	200	1	5	1	60	1	2.313	58.955	54.9	2.48
5	5	2	1	528	2	5	2	80	1	4.599	78.278	76.9	4.68
5	5	2	2	528	2	5	1	60	1	6.388	56.356	54	6.66
5	5	2	3	200	1	5	2	80	1	1.663	81.999	80.6	1.69
5	5	2	4	200	1	5	1	60	1	2.45	55.659	55.7	2.44
5	5	3	1	200	1	5	2	80	1	1.661	82.097	80.6	1.69
5	5	3	2	200	1	5	1	60	1	2.445	55.772	51.2	2.66
5	5	3	3	528	2	5	1	60	1	6.433	55.961	54.6	6.58
5	5	3	4	528	2	5	2	80	1	4.762	75.598	75.7	4.75
6	5	1	1	200	1	5	1	60	1	2.265	60.205	60.1	2.26
6	5	1	2	200	1	5	2	80	1	1.679	81.217	78.9	1.72
6	5	1	3	528	2	5	2	80	2	4.433	81.209	79.3	4.53
6	5	1	4	528	2	5	1	60	1	6.106	58.958	59.8	6.01
6	5	2	1	200	1	5	2	80	1	1.74	78.370	74.3	1.83
6	5	2	2	200	1	5	1	60	1	2.423	56.279	54.1	2.52
6	5	2	3	528	2	5	2	80	1	4.383	82.136	84.7	4.24
6	5	2	4	528	2	5	1	60	1	6.472	55.624	56.1	6.4
6	5	3	1	528	2	5	2	80	1	4.387	82.061	84.7	4.24
6	5	3	2	528	2	5	1	60	1	6.465	55.684	55.8	6.44
6	5	3	3	200	1	5	1	60	1	2.443	55.818	54.1	2.52
6	5	3	4	200	1	5	2	80	1	1.808	75.422	74.3	1.83

TABLE I.14 -- Angular - Summary Statistics

View Dist.	Eleva- tion	Course Dist.	Nom. Speed	N	Mean	Upper 90% Limit	Observed 95%-tile	Observed 99%-tile	MSE	Variance	K
Angular - Overall				576	0.738	3.906	4.650	7.332	3.3501	3.967	1.731
		200		288	1.787	3.775	6.230	7.954	1.2617	5.227	1.770
		528		288	-0.311	0.853	0.667	1.209	0.4326	0.511	1.770
		200	45	96	1.134	3.142	3.742	4.178	1.1403	2.250	1.880
		200	60	96	1.904	4.600	4.925	5.955	2.0566	3.885	1.880
		200	80	96	2.323	6.586	7.376	8.333	5.1401	8.922	1.880
		528	45	96	-0.064	0.683	0.600	1.076	0.1578	0.170	1.880
		528	60	96	-0.169	0.756	0.677	0.938	0.2419	0.305	1.880
		528	80	96	-0.700	0.798	0.730	1.264	0.6353	0.835	1.880
200	Ground	200	45	24	1.805	4.186	3.982	4.148	1.1458	2.465	2.225
200	Elevated	200	45	24	1.346	4.685	4.035	4.563	2.2516	3.538	2.225
528	Ground	200	45	24	1.002	2.823	2.634	2.944	0.6718	1.128	2.225
528	Elevated	200	45	24	1.019	2.681	1.678	1.790	0.5585	1.038	2.225
200	Ground	200	60	24	2.768	5.850	5.672	6.792	1.9185	5.211	2.225
200	Elevated	200	60	24	1.782	5.941	4.748	5.682	3.4932	5.502	2.225
528	Ground	200	60	24	1.277	3.784	3.550	4.736	1.2698	2.469	2.225
528	Elevated	200	60	24	1.790	4.082	3.636	4.629	1.0609	1.646	2.225
200	Ground	200	80	24	3.260	8.692	7.981	9.652	5.9597	10.460	2.225
200	Elevated	200	80	24	2.591	8.482	7.768	8.243	7.0091	13.165	2.225
528	Ground	200	80	24	1.646	4.532	4.637	5.182	1.6819	4.664	2.225
528	Elevated	200	80	24	1.796	7.399	6.721	7.492	6.3419	6.806	2.225
200	Ground	528	45	24	-0.123	0.872	0.593	0.790	0.2401	0.239	2.225
200	Elevated	528	45	24	-0.127	0.715	0.529	0.980	0.1433	0.204	2.225
528	Ground	528	45	24	-0.030	0.872	0.560	0.959	0.1433	0.143	2.225
528	Elevated	528	45	24	-0.035	0.478	0.513	0.733	0.0531	0.097	2.225
200	Ground	528	60	24	-0.130	0.871	0.590	0.689	0.2023	0.194	2.225
200	Elevated	528	60	24	-0.243	0.992	0.840	1.682	0.3081	0.459	2.225
528	Ground	528	60	24	-0.167	1.056	0.744	0.896	0.3023	0.356	2.225
528	Elevated	528	60	24	-0.136	0.943	0.425	0.567	0.2351	0.241	2.225
200	Ground	528	80	24	-0.881	1.318	1.035	1.319	0.9766	1.135	2.225
200	Elevated	528	80	24	-0.834	0.819	0.310	0.525	0.5520	0.597	2.225
528	Ground	528	80	24	-0.437	1.419	0.512	1.090	0.5879	0.696	2.225
528	Elevated	528	80	24	-0.649	0.839	0.930	1.119	0.4472	0.895	2.225

Angular Study

A. Variables

Group
Subjects
Replicates
Course Distance
Nominal Speed
Viewing Distance
Elevation

B. Significant Effects ($p \leq 0.05$)

Subject Number
Viewing Distance
Course Distance
Group x Viewing Distance
Group x Course Distance
Viewing Distance x Course Distance
Course Distance x Nominal Speed
Group x Viewing Distance x Course Distance

C. Nearly Significant Effects

Viewing Distance x Elevation x Course Distance ($p = 0.08$)

Angular Study - Analysis by Course Distance

A. Significant Effects for 200 Foot Course Distance

Subject Number - see summary of experiment

Replications

Replicate Number	Mean Speed Error
1	2.119
2	1.883
3	2.042
4	1.104

Viewing Distance

Viewing Distance	Mean Speed Error
200 ft	2.258
528 ft	1.316

Group x Viewing Distance

Viewing Distance	Mean Speed Error	
	Group 1	Group 2
200 ft	.406	3.185
528 ft	.475	1.736

Nominal Speed

Nominal Speed	Mean Speed Error
45	1.134
60	1.904
80	2.323

B. Significant Effects for 528 Foot Course Distance

Subject Number - see summary of experiment

Viewing Distance

Viewing Distance	Mean Speed Error
200 ft	-0.390
528 ft	-0.233

Nominal Speed

Nominal Speed	Mean Speed Error
45	-0.064
60	-0.169
80	-0.700

Group x Viewing Distance x Elevation

Viewing Distance	Mean Speed Error			
	Group 1		Group 2	
	ground	elevated	ground	elevated
200 ft	-0.510	-0.116	-0.312	-0.230
528 ft	-0.355	-0.488	-0.424	-0.166

TABLE I.15 -- Raw Data For Angular Study

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
3	3	1	1	200	1	3	1	45	2	1	1	2.962	46.038	46.2	2.95
3	3	1	2	200	1	3	3	80	2	1	2	1.701	80.167	78.9	1.72
3	3	1	3	200	1	3	2	60	2	1	1	2.278	59.861	58.3	2.34
3	3	1	4	528	2	3	2	60	2	1	2	6.049	59.514	59.1	6.08
3	3	1	5	528	2	3	3	80	2	1	1	4.458	80.754	80.6	4.46
3	3	1	6	528	2	3	1	45	2	1	1	7.948	45.294	45.2	7.95
3	3	1	7	528	2	3	3	80	1	1	1	4.475	80.447	79.3	4.53
3	3	1	8	528	2	3	2	60	1	1	1	6.156	58.480	59.1	6.08
3	3	1	9	528	2	3	1	45	1	1	1	7.793	46.195	46.5	7.74
3	3	1	10	200	1	3	1	45	1	1	2	2.997	45.500	44	3.09
3	3	1	11	200	1	3	3	80	1	1	1	1.69	80.689	82.3	1.65
3	3	1	12	200	1	3	2	60	1	1	1	2.341	58.250	55.7	2.44
3	3	1	13	528	2	3	2	60	1	2	2	6.047	59.534	59.1	6.08
3	3	1	14	528	2	3	1	45	1	2	1	7.753	46.434	46.5	7.74
3	3	1	15	528	2	3	3	80	1	2	1	4.485	80.268	80	4.5
3	3	1	16	200	1	3	1	45	1	2	1	2.969	45.929	45.1	3.02
3	3	1	17	200	1	3	3	80	1	2	2	1.691	80.641	82.3	1.65
3	3	1	18	200	1	3	2	60	1	2	1	2.282	59.756	59.2	2.3
3	3	1	19	528	2	3	1	45	2	2	1	7.883	45.668	45.4	7.92
3	3	1	20	528	2	3	3	80	2	2	1	4.496	80.071	79.3	4.53
3	3	1	21	528	2	3	2	60	2	2	1	6.059	59.416	59.5	6.04
3	3	1	22	200	1	3	1	45	2	2	1	2.947	46.272	46.7	2.91
3	3	1	23	200	1	3	3	80	2	2	1	1.71	79.745	82.3	1.65
3	3	1	24	200	1	3	2	60	2	2	1	2.291	59.521	59.2	2.3
3	3	2	1	528	2	3	1	45	1	2	1	7.822	46.024	46	7.81
3	3	2	2	528	2	3	3	80	1	2	1	4.513	79.770	79.3	4.53
3	3	2	3	528	2	3	2	60	1	2	1	6.063	59.377	59.8	6.01
3	3	2	4	200	1	3	2	60	1	2	2	2.293	59.470	60.1	2.26
3	3	2	5	200	1	3	1	45	1	2	1	2.98	45.760	47.3	2.88
3	3	2	6	200	1	3	3	80	1	2	1	1.688	80.784	84.2	1.62
3	3	2	7	528	2	3	1	45	2	2	2	7.882	45.674	45.6	7.88
3	3	2	8	528	2	3	3	80	2	2	1	4.498	80.036	78.7	4.57
3	3	2	9	528	2	3	2	60	2	2	3	6.135	58.680	58.4	6.15
3	3	2	10	200	1	3	3	80	2	2	2	1.708	79.838	82.3	1.65
3	3	2	11	200	1	3	2	60	2	2	1	2.311	59.006	60.1	2.26
3	3	2	12	200	1	3	1	45	2	2	2	2.974	45.852	47.3	2.88
3	3	2	13	200	1	3	2	60	1	1	1	2.359	57.806	59.2	2.3
3	3	2	14	200	1	3	1	45	1	1	1	2.933	46.493	45.1	3.02
3	3	2	15	200	1	3	3	80	1	1	1	1.735	78.596	78.9	1.72
3	3	2	16	528	2	3	2	60	1	1	2	6.064	59.367	59.5	6.04
3	3	2	17	528	2	3	3	80	1	1	1	4.482	80.321	80	4.5
3	3	2	18	528	2	3	1	45	1	1	1	7.768	46.344	46	7.81
3	3	2	19	528	2	3	3	80	2	1	1	4.482	80.321	79.3	4.53
3	3	2	20	528	2	3	2	60	2	1	2	6.064	59.367	58.8	6.12
3	3	2	21	528	2	3	1	45	2	1	1	7.929	45.403	45.2	7.95
3	3	2	22	200	1	3	1	45	2	1	2	3.003	45.409	45.6	2.98
3	3	2	23	200	1	3	3	80	2	1	2	1.691	80.641	80.6	1.69
3	3	2	24	200	1	3	2	60	2	1	1	2.311	59.006	60.1	2.26

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
3	3	3	1	200	1	3	1	45	2	2	1	2.98	45.760	45.1	3.02
3	3	3	2	200	1	3	3	80	2	2	1	1.699	80.261	78.9	1.72
3	3	3	3	200	1	3	2	60	2	2	2	2.29	59.547	61.1	2.23
3	3	3	4	528	2	3	1	45	2	2	2	7.839	45.924	45.6	7.88
3	3	3	5	528	2	3	2	60	2	2	2	6.028	59.721	59.5	6.04
3	3	3	6	528	2	3	3	80	2	2	1	4.509	79.840	79.3	4.53
3	3	3	7	528	2	3	3	80	1	2	1	4.487	80.232	79.3	4.53
3	3	3	8	528	2	3	2	60	1	2	1	6.058	59.426	59.5	6.04
3	3	3	9	528	2	3	1	45	1	2	2	7.821	46.030	46	7.81
3	3	3	10	200	1	3	2	60	1	2	1	2.297	59.366	59.2	2.3
3	3	3	11	200	1	3	3	80	1	2	1	1.702	80.120	80.6	1.69
3	3	3	12	200	1	3	1	45	1	2	1	2.936	46.445	46.7	2.91
3	3	3	13	200	1	3	1	45	2	1	2	2.908	46.893	46.7	2.91
3	3	3	14	200	1	3	3	80	2	1	1	1.705	79.979	80.6	1.69
3	3	3	15	200	1	3	2	60	2	1	1	2.311	59.006	60.1	2.26
3	3	3	16	528	2	3	2	60	2	1	1	5.915	60.862	60.2	5.97
3	3	3	17	528	2	3	3	80	2	1	1	4.481	80.339	79.3	4.53
3	3	3	18	528	2	3	1	45	2	1	2	7.821	46.030	46.2	7.77
3	3	3	19	200	1	3	3	80	1	1	2	1.68	81.169	80.6	1.69
3	3	3	20	200	1	3	2	60	1	1	1	2.267	60.152	59.2	2.3
3	3	3	21	200	1	3	1	45	1	1	1	2.951	46.209	46.7	2.91
3	3	3	22	528	2	3	2	60	1	1	2	6.084	59.172	58.8	6.12
3	3	3	23	528	2	3	1	45	1	1	1	7.709	46.699	46.9	7.66
3	3	3	24	528	2	3	3	80	1	1	1	4.455	80.808	80	4.5
3	3	4	1	528	2	3	1	45	2	2	1	7.784	46.249	46	7.81
3	3	4	2	528	2	3	2	60	2	2	1	6.034	59.662	59.5	6.04
3	3	4	3	528	2	3	3	80	2	2	1	4.478	80.393	80	4.5
3	3	4	4	200	1	3	1	45	2	2	1	2.952	46.194	46.2	2.95
3	3	4	5	200	1	3	2	60	2	2	1	2.338	58.325	59.2	2.3
3	3	4	6	200	1	3	3	80	2	2	1	1.689	80.736	78.9	1.72
3	3	4	7	200	1	3	3	80	1	2	1	1.69	80.689	78.9	1.72
3	3	4	8	200	1	3	1	45	1	2	2	2.964	46.007	45.6	2.98
3	3	4	9	200	1	3	2	60	1	2	1	2.302	59.237	59.2	2.3
3	3	4	10	528	2	3	1	45	1	2	1	7.796	46.178	45.4	7.92
3	3	4	11	528	2	3	2	60	1	2	1	6.132	58.708	58.4	6.15
3	3	4	12	528	2	3	3	80	1	2	2	4.477	80.411	79.3	4.53
3	3	4	13	528	2	3	2	60	2	1	1	6.013	59.870	59.1	6.08
3	3	4	14	528	2	3	3	80	2	1	2	4.518	79.681	80	4.5
3	3	4	15	528	2	3	1	45	2	1	1	7.79	46.213	45.6	7.88
3	3	4	16	200	1	3	3	80	2	1	2	1.691	80.641	80.6	1.69
3	3	4	17	200	1	3	1	45	2	1	1	3.034	44.945	45.1	3.02
3	3	4	18	200	1	3	2	60	2	1	2	2.276	59.914	59.2	2.3
3	3	4	19	528	2	3	3	80	1	1	1	4.475	80.447	78.7	4.57
3	3	4	20	528	2	3	1	45	1	1	1	7.839	45.924	46	7.81
3	3	4	21	528	2	3	2	60	1	1	1	6.023	59.771	59.5	6.04
3	3	4	22	200	1	3	2	60	1	1	1	2.303	59.211	59.2	2.3
3	3	4	23	200	1	3	1	45	1	1	1	2.999	45.470	45.6	2.98
3	3	4	24	200	1	3	3	80	1	1	1	1.689	80.736	82.3	1.65

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
4	3	1	1	200	1	3	1	45	1	1	1	2.962	46.038	46.7	2.91
4	3	1	2	200	1	3	3	80	1	1	2	1.701	80.167	80.6	1.69
4	3	1	3	200	1	3	2	60	1	1	1	2.278	59.861	60.1	2.26
4	3	1	4	528	2	3	2	60	1	1	1	6.01	59.900	59.5	6.04
4	3	1	5	528	2	3	3	80	1	1	2	4.469	80.555	80	4.5
4	3	1	6	528	2	3	1	45	1	1	1	7.948	45.294	45	7.99
4	3	1	7	528	2	3	3	80	2	1	1	4.475	80.447	79.3	4.53
4	3	1	8	528	2	3	2	60	2	1	1	6.156	58.480	58.1	6.19
4	3	1	9	528	2	3	1	45	2	1	1	7.793	46.195	45.8	7.84
4	3	1	10	200	1	3	1	45	2	1	1	2.971	45.898	46.2	2.95
4	3	1	11	200	1	3	3	80	2	1	1	1.69	80.689	82.3	1.65
4	3	1	12	200	1	3	2	60	2	1	1	2.341	58.250	59.2	2.3
4	3	1	13	528	2	3	2	60	2	2	2	6.047	59.534	59.1	6.08
4	3	1	14	528	2	3	1	45	2	2	1	7.753	46.434	46.2	7.77
4	3	1	15	528	2	3	3	80	2	2	1	4.485	80.268	80	4.5
4	3	1	16	200	1	3	1	45	2	2	1	2.969	45.929	44.5	3.06
4	3	1	17	200	1	3	3	80	2	2	2	1.691	80.641	88.1	1.54
4	3	1	18	200	1	3	2	60	2	2	1	2.282	59.756	59.2	2.3
4	3	1	19	528	2	3	1	45	1	2	1	7.883	45.668	46	7.81
4	3	1	20	528	2	3	3	80	1	2	1	4.496	80.071	79.3	4.53
4	3	1	21	528	2	3	2	60	1	2	1	6.059	59.416	58.4	6.15
4	3	1	22	200	1	3	1	45	1	2	1	2.947	46.272	46.7	2.91
4	3	1	23	200	1	3	3	80	1	2	1	1.71	79.745	82.3	1.65
4	3	1	24	200	1	3	2	60	1	2	1	2.291	59.521	58.3	2.34
4	3	2	1	528	2	3	1	45	2	2	1	7.822	46.024	45.6	7.88
4	3	2	2	528	2	3	3	80	2	2	1	4.513	79.770	79.3	4.53
4	3	2	3	528	2	3	2	60	2	2	1	6.063	59.377	59.1	6.08
4	3	2	4	200	1	3	2	60	2	2	2	2.293	59.470	61.1	2.23
4	3	2	5	200	1	3	1	45	2	2	1	2.98	45.760	44.5	3.06
4	3	2	6	200	1	3	3	80	2	2	1	1.688	80.784	80.6	1.69
4	3	2	7	528	2	3	1	45	1	2	1	7.672	46.924	48	7.48
4	3	2	8	528	2	3	3	80	1	2	1	4.498	80.036	81.3	4.42
4	3	2	9	528	2	3	2	60	1	2	1	6.09	59.113	59.1	6.08
4	3	2	10	200	1	3	3	80	1	2	2	1.691	80.641	78.9	1.72
4	3	2	11	200	1	3	2	60	1	2	1	2.311	59.006	60.1	2.26
4	3	2	12	200	1	3	1	45	1	2	1	2.987	45.652	46.2	2.95
4	3	2	13	200	1	3	2	60	2	1	2	2.338	58.325	58.3	2.34
4	3	2	14	200	1	3	1	45	2	1	1	2.933	46.493	46.2	2.95
4	3	2	15	200	1	3	3	80	2	1	1	1.735	78.596	77.3	1.76
4	3	2	16	528	2	3	2	60	2	1	1	6.078	59.230	59.1	6.08
4	3	2	17	528	2	3	3	80	2	1	1	4.482	80.321	79.3	4.53
4	3	2	18	528	2	3	1	45	2	1	1	7.768	46.344	45.4	7.92
4	3	2	19	528	2	3	3	80	1	1	1	4.482	80.321	78.1	4.6
4	3	2	20	528	2	3	2	60	1	1	2	6.064	59.367	59.5	6.04
4	3	2	21	528	2	3	1	45	1	1	1	7.929	45.403	45.2	7.95
4	3	2	22	200	1	3	1	45	1	1	1	3.003	45.409	47.9	2.84
4	3	2	23	200	1	3	3	80	1	1	2	1.691	80.641	80.6	1.69
4	3	2	24	200	1	3	2	60	1	1	1	2.311	59.006	60.1	2.26

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
4	3	3	1	200	1	3	1	45	1	2	1	2.98	45.760	47.9	2.84
4	3	3	2	200	1	3	3	80	1	2	1	1.699	80.261	80.6	1.69
4	3	3	3	200	1	3	2	60	1	2	1	2.332	58.475	60.1	2.26
4	3	3	4	528	2	3	1	45	1	2	1	7.682	46.863	46.5	7.74
4	3	3	5	528	2	3	2	60	1	2	1	6.148	58.556	59.1	6.08
4	3	3	6	528	2	3	3	80	1	2	1	4.509	79.840	80	4.5
4	3	3	7	528	2	3	3	80	2	2	1	4.487	80.232	78.7	4.57
4	3	3	8	528	2	3	2	60	2	2	1	6.058	59.426	59.1	6.08
4	3	3	9	528	2	3	1	45	2	2	1	7.821	46.030	46	7.81
4	3	3	10	200	1	3	2	60	2	2	2	2.283	59.730	60.1	2.26
4	3	3	11	200	1	3	3	80	2	2	1	1.702	80.120	78.9	1.72
4	3	3	12	200	1	3	1	45	2	2	1	2.936	46.445	46.2	2.95
4	3	3	13	200	1	3	1	45	1	1	1	3.039	44.871	47.3	2.88
4	3	3	14	200	1	3	3	80	1	1	1	1.705	79.979	82.3	1.65
4	3	3	15	200	1	3	2	60	1	1	1	2.311	59.006	63.1	2.16
4	3	3	16	528	2	3	2	60	1	1	1	5.943	60.575	60.6	5.94
4	3	3	17	528	2	3	3	80	1	1	1	4.496	80.071	79.3	4.53
4	3	3	18	528	2	3	1	45	1	1	1	7.786	46.237	46.9	7.66
4	3	3	19	200	1	3	3	80	2	1	1	1.698	80.308	82.3	1.65
4	3	3	20	200	1	3	2	60	2	1	1	2.267	60.152	60.1	2.26
4	3	3	21	200	1	3	1	45	2	1	1	2.951	46.209	46.2	2.95
4	3	3	22	528	2	3	2	60	2	1	2	6.084	59.172	59.8	6.01
4	3	3	23	528	2	3	1	45	2	1	1	7.709	46.699	46.7	7.7
4	3	3	24	528	2	3	3	80	2	1	1	4.455	80.808	80	4.5
4	3	4	1	528	2	3	1	45	1	2	1	7.784	46.249	46.2	7.77
4	3	4	2	528	2	3	2	60	1	2	1	6.034	59.662	60.6	5.94
4	3	4	3	528	2	3	3	80	1	2	1	4.478	80.393	79.3	4.53
4	3	4	4	200	1	3	1	45	1	2	1	2.952	46.194	45.6	2.98
4	3	4	5	200	1	3	2	60	1	2	1	2.338	58.325	59.2	2.3
4	3	4	6	200	1	3	3	80	1	2	1	1.689	80.736	80.6	1.69
4	3	4	7	200	1	3	3	80	2	2	1	1.69	80.689	84.2	1.62
4	3	4	8	200	1	3	1	45	2	2	1	2.922	46.668	45.1	3.02
4	3	4	9	200	1	3	2	60	2	2	1	2.302	59.237	59.2	2.3
4	3	4	10	528	2	3	1	45	2	2	1	7.796	46.178	45.6	7.88
4	3	4	11	528	2	3	2	60	2	2	1	6.132	58.708	58.4	6.15
4	3	4	12	528	2	3	3	80	2	2	2	4.477	80.411	78.1	4.06
4	3	4	13	528	2	3	2	60	1	1	1	6.013	59.870	58.8	6.12
4	3	4	14	528	2	3	3	80	1	1	1	4.502	79.964	77.5	4.64
4	3	4	15	528	2	3	1	45	1	1	1	7.79	46.213	44.8	8.02
4	3	4	16	200	1	3	3	80	1	1	1	1.688	80.784	82.3	1.65
4	3	4	17	200	1	3	1	45	1	1	1	3.034	44.945	45.6	2.98
4	3	4	18	200	1	3	2	60	1	1	1	2.288	59.599	60.1	2.26
4	3	4	19	528	2	3	3	80	2	1	1	4.479	80.375	79.3	4.53
4	3	4	20	528	2	3	1	45	2	1	1	7.839	45.924	45.8	7.84
4	3	4	21	528	2	3	2	60	2	1	1	6.023	59.771	61.7	5.83
4	3	4	22	200	1	3	2	60	2	1	1	2.303	59.211	61.1	2.23
4	3	4	23	200	1	3	1	45	2	1	1	2.999	45.470	45.6	2.98
4	3	4	24	200	1	3	3	80	2	1	1	1.689	80.736	80.6	1.69

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
5	3	1	1	200	1	3	1	45	2	1	1	2.85	47.847	49.2	2.77
5	3	1	2	200	1	3	2	60	2	1	1	2.388	57.104	58.3	2.34
5	3	1	3	200	1	3	3	80	2	1	1	1.703	80.073	84.2	1.62
5	3	1	4	528	2	3	1	45	2	1	1	8.257	43.599	43.6	8.24
5	3	1	5	528	2	3	3	80	2	1	1	4.394	81.930	81.3	4.42
5	3	1	6	528	2	3	2	60	2	1	1	6.043	59.573	59.5	6.04
5	3	1	7	200	1	3	1	45	1	1	1	3.5	38.961	40.7	3.34
5	3	1	8	200	1	3	3	80	1	1	1	1.667	81.802	88.1	1.54
5	3	1	9	200	1	3	2	60	1	1	1	2.497	54.611	57.4	2.37
5	3	1	10	528	2	3	3	80	1	1	1	4.784	75.251	74	4.86
5	3	1	11	528	2	3	1	45	1	1	1	8.745	41.166	40.8	8.82
5	3	1	12	528	2	3	2	60	1	1	1	6.059	59.416	59.5	6.04
5	3	1	13	200	1	3	2	60	1	2	1	2.267	60.152	60.1	2.26
5	3	1	14	200	1	3	3	80	1	2	1	1.746	78.101	77.3	1.76
5	3	1	15	200	1	3	1	45	1	2	1	2.737	49.822	50.5	2.7
5	3	1	16	528	2	3	1	45	1	2	1	7.287	49.403	49.5	7.27
5	3	1	17	528	2	3	3	80	1	2	1	4.725	76.190	74.6	4.82
5	3	1	18	528	2	3	2	60	1	2	1	5.845	61.591	61.7	5.83
5	3	1	19	528	2	3	1	45	2	2	1	7.881	45.679	45.8	7.84
5	3	1	20	528	2	3	3	80	2	2	1	4.344	82.873	81.9	4.39
5	3	1	21	528	2	3	2	60	2	2	1	6.419	56.084	56.1	6.4
5	3	1	22	200	1	3	2	60	2	2	1	2.357	57.855	59.2	2.3
5	3	1	23	200	1	3	3	80	2	2	1	1.566	87.078	86.1	1.58
5	3	1	24	200	1	3	1	45	2	2	1	2.986	45.668	45.6	2.98
5	3	2	1	200	1	3	1	45	1	2	1	3.282	41.549	42.1	3.24
5	3	2	2	200	1	3	3	80	1	2	1	1.733	78.686	78.9	1.72
5	3	2	3	200	1	3	2	60	1	2	1	2.38	57.296	57.4	2.37
5	3	2	4	528	2	3	3	80	1	2	1	4.432	81.227	79.3	4.53
5	3	2	5	528	2	3	2	60	1	2	1	5.997	60.030	59.5	6.04
5	3	2	6	528	2	3	1	45	1	2	1	8.34	43.165	42.9	8.38
5	3	2	7	528	2	3	3	80	2	2	1	4.134	87.083	86.2	4.17
5	3	2	8	528	2	3	1	45	2	2	1	7.508	47.949	47.6	7.56
5	3	2	9	528	2	3	2	60	2	2	1	5.855	61.486	61.3	5.86
5	3	2	10	200	1	3	2	60	2	2	2	2.169	62.869	65.3	2.08
5	3	2	11	200	1	3	3	80	2	2	1	1.626	83.864	86.1	1.58
5	3	2	12	200	1	3	1	45	2	2	1	2.842	47.982	49.8	2.73
5	3	2	13	200	1	3	3	80	1	1	1	1.595	85.494	86.1	1.58
5	3	2	14	200	1	3	1	45	1	1	1	2.991	45.591	47.9	2.84
5	3	2	15	200	1	3	2	60	1	1	1	2.318	58.828	63.1	2.16
5	3	2	16	528	2	3	3	80	1	1	1	4.73	76.110	76.3	4.71
5	3	2	17	528	2	3	2	60	1	1	1	6.547	54.987	54.6	6.58
5	3	2	18	528	2	3	1	45	1	1	1	7.827	45.995	46.2	7.77
5	3	2	19	200	1	3	3	80	2	1	1	1.669	81.704	88.1	1.54
5	3	2	20	200	1	3	1	45	2	1	1	3.259	41.842	44	3.09
5	3	2	21	200	1	3	2	60	2	1	1	2.223	61.342	64.2	2.12
5	3	2	22	528	2	3	3	80	2	1	1	4.645	77.503	77.5	4.64
5	3	2	23	528	2	3	1	45	2	1	1	7.633	47.164	46.5	7.74
5	3	2	24	528	2	3	2	60	2	1	1	6.146	58.575	57.8	6.22

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
5	3	3	1	528	2	3	2	60	1	2	1	6.05	59.504	59.1	6.08
5	3	3	2	528	2	3	1	45	1	2	1	7.717	46.650	46.7	7.7
5	3	3	3	528	2	3	3	80	1	2	1	4.497	80.053	80	4.5
5	3	3	4	200	1	3	2	60	1	2	1	2.189	62.295	63.1	2.16
5	3	3	5	200	1	3	3	80	1	2	1	1.619	84.227	82.3	1.65
5	3	3	6	200	1	3	1	45	1	2	1	3.021	45.139	45.1	3.02
5	3	3	7	528	2	3	3	80	2	2	1	4.523	79.593	78.1	4.6
5	3	3	8	528	2	3	2	60	2	2	1	5.882	61.204	61.3	5.86
5	3	3	9	528	2	3	1	45	2	2	1	8.75	41.143	40.9	8.78
5	3	3	10	200	1	3	1	45	2	2	1	3.288	41.473	42.1	3.24
5	3	3	11	200	1	3	2	60	2	2	1	2.251	60.579	63.1	2.16
5	3	3	12	200	1	3	3	80	2	2	1	1.785	76.394	75.8	1.8
5	3	3	13	528	2	3	1	45	2	1	1	7.707	46.711	46.2	7.77
5	3	3	14	528	2	3	2	60	2	1	1	6.346	56.729	55.8	6.44
5	3	3	15	528	2	3	3	80	2	1	1	4.446	80.972	78.7	4.57
5	3	3	16	200	1	3	1	45	2	1	1	2.87	47.513	52.2	2.73
5	3	3	17	200	1	3	3	80	2	1	1	1.749	77.967	86.3	1.65
5	3	3	18	200	1	3	2	60	2	1	1	2.254	60.499	65	2.19
5	3	3	19	528	2	3	3	80	1	1	1	4.39	82.005	78.7	4.57
5	3	3	20	528	2	3	2	60	1	1	1	5.775	62.338	62.1	5.79
5	3	3	21	528	2	3	1	45	1	1	1	7.479	48.135	47.3	7.59
5	3	3	22	200	1	3	2	60	1	1	1	2.224	61.315	64.2	2.12
5	3	3	23	200	1	3	1	45	1	1	1	2.858	47.713	50.5	2.7
5	3	3	24	200	1	3	3	80	1	1	1	1.743	78.235	82.3	1.65
5	3	4	1	200	1	3	3	80	1	2	1	1.774	76.868	75.8	1.8
5	3	4	2	200	1	3	2	60	1	2	1	2.253	60.525	61.1	2.23
5	3	4	3	200	1	3	1	45	1	2	1	2.76	49.407	49.8	2.73
5	3	4	4	528	2	3	1	45	1	2	1	8.748	41.152	40.6	8.85
5	3	4	5	528	2	3	3	80	1	2	1	4.572	78.740	76.9	4.68
5	3	4	6	528	2	3	2	60	1	2	1	5.876	61.266	60.2	5.97
5	3	4	7	528	2	3	2	60	2	2	1	6.015	59.850	58.4	6.15
5	3	4	8	528	2	3	1	45	2	2	1	7.558	47.632	47.6	7.56
5	3	4	9	528	2	3	3	80	2	2	1	4.509	79.840	78.1	4.6
5	3	4	10	200	1	3	1	45	2	2	1	2.859	47.696	47.3	2.88
5	3	4	11	200	1	3	2	60	2	2	1	2.137	63.811	67.6	2.01
5	3	4	12	200	1	3	3	80	2	2	1	1.716	79.466	80.6	1.69
5	3	4	13	200	1	3	2	60	1	1	1	2.446	55.750	57.4	2.37
5	3	4	14	200	1	3	1	45	1	1	1	2.911	46.844	48.5	2.8
5	3	4	15	200	1	3	3	80	1	1	1	1.736	78.550	77.3	1.76
5	3	4	16	528	2	3	1	45	1	1	1	7.911	45.506	45.4	7.92
5	3	4	17	528	2	3	3	80	1	1	1	4.503	79.947	78.1	4.6
5	3	4	18	528	2	3	2	60	1	1	1	5.773	62.359	62.1	5.79
5	3	4	19	528	2	3	1	45	2	1	1	7.212	49.917	49.2	7.3
5	3	4	20	528	2	3	2	60	2	1	1	6.44	55.901	55.2	6.51
5	3	4	21	528	2	3	3	80	2	1	1	4.567	78.826	76.9	4.68
5	3	4	22	200	1	3	1	45	2	1	2	2.767	49.282	46.2	2.95
5	3	4	23	200	1	3	2	60	2	1	1	2.11	64.627	61.1	2.23
5	3	4	24	200	1	3	3	80	2	1	1	1.678	81.266	77.3	1.76

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
6	3	1	1	200	1	3	1	45	1	1	1	2.85	47.847	51.9	2.62
6	3	1	2	200	1	3	2	60	1	1	1	2.388	57.104	64.2	2.12
6	3	1	3	200	1	3	3	80	1	1	1	1.703	80.073	90.2	1.51
6	3	1	4	528	2	3	1	45	1	1	2	8.13	44.280	44	8.17
6	3	1	5	528	2	3	3	80	1	1	1	4.394	81.930	81.3	4.42
6	3	1	6	528	2	3	2	60	1	1	1	6.043	59.573	59.8	6.01
6	3	1	7	200	1	3	1	45	2	1	1	3.5	38.961	41.1	3.31
6	3	1	8	200	1	3	3	80	2	1	1	1.667	81.802	86.1	1.58
6	3	1	9	200	1	3	2	60	2	1	1	2.497	54.611	58.3	2.34
6	3	1	10	528	2	3	3	80	2	1	1	4.784	75.251	74.6	4.82
6	3	1	11	528	2	3	1	45	2	1	1	8.745	41.166	40.9	8.78
6	3	1	12	528	2	3	2	60	2	1	1	6.059	59.416	59.5	6.04
6	3	1	13	200	1	3	2	60	2	2	1	2.267	60.152	62.1	2.19
6	3	1	14	200	1	3	3	80	2	2	1	1.746	78.101	82.3	1.65
6	3	1	15	200	1	3	1	45	2	2	1	2.679	50.901	52.6	2.59
6	3	1	16	528	2	3	1	45	2	2	1	7.287	49.403	50.2	7.16
6	3	1	17	528	2	3	3	80	2	2	2	4.649	77.436	78.1	4.6
6	3	1	18	528	2	3	2	60	2	2	1	5.845	61.591	61.3	5.86
6	3	1	19	528	2	3	1	45	1	2	1	7.881	45.679	45.8	7.84
6	3	1	20	528	2	3	3	80	1	2	1	4.344	82.873	83.3	4.32
6	3	1	21	528	2	3	2	60	1	2	1	6.419	56.084	55.8	6.44
6	3	1	22	200	1	3	2	60	1	2	1	2.357	57.855	61.1	2.23
6	3	1	23	200	1	3	3	80	1	2	1	1.566	87.078	92.4	1.47
6	3	1	24	200	1	3	1	45	1	2	1	2.986	45.668	46.7	2.91
6	3	2	1	200	1	3	1	45	2	2	1	3.282	41.549	43	3.16
6	3	2	2	200	1	3	3	80	2	2	1	1.733	78.686	80.6	1.69
6	3	2	3	200	1	3	2	60	2	2	1	2.38	57.296	60.1	2.26
6	3	2	4	528	2	3	3	80	2	2	1	4.432	81.227	81.3	4.42
6	3	2	5	528	2	3	2	60	2	2	1	5.997	60.030	59.5	6.04
6	3	2	6	528	2	3	1	45	2	2	1	8.34	43.165	43.2	8.31
6	3	2	7	528	2	3	3	80	1	2	1	4.134	87.083	85.4	4.21
6	3	2	8	528	2	3	1	45	1	2	1	7.508	47.949	48	7.48
6	3	2	9	528	2	3	2	60	1	2	1	5.855	61.486	60.9	5.9
6	3	2	10	200	1	3	2	60	1	2	1	2.279	59.835	62.1	2.19
6	3	2	11	200	1	3	3	80	1	2	1	1.626	83.864	88.1	1.54
6	3	2	12	200	1	3	1	45	1	2	1	2.842	47.982	50.5	2.7
6	3	2	13	200	1	3	3	80	2	1	2	1.595	85.494	92.4	1.47
6	3	2	14	200	1	3	1	45	2	1	1	2.991	45.591	47.3	2.88
6	3	2	15	200	1	3	2	60	2	1	1	2.318	58.828	63.1	2.16
6	3	2	16	528	2	3	3	80	2	1	1	4.73	76.110	74.6	4.82
6	3	2	17	528	2	3	2	60	2	1	1	6.547	54.987	54.6	6.58
6	3	2	18	528	2	3	1	45	2	1	1	7.827	45.995	45.8	7.84
6	3	2	19	200	1	3	3	80	1	1	2	1.645	82.896	90.2	1.51
6	3	2	20	200	1	3	1	45	1	1	1	3.259	41.842	43.5	3.13
6	3	2	21	200	1	3	2	60	1	1	1	2.223	61.342	66.4	2.05
6	3	2	22	528	2	3	3	80	1	1	1	4.645	77.503	76.9	4.68
6	3	2	23	528	2	3	1	45	1	1	1	7.633	47.164	46.9	7.66
6	3	2	24	528	2	3	2	60	1	1	1	6.146	58.575	58.1	6.19

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
6	3	3	1	528	2	3	2	60	2	2	1	6.097	59.045	58.8	6.12
6	3	3	2	528	2	3	1	45	2	2	1	7.717	46.650	47.1	7.63
6	3	3	3	528	2	3	3	80	2	2	1	4.497	80.053	80	4.5
6	3	3	4	200	1	3	2	60	2	2	1	2.189	62.295	65.3	2.08
6	3	3	5	200	1	3	3	80	2	2	1	1.619	84.227	88.1	1.54
6	3	3	6	200	1	3	1	45	2	2	1	3.021	45.139	45.6	2.98
6	3	3	7	528	2	3	3	80	1	2	1	4.523	79.593	80	4.5
6	3	3	8	528	2	3	2	60	1	2	1	5.882	61.204	61.3	5.86
6	3	3	9	528	2	3	1	45	1	2	1	8.75	41.143	41.6	8.64
6	3	3	10	200	1	3	1	45	1	2	1	3.288	41.473	43	3.16
6	3	3	11	200	1	3	2	60	1	2	2	2.279	59.835	63.1	2.16
6	3	3	12	200	1	3	3	80	1	2	1	1.785	76.394	80.6	1.69
6	3	3	13	528	2	3	1	45	1	1	1	7.707	46.711	46.5	7.74
6	3	3	14	528	2	3	2	60	1	1	1	6.346	56.729	56.4	6.37
6	3	3	15	528	2	3	3	80	1	1	1	4.446	80.972	79.3	4.53
6	3	3	16	200	1	3	1	45	1	1	1	2.87	47.513	51.2	2.66
6	3	3	17	200	1	3	3	80	1	1	1	1.749	77.967	86.1	1.58
6	3	3	18	200	1	3	2	60	1	1	1	2.254	60.499	65.3	2.08
6	3	3	19	528	2	3	3	80	2	1	1	4.397	81.874	80.6	4.46
6	3	3	20	528	2	3	2	60	2	1	2	5.775	62.338	61.7	5.83
6	3	3	21	528	2	3	1	45	2	1	1	7.479	48.135	47.6	7.56
6	3	3	22	200	1	3	2	60	2	1	1	2.224	61.315	64.2	2.12
6	3	3	23	200	1	3	1	45	2	1	1	2.858	47.713	50.5	2.7
6	3	3	24	200	1	3	3	80	2	1	1	1.743	78.235	82.3	1.65
6	3	4	1	200	1	3	3	80	2	2	1	1.774	76.868	84.2	1.62
6	3	4	2	200	1	3	2	60	2	2	1	2.253	60.525	62.1	2.19
6	3	4	3	200	1	3	1	45	2	2	1	2.76	49.407	50.5	2.7
6	3	4	4	528	2	3	1	45	2	2	1	8.748	41.152	41.3	8.71
6	3	4	5	528	2	3	3	80	2	2	1	4.572	78.740	78.1	4.6
6	3	4	6	528	2	3	2	60	2	2	1	5.876	61.266	61.7	5.83
6	3	4	7	528	2	3	2	60	1	2	1	6.015	59.850	59.8	6.01
6	3	4	8	528	2	3	1	45	1	2	1	7.558	47.632	47.3	7.59
6	3	4	9	528	2	3	3	80	1	2	1	4.509	79.840	79.3	4.53
6	3	4	10	200	1	3	1	45	1	2	1	2.859	47.696	49.2	2.77
6	3	4	11	200	1	3	2	60	1	2	1	2.137	63.811	68.9	1.98
6	3	4	12	200	1	3	3	80	1	2	1	1.716	79.466	84.2	1.62
6	3	4	13	200	1	3	2	60	2	1	1	2.447	55.727	59.2	2.3
6	3	4	14	200	1	3	1	45	2	1	1	2.911	46.844	49.8	2.73
6	3	4	15	200	1	3	3	80	2	1	1	1.736	78.550	84.2	1.62
6	3	4	16	528	2	3	1	45	2	1	1	7.911	45.506	45.4	7.92
6	3	4	17	528	2	3	3	80	2	1	1	4.503	79.947	78.1	4.6
6	3	4	18	528	2	3	2	60	2	1	1	5.773	62.359	61.3	5.86
6	3	4	19	528	2	3	1	45	1	1	1	7.212	49.917	50.2	7.16
6	3	4	20	528	2	3	2	60	1	1	1	6.44	55.901	55.2	6.51
6	3	4	21	528	2	3	3	80	1	1	1	4.567	78.826	78.1	4.6
6	3	4	22	200	1	3	1	45	1	1	1	2.767	49.282	51.2	2.66
6	3	4	23	200	1	3	2	60	1	1	1	2.11	64.627	67.6	2.01
6	3	4	24	200	1	3	3	80	1	1	1	1.678	81.266	84.2	1.62

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
7	3	1	1	200	1	3	1	45	1	2	1	3.195	42.680	44	3.09
7	3	1	2	200	1	3	3	80	1	2	1	1.698	80.308	82.3	1.65
7	3	1	3	200	1	3	2	60	1	2	1	2.347	58.101	59.2	2.3
7	3	1	4	528	2	3	2	60	1	2	1	6.372	56.497	55.8	6.44
7	3	1	5	528	2	3	1	45	1	2	1	7.189	50.077	49.7	7.23
7	3	1	6	528	2	3	3	80	1	2	1	4.753	75.742	75.1	4.78
7	3	1	7	200	1	3	2	60	2	2	1	2.292	59.495	62.1	2.19
7	3	1	8	200	1	3	3	80	2	2	1	1.714	79.559	82.3	1.65
7	3	1	9	200	1	3	1	45	2	2	1	3.122	43.678	44.5	3.06
7	3	1	10	528	2	3	2	60	2	2	1	6.335	56.827	55.5	6.48
7	3	1	11	528	2	3	3	80	2	2	1	4.432	81.227	81.3	4.42
7	3	1	12	528	2	3	1	45	2	2	1	7.928	45.409	45.4	7.92
7	3	1	13	528	2	3	3	80	1	1	1	4.503	79.947	81.3	4.42
7	3	1	14	528	2	3	2	60	1	1	1	6.462	55.710	56.1	6.4
7	3	1	15	528	2	3	1	45	1	1	1	7.644	47.096	46.2	7.77
7	3	1	16	200	1	3	3	80	1	1	3	1.665	81.900	86.1	1.58
7	3	1	17	200	1	3	2	60	1	1	2	2.258	60.391	64.2	2.12
7	3	1	18	200	1	3	1	45	1	1	1	2.93	46.540	47.9	2.84
7	3	1	19	528	2	3	2	60	2	1	1	6.471	55.633	54.6	6.58
7	3	1	20	528	2	3	1	45	2	1	1	8.599	41.865	41.8	8.6
7	3	1	21	528	2	3	3	80	2	1	1	4.276	84.191	83.3	4.32
7	3	1	22	200	1	3	3	80	2	1	1	1.638	83.250	84.2	1.62
7	3	1	23	200	1	3	2	60	2	1	1	2.249	60.633	64.2	2.12
7	3	1	24	200	1	3	1	45	2	1	1	3.153	43.249	46.2	2.95
7	3	2	1	200	1	3	3	80	2	2	1	1.75	77.922	80.6	1.69
7	3	2	2	200	1	3	1	45	2	2	1	2.651	51.439	50.5	2.7
7	3	2	3	200	1	3	2	60	2	2	1	2.184	62.438	64.2	2.12
7	3	2	4	528	2	3	1	45	2	2	2	7.822	46.024	46	7.81
7	3	2	5	528	2	3	3	80	2	2	1	4.704	76.531	75.1	4.78
7	3	2	6	528	2	3	2	60	2	2	1	6.247	57.628	57.8	6.22
7	3	2	7	528	2	3	3	80	1	2	1	4.807	74.891	74	4.86
7	3	2	8	528	2	3	2	60	1	2	1	5.67	63.492	63.6	5.65
7	3	2	9	528	2	3	1	45	1	2	1	8.013	44.927	45	7.99
7	3	2	10	200	1	3	2	60	1	2	1	2.32	58.777	62.1	2.19
7	3	2	11	200	1	3	1	45	1	2	1	2.765	49.318	49.8	2.73
7	3	2	12	200	1	3	3	80	1	2	1	1.659	82.196	84.2	1.62
7	3	2	13	528	2	3	1	45	1	1	1	8.095	44.472	44	8.17
7	3	2	14	528	2	3	3	80	1	1	1	4.264	84.428	83.3	4.32
7	3	2	15	528	2	3	2	60	1	1	1	5.929	60.719	60.2	5.97
7	3	2	16	200	1	3	2	60	1	1	1	2.224	61.315	63.1	2.16
7	3	2	17	200	1	3	1	45	1	1	1	3.068	44.447	47.3	2.88
7	3	2	18	200	1	3	3	80	1	1	1	1.87	72.922	75.8	1.8
7	3	2	19	200	1	3	1	45	2	1	1	3.218	42.375	42.1	3.24
7	3	2	20	200	1	3	2	60	2	1	1	2.176	62.667	62.1	2.19
7	3	2	21	200	1	3	3	80	2	1	2	1.668	81.753	84.2	1.62
7	3	2	22	528	2	3	2	60	2	1	1	5.694	63.224	62.8	5.72
7	3	2	23	528	2	3	1	45	2	1	1	8.723	41.270	41.8	8.6
7	3	2	24	528	2	3	3	80	2	1	1	4.636	77.653	76.3	4.71

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
7	3	3	1	528	2	3	2	60	2	1	1	5.879	61.235	60.6	5.94
7	3	3	2	528	2	3	1	45	2	1	1	7.247	49.676	50.2	7.16
7	3	3	3	528	2	3	3	80	2	1	1	4.823	74.642	74	4.86
7	3	3	4	200	1	3	3	80	2	1	1	1.909	71.432	68.9	1.98
7	3	3	5	200	1	3	1	45	2	1	1	2.934	46.477	46.7	2.91
7	3	3	6	200	1	3	2	60	2	1	1	2.423	56.279	57.4	2.37
7	3	3	7	528	2	3	1	45	1	1	1	7.272	49.505	49.7	7.23
7	3	3	8	528	2	3	2	60	1	1	1	6.41	56.162	55.5	6.48
7	3	3	9	528	2	3	3	80	1	1	1	4.755	75.710	74.6	4.82
7	3	3	10	200	1	3	2	60	1	1	1	2.304	59.186	62.1	2.19
7	3	3	11	200	1	3	1	45	1	1	1	2.975	45.837	48.5	2.8
7	3	3	12	200	1	3	3	80	1	1	1	1.678	81.266	86.1	1.58
7	3	3	13	528	2	3	1	45	2	2	1	7.73	46.572	47.1	7.63
7	3	3	14	528	2	3	3	80	2	2	1	4.242	84.866	82.6	4.35
7	3	3	15	528	2	3	2	60	2	2	1	6.586	54.661	54.9	6.55
7	3	3	16	200	1	3	1	45	2	2	1	2.831	48.168	49.2	2.77
7	3	3	17	200	1	3	2	60	2	2	1	2.217	61.508	66.4	2.05
7	3	3	18	200	1	3	3	80	2	2	1	1.672	81.557	82.3	1.65
7	3	3	19	528	2	3	3	80	1	2	1	4.402	81.781	81.9	4.39
7	3	3	20	528	2	3	2	60	1	2	1	6.39	56.338	55.5	6.48
7	3	3	21	528	2	3	1	45	1	2	1	7.76	46.392	46.5	7.74
7	3	3	22	200	1	3	1	45	1	2	1	2.788	48.911	50.5	2.7
7	3	3	23	200	1	3	2	60	1	2	1	2.182	62.495	63.1	2.16
7	3	3	24	200	1	3	3	80	1	2	1	1.577	86.470	90.2	1.51
7	3	4	1	528	2	3	2	60	2	1	1	5.798	62.090	62.1	5.79
7	3	4	2	528	2	3	3	80	2	1	1	4.484	80.285	80	4.5
7	3	4	3	528	2	3	1	45	2	1	1	7.463	48.238	48	7.48
7	3	4	4	200	1	3	2	60	2	1	1	2.333	58.450	57.4	2.37
7	3	4	5	200	1	3	3	80	2	1	1	1.58	86.306	84.2	1.62
7	3	4	6	200	1	3	1	45	2	1	1	2.9	47.022	46.7	2.91
7	3	4	7	200	1	3	2	60	1	1	1	2.296	59.392	63.1	2.16
7	3	4	8	200	1	3	1	45	1	1	1	2.926	46.604	46.2	2.95
7	3	4	9	200	1	3	3	80	1	1	1	1.724	79.097	77.3	1.76
7	3	4	10	528	2	3	1	45	1	1	1	7.991	45.051	44.8	8.02
7	3	4	11	528	2	3	2	60	1	1	1	5.815	61.909	62.1	5.79
7	3	4	12	528	2	3	3	80	1	1	1	4.439	81.099	80	4.5
7	3	4	13	200	1	3	2	60	2	2	1	2.28	59.809	61.1	2.23
7	3	4	14	200	1	3	3	80	2	2	1	1.675	81.411	80.6	1.69
7	3	4	15	200	1	3	1	45	2	2	1	2.762	49.371	49.8	2.73
7	3	4	16	528	2	3	3	80	2	2	1	4.834	74.472	72.9	4.93
7	3	4	17	528	2	3	2	60	2	2	1	5.977	60.231	60.6	5.94
7	3	4	18	528	2	3	1	45	2	2	1	7.892	45.616	45.8	7.84
7	3	4	19	200	1	3	3	80	1	2	1	1.718	79.373	80.6	1.69
7	3	4	20	200	1	3	2	60	1	2	1	2.152	63.366	63.1	2.16
7	3	4	21	200	1	3	1	45	1	2	1	2.851	47.830	47.9	2.84
7	3	4	22	528	2	3	2	60	1	2	1	5.579	64.528	63.2	5.68
7	3	4	23	528	2	3	1	45	1	2	1	6.94	51.873	52	6.91
7	3	4	24	528	2	3	3	80	1	2	1	4.714	76.368	76.9	4.68

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
8	3	1	1	200	1	3	1	45	2	2	1	3.195	42.680	44	3.09
8	3	1	2	200	1	3	3	80	2	2	1	1.698	80.308	84.2	1.62
8	3	1	3	200	1	3	2	60	2	2	1	2.347	58.101	60.1	2.26
8	3	1	4	528	2	3	2	60	2	2	1	6.372	56.497	56.8	6.33
8	3	1	5	528	2	3	1	45	2	2	1	7.189	50.077	50	7.2
8	3	1	6	528	2	3	3	80	2	2	1	4.753	75.742	76.9	4.68
8	3	1	7	200	1	3	2	60	1	2	1	2.292	59.495	63.1	2.16
8	3	1	8	200	1	3	3	80	1	2	1	1.714	79.559	82.3	1.65
8	3	1	9	200	1	3	1	45	1	2	1	3.122	43.678	46.2	2.95
8	3	1	10	528	2	3	2	60	1	2	2	6.39	56.338	57.1	6.3
8	3	1	11	528	2	3	3	80	1	2	1	4.432	81.227	81.3	4.42
8	3	1	12	528	2	3	1	45	1	2	1	7.928	45.409	45.4	7.92
8	3	1	13	528	2	3	3	80	2	1	1	4.503	79.947	78.1	4.6
8	3	1	14	528	2	3	2	60	2	1	1	6.462	55.710	55.8	6.44
8	3	1	15	528	2	3	1	45	2	1	1	7.644	47.096	47.3	7.59
8	3	1	16	200	1	3	3	80	2	1	1	1.658	82.246	90.2	1.51
8	3	1	17	200	1	3	2	60	2	1	1	2.256	60.445	66.4	2.05
8	3	1	18	200	1	3	1	45	2	1	1	2.93	46.540	50.5	2.7
8	3	1	19	528	2	3	2	60	1	1	1	6.471	55.633	56.1	6.4
8	3	1	20	528	2	3	1	45	1	1	1	8.599	41.865	41.8	8.6
8	3	1	21	528	2	3	3	80	1	1	1	4.276	84.191	85.4	4.21
8	3	1	22	200	1	3	3	80	1	1	2	1.646	82.845	90.2	1.51
8	3	1	23	200	1	3	2	60	1	1	1	2.249	60.633	65.3	2.08
8	3	1	24	200	1	3	1	45	1	1	1	3.153	43.249	46.7	2.91
8	3	2	1	200	1	3	3	80	1	2	1	1.75	77.922	80.6	1.69
8	3	2	2	200	1	3	1	45	1	2	1	2.651	51.439	54.1	2.52
8	3	2	3	200	1	3	2	60	1	2	1	2.184	62.438	65.3	2.08
8	3	2	4	528	2	3	1	45	1	2	1	7.134	50.463	50.7	7.09
8	3	2	5	528	2	3	3	80	1	2	1	4.704	76.531	76.9	4.68
8	3	2	6	528	2	3	2	60	1	2	1	6.247	57.628	57.8	6.22
8	3	2	7	528	2	3	3	80	2	2	1	4.807	74.891	75.1	4.78
8	3	2	8	528	2	3	2	60	2	2	1	5.67	63.492	64.1	5.61
8	3	2	9	528	2	3	1	45	2	2	1	8.013	44.927	44.8	8.02
8	3	2	10	200	1	3	2	60	2	2	2	2.259	60.365	63.1	2.16
8	3	2	11	200	1	3	1	45	2	2	2	2.709	50.337	51.2	2.66
8	3	2	12	200	1	3	3	80	2	2	1	1.659	82.196	80.6	1.69
8	3	2	13	528	2	3	1	45	2	1	1	8.095	44.472	44.4	8.1
8	3	2	14	528	2	3	3	80	2	1	1	4.264	84.428	84.7	4.24
8	3	2	15	528	2	3	2	60	2	1	1	5.929	60.719	60.6	5.94
8	3	2	16	200	1	3	2	60	2	1	1	2.224	61.315	65.3	2.08
8	3	2	17	200	1	3	1	45	2	1	1	3.068	44.447	48.5	2.8
8	3	2	18	200	1	3	3	80	2	1	1	1.87	72.922	77.3	1.76
8	3	2	19	200	1	3	1	45	1	1	1	3.218	42.375	44.5	3.06
8	3	2	20	200	1	3	2	60	1	1	1	2.176	62.667	66.4	2.05
8	3	2	21	200	1	3	3	80	1	1	1	1.628	83.761	90.2	1.51
8	3	2	22	528	2	3	2	60	1	1	1	5.694	63.224	63.2	5.68
8	3	2	23	528	2	3	1	45	1	1	1	8.723	41.270	42.1	8.53
8	3	2	24	528	2	3	3	80	1	1	1	4.636	77.653	76.9	4.68

TABLE I.15 -- Raw Data For Angular Study (Continued)

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
8	3	3	1	528	2	3	2	60	1	1	1	5.98	60.201	59.8	6.01
8	3	3	2	528	2	3	1	45	1	1	1	7.247	49.676	49.7	7.23
8	3	3	3	528	2	3	3	80	1	1	1	4.823	74.642	74.6	4.82
8	3	3	4	200	1	3	3	80	1	1	1	1.909	71.432	74.3	1.83
8	3	3	5	200	1	3	1	45	1	1	1	2.934	46.477	49.8	2.73
8	3	3	6	200	1	3	2	60	1	1	1	2.423	56.279	62.1	2.19
8	3	3	7	528	2	3	1	45	2	1	1	6.993	51.480	52.6	6.84
8	3	3	8	528	2	3	2	60	2	1	1	6.41	56.162	56.4	6.37
8	3	3	9	528	2	3	3	80	2	1	1	4.755	75.710	76.3	4.71
8	3	3	10	200	1	3	2	60	2	1	1	2.304	59.186	62.1	2.19
8	3	3	11	200	1	3	1	45	2	1	1	2.975	45.837	49.2	2.77
8	3	3	12	200	1	3	3	80	2	1	1	1.678	81.266	88.1	1.54
8	3	3	13	528	2	3	1	45	1	2	1	8.091	44.494	44.6	8.06
8	3	3	14	528	2	3	3	80	1	2	1	4.242	84.866	84.7	4.24
8	3	3	15	528	2	3	2	60	1	2	1	6.586	54.661	54.3	6.62
8	3	3	16	200	1	3	1	45	1	2	1	2.831	48.168	51.2	2.66
8	3	3	17	200	1	3	2	60	1	2	1	2.217	61.508	62.1	2.19
8	3	3	18	200	1	3	3	80	1	2	1	1.672	81.557	84.2	1.62
8	3	3	19	528	2	3	3	80	2	2	1	4.374	82.305	83.3	4.32
8	3	3	20	528	2	3	2	60	2	2	1	6.39	56.338	56.4	6.37
8	3	3	21	528	2	3	1	45	2	2	1	7.76	46.392	46.2	7.77
8	3	3	22	200	1	3	1	45	2	2	1	2.788	48.911	50.5	2.7
8	3	3	23	200	1	3	2	60	2	2	1	2.182	62.495	65.3	2.08
8	3	3	24	200	1	3	3	80	2	2	1	1.577	86.470	90.2	1.51
8	3	4	1	528	2	3	2	60	1	1	1	5.798	62.090	62.8	5.72
8	3	4	2	528	2	3	3	80	1	1	1	4.484	80.285	80.6	4.46
8	3	4	3	528	2	3	1	45	1	1	1	7.463	48.238	48.5	7.41
8	3	4	4	200	1	3	2	60	1	1	1	2.333	58.450	63.1	2.16
8	3	4	5	200	1	3	3	80	1	1	1	1.58	86.306	92.4	1.47
8	3	4	6	200	1	3	1	45	1	1	1	2.9	47.022	51.2	2.66
8	3	4	7	200	1	3	2	60	2	1	1	2.296	59.392	64.2	2.12
8	3	4	8	200	1	3	1	45	2	1	1	2.926	46.604	49.8	2.73
8	3	4	9	200	1	3	3	80	2	1	1	1.724	79.097	86.1	1.58
8	3	4	10	528	2	3	1	45	2	1	1	7.991	45.051	45.2	7.95
8	3	4	11	528	2	3	2	60	2	1	1	5.815	61.909	62.8	5.72
8	3	4	12	528	2	3	3	80	2	1	1	4.439	81.099	81.3	4.42
8	3	4	13	200	1	3	2	60	1	2	1	2.28	59.809	61.1	2.23
8	3	4	14	200	1	3	3	80	1	2	1	1.675	81.411	84.2	1.62
8	3	4	15	200	1	3	1	45	1	2	1	2.762	49.371	50.5	2.7
8	3	4	16	528	2	3	3	80	1	2	1	4.834	74.472	74.6	4.82
8	3	4	17	528	2	3	2	60	1	2	1	5.977	60.231	60.9	5.9
8	3	4	18	528	2	3	1	45	1	2	1	7.892	45.616	46.2	7.77
8	3	4	19	200	1	3	3	80	2	2	1	1.718	79.373	80.6	1.69
8	3	4	20	200	1	3	2	60	2	2	1	2.152	63.366	64.2	2.12
8	3	4	21	200	1	3	1	45	2	2	1	2.851	47.830	48.5	2.8
8	3	4	22	528	2	3	2	60	2	2	1	5.695	63.213	63.6	5.65
8	3	4	23	528	2	3	1	45	2	2	1	6.94	51.873	52	6.91
8	3	4	24	528	2	3	3	80	2	2	1	4.714	76.368	76.3	4.71

TABLE I.16 -- Reference Marker Alignment - Summary Statistics

View Dist.	Elevation	Course Dist.	Nom. Speed	N	Mean	Upper 90% Limit	Observed 95%-tile	Observed 99%-tile	MSE	Variance	K
Align - Overall				24	-0.063	3.999	2.698	2.877	3.3320	3.182	2.225
200	Ground	200	45	8	-0.346	5.181	0.901	0.954	3.1064	1.629	3.136
200	Ground	200	60	8	0.199	4.953	2.169	2.373	2.3753	1.797	3.136
200	Ground	200	80	8	0.040	4.276	3.442	3.802	1.8244	6.887	3.136

View Dist.	Elevation	Course Dist.	Nom. Speed	N	Mean	Upper 90% Limit	Observed 95%-tile	Observed 99%-tile	MSE	Variance	K
Angular - Comparable Conditions				24	3.479	8.492	6.372	7.137	5.0754	4.183	2.225
200	Ground	200	45	8	2.444	7.472	3.887	4.120	2.5710	2.057	3.136
200	Ground	200	60	8	3.886	6.027	5.359	5.729	0.4661	1.480	3.136
200	Ground	200	80	8	4.109	13.054	6.989	7.282	8.1365	8.339	3.136

Reference Marker Alignment Study - Aligned vs. Unaligned Reference Marks

A. Variables

Subject Number
Nominal Speed
Replication
Alignment

B. Significant Effects ($p \leq 0.05$)

Alignment

Alignment	Mean Error
Not Aligned	3.479
Aligned	-0.063

Subject Number- see summary of experiment

TABLE I.17 -- Raw Data For Reference Marker Alignment Study

SubNum	SessNum	RepNum	TrialNo	CrsDist	CrsDistR	RefType	NomSpd	DesrdSpd	Elevatn	ViewDist	NoAttempt	TrueTime	TrueSpd	VASspeed	VAStime
7	6	1	1	200	1	3	2	60	1	1	1	2.49	54.765	54.1	2.52
7	6	1	2	200	1	3	3	80	1	1	1	1.649	82.695	80.6	1.69
7	6	1	3	200	1	3	1	45	1	1	1	3.356	40.633	41.6	3.27
7	6	2	1	200	1	3	2	60	1	1	1	2.392	57.008	57.4	2.37
7	6	2	2	200	1	3	3	80	1	1	1	1.841	74.070	70.1	1.94
7	6	2	3	200	1	3	1	45	1	1	1	2.913	46.812	45.6	2.98
7	6	3	1	200	1	3	2	60	1	1	1	2.324	58.676	61.1	2.23
7	6	3	2	200	1	3	1	45	1	1	1	2.7	50.505	50.5	2.7
7	6	3	3	200	1	3	3	80	1	1	1	1.804	75.590	74.3	1.83
7	6	4	1	200	1	3	1	45	1	1	1	3.082	44.245	43.5	3.13
7	6	4	2	200	1	3	2	60	1	1	1	2.199	62.012	61.1	2.23
7	6	4	3	200	1	3	3	80	1	1	1	1.697	80.356	80.6	1.69
8	6	1	1	200	1	3	2	60	1	1	1	2.449	55.681	55.7	2.44
8	6	1	2	200	1	3	3	80	1	1	1	1.698	80.308	84.2	1.62
8	6	1	3	200	1	3	1	45	1	1	1	3.19	42.747	39.8	3.42
8	6	2	1	200	1	3	2	60	1	1	1	2.299	59.314	61.1	2.23
8	6	2	2	200	1	3	3	80	1	1	1	1.744	78.190	77.3	1.76
8	6	2	3	200	1	3	1	45	1	1	1	2.894	47.119	47.3	2.88
8	6	3	1	200	1	3	2	60	1	1	1	2.331	58.500	57.4	2.37
8	6	3	2	200	1	3	1	45	1	1	1	2.783	48.999	49.8	2.73
8	6	3	3	200	1	3	3	80	1	1	1	1.752	77.833	80.6	1.69
8	6	4	1	200	1	3	1	45	1	1	1	2.964	46.007	46.2	2.95
8	6	4	2	200	1	3	2	60	1	1	1	2.196	62.096	61.1	2.23
8	6	4	3	200	1	3	3	80	1	1	1	1.691	80.641	82.3	1.65

APPENDIX J

A Second Statistical Analysis

A second statistical analysis was performed to determine statistically significant variables. This analysis took into account the lack of complete randomization for the different studies. The lack of complete randomization created what is called a split-plot experimental design. The statistical analysis in the body of the report did not examine the effect of the split-plot design. The results of this second analysis (w/ split-plot) is compared to the results of the first analysis (w/o split-plot) in Table J.1.

Table J.1 -- Comparison of Statistical Analyses With and With Out Split-Plot

Study	Statistically Significant Variables	
	w/ split-plot	w/o split-plot
Moving	Subjects Distance x Method Speed x Distance x Method	Subjects Method Distance Speed x Method Distance x Method Speed x Distance x Method
Reference Marker Alignment	Alignment	Alignment Subjects
Parking	Subjects Speed x Distance	Subjects Speed x Distance -nearly significant
Angular - (see note)	Subjects Replicate Distance x Viewing Distance Distance x Speed	Subjects Distance Subject x Distance Distance x Speed

Note - The analyses for the angular study presented in Table J.1 do not include group effects.

The results presented in Table J.1 show that the two analyses are very similar. Since this was the case, it was decided not to pursue the split-plot analysis further.

APPENDIX K

Preliminary Study Results

OBJECTIVE

The main objective of this preliminary evaluation was to determine the accuracy of the VASCAR-plus hardware, without including the human factors involved with typical usage. A secondary objective was to compare user operated VASCAR speed measurements to "true" average speed measurements. The results of these tests must be considered preliminary.

TEST PROCEDURE

To check the accuracy of the drive in distance method, officers A and B were asked to drive in distances between two sets of reference points. The first set of reference points were 240 feet apart, the second set were 440 feet apart. The accuracy of these distances is +/- 1/2 inch. Each officer was asked to drive in the distance 5 times. The officers set the VASCAR units to display the measured distance to the nearest foot. [It was later discovered that this set up for the display was not the highest resolution VASCAR can achieve. It has a higher resolution when the distance is displayed in miles.]

To test the accuracy of the timing mechanism of the VASCAR-plus, a vehicle was driven repeatedly over a known distance (in this case a separate course which was measured to be 439 feet 8-9/16 inches) at three different nominal speeds (35, 55, and 65 mph). A separate VASCAR-plus unit and a Nicolet oscilloscope were wired to two electronic trip switches; one at the beginning of the course, and one at the end. The trip switches were tripped by the vehicle tires rolling over them. Since both the front and rear tires will cause the trip switches to trip, a "flip-flop" circuit was used to insure that only the front tire of the vehicle would trip the Nicolet and the VASCAR-plus timing mechanism. [It was later discovered that the flip-flop circuit and the VASCAR-plus timing mechanism were incompatible. The flip flop circuit induced inconsistent timing delays in the VASCAR timing mechanism that were not found in later bench tests conducted without the flip-flop circuit. The flip-flop circuit did not affect the Nicolet timing mechanism.]

The VASCAR-plus manual states that the device collects data every 36 milliseconds (msec). The Nicolet can collect data at user selected time increments. For the 35 mph tests, the Nicolet sample interval was set at 2 msec, and for the 55 and 65 mph tests, a sample interval of 1 msec was chosen. These Nicolet sample rates yield a speed measurement resolution of .014 mph or better, so the Nicolet times were taken as the true times and the VASCAR-plus times were compared to them. The trip switches and the flip-flop board reaction times were at least 100 times less than the Nicolet sample intervals used, so they did not introduce significant error for the Nicolet time measurements. The flip-flop circuit measured reaction times are given in the attachment to this appendix.

Officers A and B also measured the vehicle speed during the above tests, as well as others. The officers first entered the course distance using the "drive-in" method. They then were positioned approximately 300 feet away from the center of the course (see Figure K.1). Officer A was in a squad car elevated approximately 7 feet above the ground, while officer B was in a car at ground level. Poles were positioned at the beginning and the end of the course, so the officers had good reference markers. The officers watched the vehicle pass the poles. As the vehicle passed the first pole, the officers switched on the red time toggle switch, and as it passed the second pole, they switched it off. The VASCAR-plus computer then calculated the speed based on the entered distance and the time the red time switch was on. These speeds were recorded and compared to the Nicolet calculated speeds which were based on dividing the distance of the course by the Nicolet recorded time.

The officers also recorded speeds on a 200 foot course. The officers were again positioned near the center of the course, but officer A was positioned right next to the course and officer B was positioned approximately 150 feet away (see Figure K.2). The officers objected to these conditions. The reference markers for this course were yellow strips of tape that were placed on the ground at the beginning and end of the course. The officer measured the speed the same way as described before. Nominal speeds of 35 and 60 mph were used on this course. The Nicolet and trip switches were also used on this course to measure the true speed. The Nicolet sample interval was 1 msec for the 35 mph tests and .5 msec for the 60 mph tests. Again, the officers' speeds were recorded and compared to the Nicolet's calculated speed.

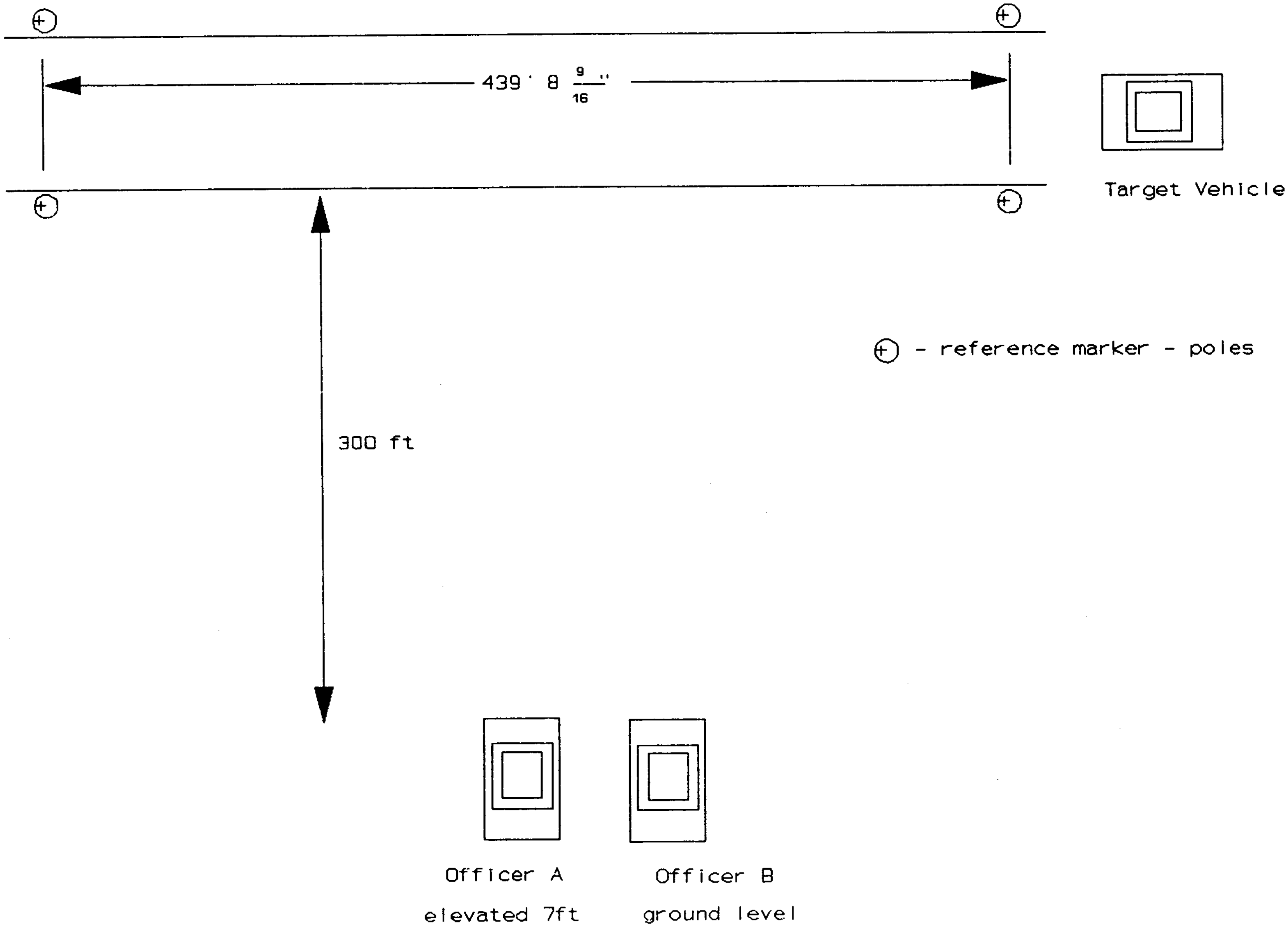


FIGURE K.1 - Course and Officer Locations for the 439.71 Foot Course

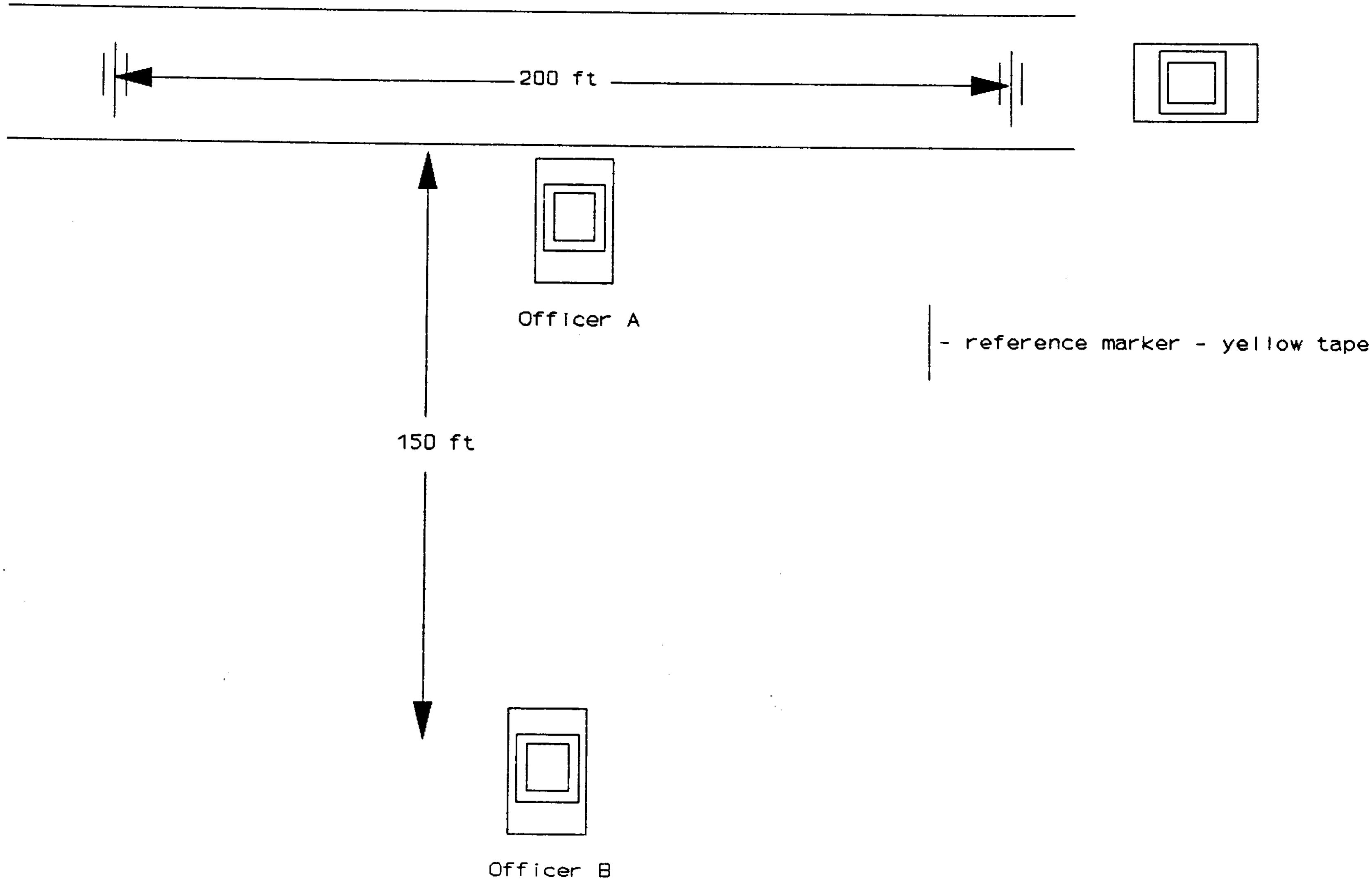


FIGURE K.2 - Course and Officer Locations for the 200 Foot Course

PRESENTATION OF RESULTS

The results of the distance measurements performed by officers A and B are shown in Table K.1. The left half of the table is for the 240 foot distance, while the right half is for the 440 foot distance. The mean and standard deviation for each distance and for each officer are presented at the bottom of the table.

TABLE K.1

Distance Measurement Using VASCAR-plus

	Officer Measurement of 240 Foot Distance Using VASCAR-plus		Officer Measurement of 440 Foot Distance Using VASCAR-plus	
	Officer A	Officer B	Officer A	Officer B
	239	239	441	440
	240	239	440	440
	240	240	442	441
	241	239	440	439
	241	239	441	440
Mean	240.2	239.2	440.8	440
Standard Deviation	0.84	0.45	0.84	0.71

The Nicolet and VASCAR-plus time measurements for the 35 mph tests on the 439 feet 8-9/16 inch (439.71 feet) course are compared in Table K.2. Both the Nicolet and VASCAR were triggered with the same electronic switches, so no human factors were involved in the time measurements. The Nicolet times are presented in the first column and the VASCAR-plus times are in the second column. Time error (VASCAR time - Nicolet Time) is presented in the third column and the percent time error is presented in the fourth column.

Nicolet and VASCAR velocities that were calculated using the time values in Table K.2 and the course distance (439.71 feet) are compared in Table K.3. Tables for the 55 and 65 mph tests are in the attachment to this appendix.

TABLE K.2

Comparison of NICOLET and VASCAR Time Measurements

NOMINAL SPEED = 35 mph
DISTANCE = 439.71 ft

	Nicolet 2 ms	VASCAR Tripped	Time Error	Percent Time Error
	8.282	8.24	-0.042	-0.51
	8.566	8.53	-0.036	-0.42
	8.552	8.49	-0.062	-0.72
	8.316	8.28	-0.036	-0.43
	8.490	8.46	-0.030	-0.35
	8.408	8.35	-0.058	-0.69
	8.400	8.35	-0.050	-0.60
	8.244	8.20	-0.044	-0.53
	8.246	8.20	-0.046	-0.56
	8.340	8.31	-0.030	-0.36
Mean	8.384	8.34	-0.043	-0.52
Standard Deviation	0.120	0.119	0.011	0.129

TABLE K.3
Comparison of NICOLET and VASCAR Velocity Calculations

NOMINAL SPEED = 35 mph
DISTANCE = 439.71 ft

	Nicolet Calculation	VASCAR Calculation	Speed Error	Percent Speed Error
	36.20	36.38	0.185	0.51
	35.00	35.15	0.148	0.42
	35.06	35.31	0.256	0.73
	36.05	36.21	0.157	0.43
	35.31	35.44	0.125	0.35
	35.66	35.90	0.248	0.69
	35.69	35.90	0.214	0.60
	36.37	36.56	0.195	0.54
	36.36	36.56	0.204	0.56
	35.95	36.08	0.130	0.36
Mean	35.76	35.95	0.186	0.52
Standard Deviation	0.508	0.510	0.046	0.130

The mean absolute and percent differences between the Nicolet and VASCAR computed velocities for the 35, 55, and 65 mph tests are listed in Table K.4.

TABLE K.4
Mean Errors and Mean Percent Errors for VASCAR Computed Velocities

Test Condition (nominal speed/course length) (mph/feet)	Mean Error (mph)	Mean Percent Error (%)
35/439.71	.186	0.52
55/439.71	.404	0.74
65/439.7	.535	0.83

Comparisons of officer A's and B's measured velocities to the "true" velocities for the 35 mph tests on the 200 foot course are shown in Tables K.5 - K.7. The true velocities are calculated using the Nicolet times and the course distance. The true velocities and officer A's and B's velocities are listed in Table K.5. For these tests, officer A was next to the course (distance=0) and officer B was 150 feet away from the course (distance=150).

TABLE K.5

Comparison of True and Officer Measured Velocities Using VASCAR-plus

NOMINAL SPEED = 35 mph
DISTANCE = 200 ft

	True Velocity	Officer A Distance* = 0	Officer B Distance* = 150
	35.24	36.4	35.3
	33.15	33.8	33.1
	34.56	35.1	34.6
	37.03	37.1	36.3
	36.19	36.4	36.6
	34.62	35.7	34.6
	33.99	34.8	34.3
	34.69	35.7	35.0
	34.77	35.7	34.6
	33.75	35.1	33.4
Mean	34.80	35.58	34.78
Standard Deviation	1.139	0.939	1.105

*Distance = Distance From Target Vehicle Path in Feet

The percent speed errors are listed in Table K.6. The mean and standard deviation for each officers percent speed error are presented at the bottom of the table.

TABLE K.6

Officers' Percent Speed Error

NOMINAL SPEED = 35 mph
DISTANCE = 200 ft

	Officer A Distance = 0	Officer B Distance = 150
	3.30	0.18
	1.97	-0.14
	1.57	0.12
	0.20	-1.96
	0.58	1.13
	3.12	-0.05
	2.39	0.92
	2.91	0.90
	2.68	-0.49
	3.99	-1.04
Mean	2.27	-0.04
Standard Deviation	1.204	0.951

The speed errors are listed in Table K.7. The mean and standard deviation for speed error are at the bottom of the table. Similar tables for the other test conditions are in the attachment to this appendix.

TABLE K.7

Officers' Speed Error

NOMINAL SPEED = 35 mph
DISTANCE = 200 ft

	Officer A Distance = 0	Officer B Distance = 150
	1.16	0.06
	0.65	-0.05
	0.54	0.04
	0.07	-0.73
	0.21	0.41
	1.08	-0.02
	0.81	0.31
	1.01	0.31
	0.93	-0.17
	1.35	-0.35
Mean	0.78	-0.02
Standard Deviation	0.412	0.341

Each officers' mean percent speed error for each test condition is listed in Table K.8.

TABLE K.8
Officer A and B Mean Percent Speed Error

Test Condition (nominal speed/course length) (mph/feet)	Officer A (%)	Officer B (%)
35/200	2.27	-0.04
60/200	5.41	1.11
35/439.71	0.55	1.08
55/439.71	0.67	1.37
65/439.71	0.71	1.25

Tables K.9 and K.10 list the mean and standard deviation for speed error for each test condition for officers A and B respectively.

TABLE K.9
Officer A's Mean and Standard Deviation for Speed Error

Test Condition (nominal speed/course length) (mph/feet)	Mean (mph)	Standard Deviation (mph)
35/200	0.78	0.412
60/200	3.26	1.602
35/439.71	0.20	0.261
55/439.71	0.37	0.392
65/439.71	0.45	0.631

TABLE K.10
Officer B's Mean and Standard Deviation for Speed Error

Test Condition (nominal speed/course length) (mph/feet)	Mean (mph)	Standard Deviation (mph)
35/200	-0.02	0.341
60/200	0.68	0.789
35/439.71	0.39	0.253
55/439.71	0.75	0.447
65/439.71	0.80	0.540

The upper 90th percentile tolerance limit (with 95% confidence) for each test condition and each officer is listed in Table K.11. The following formula is used to calculate these tolerance limits:

$$\text{Upper 90th Percentile Tolerance Limit} = \bar{X} + K \times S \qquad (K.1)$$

$$\bar{X} = \text{Sample Mean}$$
$$S = \text{Sample Standard Deviation}$$
$$K = \text{Factor for Two-Sided Tolerance Limit}$$

K for ten samples is 2.839.

TABLE K.11
Upper 90th Percentile Tolerance Limits for Speed Error

Test Condition (nominal speed/course length) (mph/feet)	Upper 90th Percentile Tolerance Limit for Speed Error Officer A (mph)	Officer B (mph)
35/200	1.95	0.95
60/200	7.81	2.92
35/439.71	0.94	1.10
55/439.71	1.48	2.02
65/439.71	2.25	2.34

The upper 90th percentile tolerance limits for the 200 foot course distance are plotted in Figure K.3. From Figure K.3, the upper 90th percentile tolerance limits for officer B were less than those for officer A. This probably was primarily due to officer location. Referring to Figure K.2, officer A was right next to the course, while officer B was 150 feet away. This probably gave officer B a better vantage point. The tolerance limits increased as speed increased. The officers strongly objected to the set up of the test conditions. They said they would never set up a course like this.

The upper 90th percentile tolerance limits for the 439.71 foot course distance are plotted in Figure K.4. From this figure, the upper tolerance limits for both officers were fairly comparable. The tolerance limits increased as speed increased.

Upper 90th percentile tolerance limits for the VASCAR distance measurements and the VASCAR timing mechanism were not appropriate due to complications with the testing. As stated earlier, the VASCAR timing errors for these tests were incorrect due to complications with the flip-flop circuit. The VASCAR distance

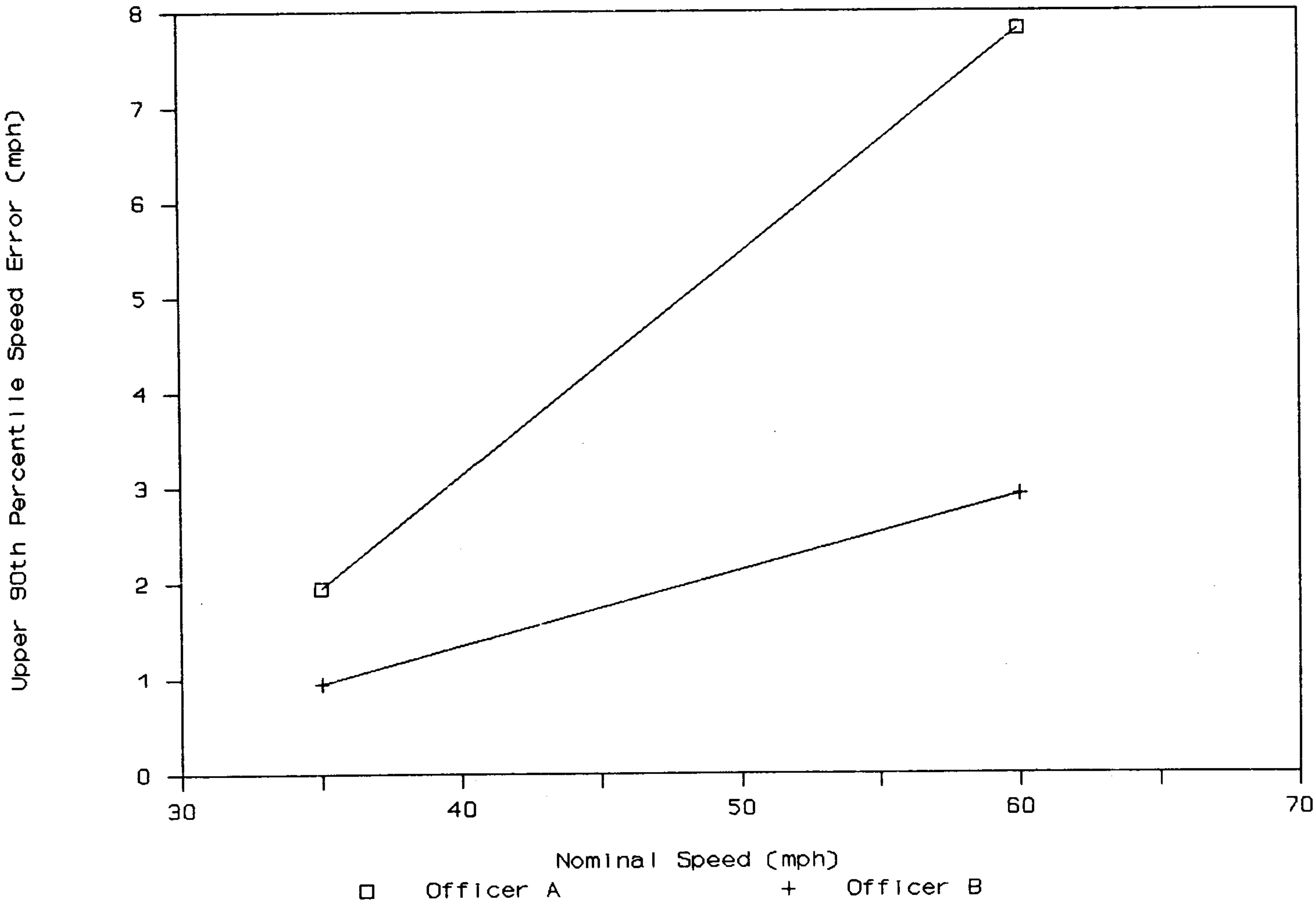


FIGURE K.3 - Upper 90th Percentile Speed Errors for the 200 Foot Course

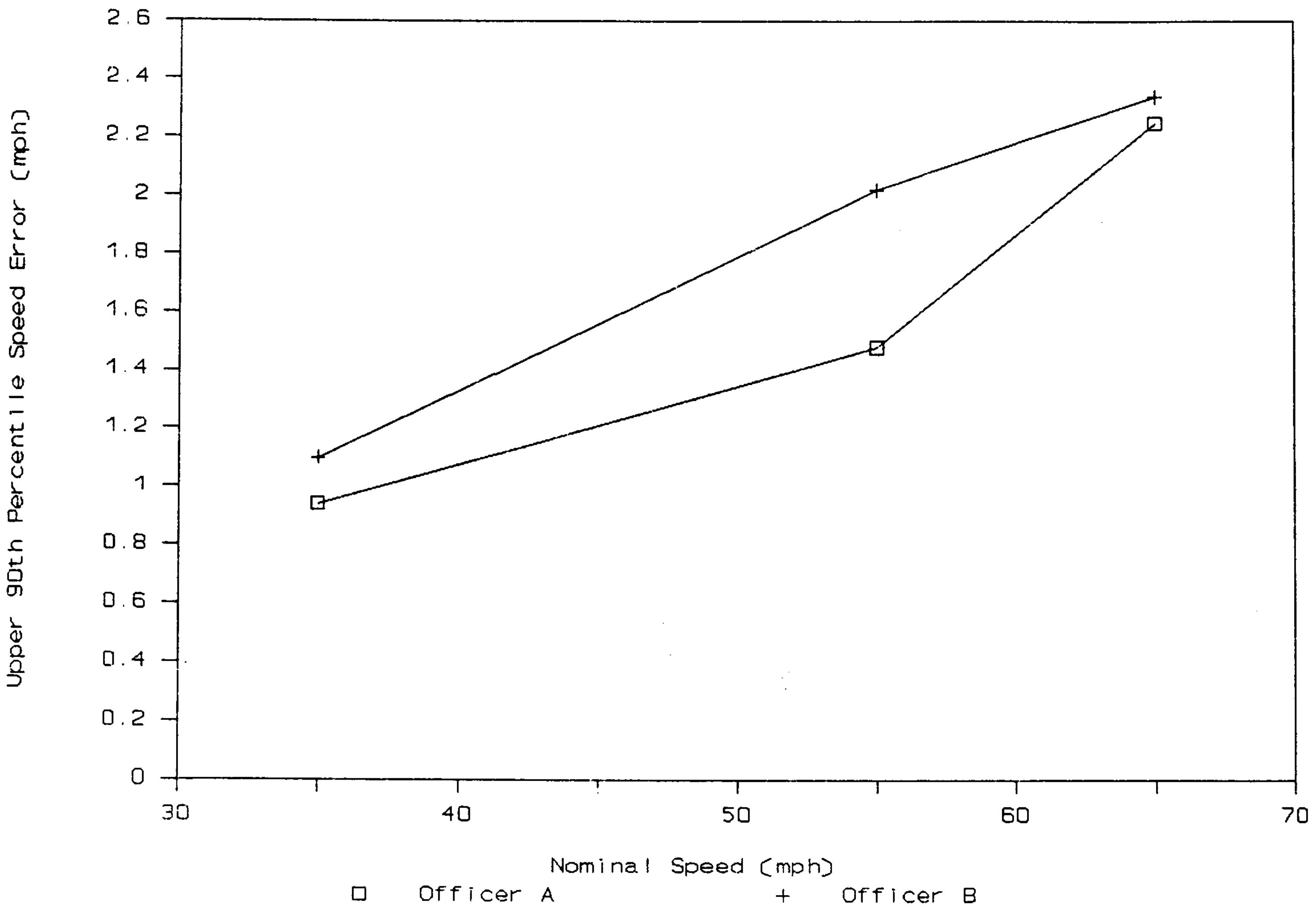


FIGURE K.4 - Upper 90th Percentile Speed Errors for the 439.71 Foot Course

errors were incorrect because the VASCAR was set up to display in feet instead of miles.

SUMMARY

Since this study was considered preliminary, and since it was limited to only two officers, no definitive conclusions were drawn. The following statements summarize the results of this study:

1. The mean speed errors were less than 1 mph for 9 of the 10 combinations of officer, speed, and course distance. The errors increased as speed increased and as course distance decreased.

2. The upper 90th percentile tolerance limits for speed error were less than 2.5 mph for 8 of the 10 combinations of officer, speed, and course distance. The two conditions which produced higher tolerance limits were the 60 mph/200 foot course distance combination for each officer. This combination of speed and course distance gave the shortest timing interval for the study.

3. The two officers that participated in this study objected to some of the viewing distance/course distance combinations. Their strongest objections were for the officer adjacent to the roadway/200 foot course distance combination.

4. The errors in the distance measurements taken with the VASCAR-plus device were not representative, since the device was not set at its highest resolution. This was not learned until after the completion of the testing for this study.

5. The error in the timing mechanism of the VASCAR-plus device were not accurate due to an incompatibility between the VASCAR-plus timing mechanism and the flip-flop circuit. This incompatibility was not discovered until after the completion of the testing for this study.

ATTACHMENT TO APPENDIX K

TABLE K.12

Raw Data from VASCAR-plus Testing

Nominal Speed/ Course Distance	Nicolet Time	VASCAR Time	Officer A (mph)	Officer B (mph)
	8.282	8.24	36.3	36.9
	8.566	8.53	35.2	35.7
	8.552	8.49	35.1	35.1
	8.316	8.28	36.0	36.5
35 mph/439.71 feet	8.490	8.46	35.7	35.8
	8.408	8.35	35.5	36.1
	8.400	8.35	35.8	36.3
	8.244	8.20	37.1	36.5
	8.246	8.20	36.8	36.6
	8.340	8.31	36.1	36.0
	5.531	5.50	54.2	55.0
	5.376	5.32	56.4	56.4
	5.463	5.43	55.3	56.1
	5.553	5.50	54.2	55.0
55 mph/439.71 feet	5.470	5.43	55.0	55.0
	5.399	5.36	55.3	56.8
	5.412	5.36	56.1	55.3
	5.565	5.54	53.9	55.0
	5.434	5.40	56.1	55.7
	5.395	5.36	56.4	56.4
	4.735	4.71	63.8	64.8
	4.564	4.53	66.3	66.8
	4.546	4.50	64.8	66.8
	4.609	4.57	65.8	65.8
	4.671	4.64	64.8	64.8
65 mph/439.71 feet	4.657	4.60	65.3	65.3
	4.686	4.64	64.3	65.3
	4.655	4.60	65.3	65.3
	4.705	4.68	63.8	64.3
	4.663	4.64	65.3	63.8
	3.870		36.4	35.3
	4.114		33.8	33.1
	3.946		35.1	34.6
	3.683		37.1	36.3
35 mph/200 feet	3.768		36.4	36.6
	3.939		35.7	34.6
	4.012		34.8	34.3
	3.931		35.7	35.0
	3.922		35.7	34.6
	4.040		35.1	33.4
	2.1230		66.5	65.1
	2.3120		62.1	58.1
	2.2390		62.1	61.9
	2.1930		64.3	63.0
60 mph/200 feet	2.3475		60.2	59.0
	2.2875		65.4	60.9
	2.3355		61.1	59.0
	2.2150		67.7	63.0
	2.2515		64.3	61.9
	2.3240		62.1	58.1

TABLE K.13

Comparison of NICOLET and VASCAR Time Measurements

NOMINAL SPEED = 55 mph
DISTANCE = 439.71 ft

	Nicolet 1 ms.	VASCAR Tripped	Absolute Diff.	% diff. (%)
	5.531	5.50	-0.031	-0.56
	5.376	5.32	-0.056	-1.04
	5.463	5.43	-0.033	-0.60
	5.553	5.50	-0.053	-0.95
	5.470	5.43	-0.040	-0.73
	5.399	5.36	-0.039	-0.72
	5.412	5.36	-0.052	-0.96
	5.565	5.54	-0.025	-0.45
	5.434	5.40	-0.034	-0.63
	5.395	5.36	-0.035	-0.65
Mean	5.460	5.42	-0.040	-0.73
Std. Dev.	0.069	0.073	0.010	0.195

TABLE K.14

Comparison of NICOLET and VASCAR Velocity Calculations

NOMINAL SPEED = 55 mph
DISTANCE = 439.71 ft

	Nicolet Calc.	VASCAR Calc.	Absolute Diff.	% diff. (%)
	54.20	54.51	0.306	0.56
	55.77	56.35	0.587	1.05
	54.88	55.21	0.334	0.61
	53.99	54.51	0.520	0.96
	54.81	55.21	0.404	0.74
	55.53	55.93	0.404	0.73
	55.40	55.93	0.537	0.97
	53.87	54.12	0.243	0.45
	55.17	55.52	0.347	0.63
	55.57	55.93	0.363	0.65
Mean	54.92	55.32	0.404	0.74
Std. Dev.	0.690	0.747	0.111	0.198

TABLE K.15

Comparison of Nicolet and VASCAR Time Measurements

NOMINAL SPEED = 65 mph
DISTANCE = 439.71 ft

	Nicolet 1 ms.	VASCAR Tripped	Absolute Diff.	% diff. (%)
	4.735	4.71	-0.025	-0.53
	4.564	4.53	-0.034	-0.74
	4.546	4.50	-0.046	-1.01
	4.609	4.57	-0.039	-0.85
	4.671	4.64	-0.031	-0.66
	4.657	4.60	-0.057	-1.22
	4.686	4.64	-0.046	-0.98
	4.655	4.60	-0.055	-1.18
	4.705	4.68	-0.025	-0.53
	4.663	4.64	-0.023	-0.49
Mean	4.649	4.61	-0.038	-0.82
Std. Dev.	0.060	0.065	0.013	0.271

TABLE K.16

Comparison of NICOLET and VASCAR Velocity Calculations

NOMINAL SPEED = 65 mph
DISTANCE = 439.71 ft

	Nicolet Calc.	VASCAR Calc.	Absolute Diff.	% diff. (%)
	63.32	63.65	0.336	0.53
	65.69	66.18	0.493	0.75
	65.95	66.62	0.674	1.02
	65.05	65.60	0.555	0.85
	64.18	64.61	0.429	0.67
	64.38	65.17	0.798	1.24
	63.98	64.61	0.634	0.99
	64.40	65.17	0.770	1.20
	63.72	64.06	0.340	0.53
	64.29	64.61	0.319	0.50
Mean	64.50	65.03	0.535	0.83
Std. Dev.	0.834	0.919	0.180	0.276

TABLE K.17

Comparison of True and Officer Measured Velocities Using VASCAR-plus

NOMINAL SPEED = 60 mph
DISTANCE = 200 ft

	True Velocity	Officer A Distance = 0	Officer B Distance = 150
	64.23	66.5	65.1
	58.98	62.1	58.1
	60.90	62.1	61.9
	62.18	64.3	63.0
	58.09	60.2	59.0
	59.61	65.4	60.9
	58.39	61.1	59.0
	61.56	67.7	63.0
	60.57	64.3	61.9
	58.68	62.1	58.1
Mean	60.32	63.58	61.00
Standard Deviation	1.954	2.449	2.387

Distance = Distance from Target Vehicle Path in Feet

TABLE K.18

Officers Percent Speed Error

NOMINAL SPEED = 60 mph
DISTANCE = 200 ft

	Officer A Distance = 0	Officer B Distance = 150
	3.53	1.35
	5.29	-1.49
	1.97	1.64
	3.41	1.32
	3.63	1.57
	9.71	2.16
	4.64	1.04
	9.97	2.34
	6.16	2.20
	5.83	-0.98
Mean	5.41	1.11
Standard Deviation	2.649	1.313

TABLE K.19

Officers' Speed Error

NOMINAL SPEED = 60 mph
DISTANCE = 200 ft

	Officer A Distance = 0	Officer B Distance = 150
	2.27	0.87
	3.12	-0.88
	1.20	1.00
	2.12	0.82
	2.11	0.91
	5.79	1.29
	2.71	0.61
	6.14	1.44
	3.73	1.33
	1.02	-2.98
Mean	3.26	0.68
Standard Deviation	1.602	0.789

TABLE K.20

Comparison of True and Officer Measured Velocities Using VASCAR-plus

NOMINAL SPEED = 35 mph
DISTANCE = 439.71 ft

	True Velocity	Officer A Distance = 300	Officer B Distance = 300
	36.20	36.3	36.9
	35.00	35.2	35.7
	35.06	35.1	35.1
	36.05	36.0	36.5
	35.31	35.7	35.8
	35.66	35.5	36.1
	35.69	35.8	36.3
	36.37	37.1	36.5
	36.36	36.8	36.6
	35.95	36.1	36.0
Mean	35.76	35.96	36.15
Standard Deviation	0.508	0.647	0.525

TABLE K.21

Officers' Percent Speed Error

NOMINAL SPEED = 35 mph
DISTANCE = 439.71 ft

	Officer A Distance = 300	Officer B Distance = 300
	0.28	1.94
	0.57	2.00
	0.12	0.12
	-0.14	1.24
	1.10	1.38
	-0.44	1.24
	0.31	1.71
	2.02	0.37
	1.22	0.67
	0.42	0.15
Mean	0.55	1.08
Standard Deviation	0.722	0.714

TABLE K.22

Officers' Speed Error

NOMINAL SPEED = 35 mph
DISTANCE = 439.71 ft

	Officer A Distance = 300	Officer B Distance = 300
	0.10	0.70
	0.20	0.70
	0.04	0.04
	-0.05	0.45
	0.39	0.49
	-0.16	0.44
	0.11	0.61
	0.73	0.13
	0.44	0.24
	0.15	0.05
Mean	0.20	0.39
Standard Deviation	0.261	0.253

TABLE K.23

Comparison of True and Officer Measured Velocities Using VASCAR-plus

NOMINAL SPEED = 55 mph
DISTANCE = 439.71 ft

	True Velocity	Officer A Distance = 300	Officer B Distance = 300
	54.20	54.2	55.0
	55.77	56.4	56.4
	54.88	55.3	56.1
	53.99	54.2	55.0
	54.81	55.0	55.0
	55.53	55.3	56.8
	55.40	56.1	55.3
	53.87	53.9	55.0
	55.17	56.1	55.7
	55.57	56.4	56.4
Mean	54.92	55.29	55.67
Standard Deviation	0.690	0.953	0.704

TABLE K.24

Officers' Percent Speed Error

NOMINAL SPEED = 55 mph
DISTANCE = 439.71 ft

	Officer A Distance = 300	Officer B Distance = 300
	-0.01	1.47
	1.14	1.14
	0.77	2.23
	0.39	1.87
	0.35	0.35
	-0.41	2.29
	1.27	-0.17
	0.05	2.09
	1.68	0.96
	1.49	1.49
Mean	0.67	1.37
Standard Deviation	0.706	0.818

TABLE K.25

Officers' Speed Error

NOMINAL SPEED = 55 mph
DISTANCE = 439.71 ft

	Officer A Distance = 300	Officer B Distance = 300
	-0.00	0.80
	0.63	0.63
	0.42	1.22
	0.21	1.01
	0.19	0.19
	-0.23	1.27
	0.70	-0.10
	0.03	1.13
	0.93	0.53
	0.83	0.83
Mean	0.37	0.75
Standard Deviation	0.392	0.447

TABLE K.26

Comparison of True and Officer Measured Velocities Using VASCAR-plus

NOMINAL SPEED = 65 mph
DISTANCE = 439.71 ft

	True Velocity	Officer A Distance = 300	Officer B Distance = 300
	63.32	63.8	64.8
	65.69	66.3	66.8
	65.95	64.8	66.8
	65.05	65.8	65.8
	64.18	64.8	64.8
	64.38	65.3	65.3
	63.98	64.3	65.3
	64.40	65.3	65.3
	63.72	63.8	64.3
	64.29	65.3	63.8
Mean	64.50	64.95	65.30
Standard Deviation	0.834	0.818	0.972

TABLE K.27

Officers' Percent Speed Error

NOMINAL SPEED = 65 mph
DISTANCE = 439.71 ft

	Officer A Distance = 300	Officer B Distance = 300
	0.76	2.34
	0.93	1.69
	-1.74	1.29
	1.16	1.16
	0.96	0.96
	1.43	1.43
	0.50	2.07
	1.39	1.39
	0.13	0.91
	1.56	-0.77
Mean	0.71	1.25
Standard Deviation	0.968	0.843

TABLE K.28

Officers' Speed Error

NOMINAL SPEED = 65 mph
DISTANCE = 439.71 ft

	Officer A Distance = 300	Officer B Distance = 300
	0.48	1.48
	0.61	1.11
	-1.15	0.85
	0.75	0.75
	0.62	0.62
	0.92	0.92
	0.32	1.32
	0.90	0.90
	0.08	0.58
	1.01	-0.49
Mean	0.45	0.80
Standard Deviation	0.631	0.540