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An Investigation of Signing Needs At Uncontrolled Local Road Intersections

April 1982

Iowa DOT Project HR-230
ERI Project 1513
ISU-ERI-Ames 82167

Sponsored by the Iowa Department of Transportation, Highway Division, and the Iowa Highway Research Board

report

College of Engineering
Iowa State University

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Departments of Civil Engineering
and Sociology and Anthropology
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Finally, our graduate student employees and our families who suffered along with us during the birthing pains of this project deserve a hearty thanks.

The opinions, findings, and conclusions expressed in this publication are those of the author and not necessarily those of the Highway Division of the Iowa Department of Transportation.

OVERVIEW OF RESEARCH CONDUCTED

1. INTRODUCTION

In this overview section, which comprises the first part of this report, the authors outline the methods used in Project HR-230 activities and summarize the findings and recommendations arising from the research effort. Sections 1 and 2 contain a summary of methods, sampling procedures, and techniques employed in this project. Section 3 contains a summary analysis of the data gathered in the project as well as some interpretation of the data. This leads logically to Sections 4 and 5 wherein the authors offer their recommendations based on the data gathered and the analysis performed.

Detailed data appear in the second part of this volume, Detailed Documentation (white pages).

1.1. Background

Project HR-230 began at the behest of the Iowa Department of Transportation. Research personnel outlined a problem relating to increasing concern about tort claims against Iowa counties resulting from accidents at uncontrolled county road intersections.

Iowa D.O.T. personnel were asked by some county engineers to consider the problem of signing such intersections where significant limitations to driver sight distance, either permanent or temporary, may exist. When asked to comment, the response of Iowa State University traffic engineering faculty was that the standard CROSS ROAD sign (W2-1, Section 2C-11, Manual on Uniform Traffic Control Devices) [1] appeared to be adequate and appropriate. However, further communication with local governments revealed that some county officials and county traffic engineers did not consider this a complete treatment of a rather complex question. Iowa State University was asked to develop a formal research response. In the past, personnel of the Civil Engineering Department and Engineering Research Institute have been active in assisting both the Iowa Department of Transportation and the various counties in developing engineering solutions to certain aspects of these problems. The present research project appears consistent with this long-standing pattern of cooperation in the study of local transportation problems. This project is the result of that process.

1.2. Problem Researched

Iowa counties have been experiencing significant tort claim liability due to the signing of local roads. One such problem is relative to the real or alleged need for signing at uncontrolled intersections of local roads. Traffic engineering faculty at Iowa State University have, in the past, taken for granted the adequacy of the guidelines and criteria contained in the 1978 Manual on Uniform Traffic Control Devices (MUTCD) [1]. Thus, it has been assumed that the standard CROSS ROAD sign, which calls for a yellow diamond with a black cross, was sufficient to provide the necessary warning that a driver may be approaching an intersection which requires special precautionary driving attention. Some county attorneys advised that the MUTCD guidance to apply the CROSS ROAD sign on a through highway conflicted with the legal status of the local county road. It is known that in several states this sign is used for warning purposes on local roads.

Section 2C-11 of MUTCD states that, "The CROSS ROAD sign is intended for use on a through highway to indicate the presence of an obscured intersection." Chapter 321 of the Iowa Code defines a through highway as one "...at the entrances to which vehicular traffic from intersecting highways is required by law to stop before entering or crossing...." Therefore, a legal conflict would appear to exist with regard to engineering intent, enforcement, and usage. The problem is further compounded by the fact that some counties have placed stop signs on one of two roads at all local road intersections while other counties have a policy of using stop or yield signs to control only designated through routes. For a driver crossing county lines, especially at night, this could lead to some misinterpretation as to how right-of-way is assigned from one intersection to the next.

In light of this situation, it seemed worthwhile to know the extent to which uncontrolled local road intersections were perceived as a potential liability problem; the degree to which the standard CROSS ROAD sign communicated to the driver the message a county engineer wanted at these local road intersections; and whether there were any better signing alternatives available to communicate this hazard to the driver in this situation.

Such information could then become the basis of a request for legislative change in Code Chapter 321, or the basis for a county board of supervisors developing a documented policy on signing of uncontrolled intersections. In the most extreme case, the information was seen as a possible basis for an Iowa Department of Transportation request to the Federal Highway Administration for permission to conduct a new sign field test for possible incorporation into the MUTCD.

This research has recognized the previous research conducted by Dr. R. L. Carstens under Iowa D.O.T. Highway Research Board Contract HR-204 under the direction of the Iowa Highway Research Board [2]. All research conducted was accomplished using as a guideline the eight recommendations contained in the final report of Project HR-204.

1.3. Objectives of this Research

In order to research the problem outlined above, a research plan was directed toward satisfying the following objectives:

1) Identify the degree to which the 99 Iowa counties perceive a current or potential problem exists in terms of current signing at uncontrolled intersections.
2) Identify the variety of measures being used by the other 49 states to sign for local uncontrolled intersections.
3) Establish exactly what message is communicated to drivers upon encountering the standard CROSS ROAD sign in advance of entering an uncontrolled local road intersection.
4) Investigate the variety of legend and symbol face combinations of the sign designs based upon USA and international signing conventions to determine whether there are any other legend and symbol face combinations which may better communicate with drivers approaching local uncontrolled intersections.

5) Identify the alternative courses of action available to any county encountering such a problem intersection on their local road system.

2. METHODS DEVELOPED AND USED

2.1. Method Development Procedures

Phase One of Project HR-230 began with a survey of county engineers in all 99 Iowa counties in order to ascertain the extent to which the problems listed were seen to be relevant to the Iowa traffic system. A summary of the findings from this survey appears in Section 4.4 of the Detailed Documentation section of this report.

In *Phase Two* the researchers expanded the survey in Phase One to include Departments of Transportation in the other 49 states in order to further put the problem in perspective. The results of this survey appear in the section titled "State Departments of Transportation Survey Results" (Section 4.1 of Detailed Documentation).

In *Phase Three* a computer-video tape system was constructed which contained the following elements: a small computer (Apple II); a video tape playback/record deck of industrial grade (Panasonic NV-8200); an interface between computer and video tape deck (built by Cavri, Inc. of Connecticut); a video tape containing edited sequences of drive-throughs of Iowa uncontrolled local roads.

2.2. Summary of Survey of Iowa County Engineers and Officials Outside Iowa

Data from the survey of Iowa county engineers were compared to the data obtained from agencies outside Iowa (see Section 4.4, Detailed Documentation). Officials outside Iowa placed a significantly more important ranking on strictly following the *MUTCD* in the use of warning signs and on developing timely notification of accidents on roads under county jurisdiction than did Iowa county engineers. At the same time, officials outside Iowa were significantly more likely than Iowa county engineers to assign a very low importance to establishing a continuing sign inventory and to developing written agreements for county line roads. These officials from outside Iowa were also much less likely than Iowa county engineers to assign a low importance to use of the ball bank indicator to establish advisory speed curves. Since the responses of both officials outside Iowa and the Iowa county engineers on the acceptability and applicability of these policies are almost identical, the perception of different degrees of importance to the policies suggests that the local road signing problem in Iowa has unique characteristics that must be recognized and dealt with.

Officials outside Iowa and Iowa county engineers agreed on the importance of the four signing problems. Both groups considered the inability to respond to damaged signs as the most serious of the four problems presented, and a close second was the cost of a complete traffic control device inventory. Therefore, any policy or program resulting from this research must recognize these two administrative concerns in order for the policy to be effective. A universal call to erect more signs may not result in any overall net gain in safety to the motoring public if the reallocation of resources and effort to deal with the problems of sign damage and inventory are excessively aggravated.

2.3. Interpretation of Findings of Sign Data

The most significant finding of the response to evaluating nine different signs in the context of local uncontrolled intersections is that there are drivers with strong preference for symbol-legend signs, while other drivers have a strong preference for word-legend signs. Data in this research suggested that these two strong preference groups are each probably about 10% of the driving population. Since other research in experimental psychology has shown that persons recognize and interpret word messages more quickly than abstract symbols in the perception-intellection phase of the perception-intellection-emotion-volition (PIEV) process [3,4,5], these data from this research suggest that any new sign developed to be applied as a warning for a local uncontrolled intersection should be word-based. Conversely, if there is an overriding reason to use a symbol-based sign, then a supplementary word message plate should be devised an used. Research sponsored by the American Automobile Association has shown (with a highly selective and perhaps biased sample) that several commonly used standardized symbol signs such as the "Yield" and "Keep Right" signs are misinterpreted by the majority of drivers [6,7].

A second interpretation that can be made of these data is that when a sign is a totally graphic symbol in the composition of its message, consideration should be given to adding a word legend supplementary plate. This principle would apply to all warning sign installations, not just to local uncontrolled intersections. Engineering judgment should be exercised if a person or agency were to adopt this principle, however. In situations where the warning symbol can be associated with the additional need for driver attention through driving experience specific to local road systems, engineers responsible for local roads should not place supplementary word legends on symbol signs unless the same practice were to be applied to higher functional classifications of roads. Uniformity in driver expectancy should be encouraged.

The responses to the question of which sign is best for the local uncontrolled road intersection can obviously be interpreted to mean that no one sign was perceived as best. Beyond that surface observation is the implication that drivers want a sign to tell them something specific. Some of the resistance to the CROSS ROAD sign (most popular best sign) centered around the reaction of a number of respondents that "it does not tell me anything about the intersection." In the opinion of the researchers, this desire on the part of the driver for specific guidance is related to the preference expressed for the "Dangerous Intersection" and "Blind Intersection Ahead" signs (second and third most popular best sign). Any attempt to consider this interpretation on a broad scale in signing practice could result in conflict with the long accepted principles of uniformity in signing. This interpretation is not a stone upon which to construct a path to erecting a singularly unique sign at every intersection requiring signs. However, this does suggest that symbol-graphic signs are difficult to design so that the sign communicates (see Section 4.3, Detailed Documentation, on the independent survey of sign interpretation). Further research needs to be conducted to establish the validity of a hypothesis that has arisen as a result of this research: most symbol-graphic signs communicate only by a learned and continually reinforced response. If this hypothesis has any validity, then word-oriented drivers are constantly in the process of learning, forgetting, and relearning the meaning of symbol signs. Therefore, symbol signs should be used sparingly and always for the same and consistent traffic purpose.

When asked to evaluate the intersection shown in the establishing shot with respect to whether it needed a sign, 73% of the respondents indicated it definitely did and another 23% said it probably did. No one was undecided and the remainder of the respondents indicated the intersection probably or definitely did not need a sign. On the surface, this suggests that the sample was strongly of the opinion that local roads in Iowa with some type of sight restriction need warning signs placed at them. However, when these same persons were required to evaluate the priorities of county engineering activities and to decide on the allocation of additional resources with respect to erecting more signing, a far different pattern emerged (see Section 4.3, Detailed Documentation).

It is the opinion of the researchers that the resulting responses on whether the intersection needed a sign is related to the previously noted interpretation that the sample drivers expressed a concern for specific guidance in carrying out their driving task. This response is a little like the answer to the old question in urban areas "Would you ride a bus if it came to your door?" for which the answer is always yes. What people really mean is "maybe" or "since you want me to say yes I will cooperate" or "under certain conditions." When people were forced to be specific about their interest in adding signs to the local road system they were much less interested.

The selection of which sign was the worst to be applied to these types of local road intersections produced an almost equally strong response for the "Limited Intersection Sight Distance" and the crashing cars symbol signs. While a number of persons verbally indicated that the legend "Limited Intersection Sight Distance" was too many words, two other signs had one more word. It does contain the most characters and is the most technical; hence, it requires the most concentration to interpret for possible evasive action. Again, since the previous interpretation suggested that drivers prefer positive action guidance in signing, then this legend tells them about the situation but does not tell them what to do (i.e., slow down, keep right). The crashing cars symbol created the reaction among a number of persons that it implied that if you drove through the intersection you would, in fact, have a collision. This is much the same frustration drivers associate with the word legend, "Men Working Ahead" or "Road Work Ahead," and when driving through the area finding nothing they can consider as road work occurring. The symbol apparently communicated event certainty, not probable hazard of the event. The implication of this is (as above) that for many people, symbols do not communicate a clear meaning with respect to driver action, unless the process of learning and reinforcement is continuous. Hence, symbol signs as a general traffic control and driver communication policy need to be coordinated with a program of driver communication education (preferably not the school of hard knocks. See Section 4.5, Detailed Documentation).

2.4. Regression Analysis to Further Isolate Subsamples

A stepwise regression series focused on the preferences of the sample for some signs over others. Specifically, the focus was on the affinity of some in the sample for signs using word messages as opposed to other signs bearing only symbol messages. An analysis of the overall percentages and the regressions done earlier indicated that two such signs were clearly chosen more often and with greater fervor than were any others. These signs were the CROSS ROAD sign (a purely symbol representation) and the word sign reading "Dangerous Intersection." Further, it began to appear, as the preference for these two signs was used as a starting point, that some kinds of differences (which transcended mere attitudinal predisposition) separated or distinguished these two groups. Specifically, as the group preference for either the word sign ("Dangerous Intersection") or the symbol sign (CROSS ROAD) was more finely drawn out, the two groups appeared to more markedly differ from each other. Just as important, they appeared to increasingly display patterns of response and preference which differed from the total sample.

The process of isolation of the group preferring word signs from the group preferring symbol signs was accomplished as follows. When the first frequencies printouts were used, there appeared to be little to suggest such a division. The reason was that taking each sign one at a time or taking the entire sample's responses did not suggest that the composition of each set of preferences was significant. However, the use of cross-tabulations of responses by sign and independent variables suggested some anomalies which could not easily be explained. For example, the group which selected the CROSS ROAD sign with the greatest frequency tended to reject word-signs with uncommon consistency. Similarly, those selecting the "Dangerous Intersection" sign were shown to similarly reject the symbol signs (crashing cars, CROSS ROAD, and the embellished CROSS ROAD sign containing arrows to accentuate the intersection). What was clearly needed, it appeared, was a more distinct picture of these two groups (dubbed the "word-oriented" and the "symbol-oriented" subsamples). Through successive iterations, the computer breakdowns of responses were refined until the purest sets of responses of each category were isolated. Essentially, the traits used as the criteria for inclusion in the two groups were as follows:

- Word-Oriented Respondents: These respondents were identified as having selected the "Dangerous Intersection" sign as either a good or very good sign, while at the same time rating the "Dangerous Intersection" sign as the best sign shown (in the overall comparison); and simultaneously rating one of the symbol signs used as the worst signs shown. To the researchers very great surprise, 40 persons fell into this consistent response group (representing some 9.87% of the total sample of 405).
- Symbol-Oriented Respondents: These respondents were identified as having selected the CROSS ROAD sign as a good or very good sign, while at the same time rating the CROSS ROAD sign as the best sign shown (in the overall comparison); and simultaneously

rating any of the six word-legend signs as the worst shown. Forty-nine persons were found to fall into this response group (representing some 12.09% of the total sample of 405).

It was obvious that a small bias existed in the criteria for inclusion into the symbol-oriented as opposed to the word-oriented group. That is, while the criteria were otherwise identical, the symbol group could improve their chances of being included by rating six word-legend signs as worst while word-oriented respondents could select from only three symbol-message signs which could earn a worst rating. This imbalance in offerings of word as opposed to symbol signs had not been thought of as important in any way during the design of the research. There existed no reason to suspect that the need would arise to compare subsample groups on symbol versus word criteria. Thus, in light of this fact, the two groups can be thought of as almost identical equivalents in proportion of the total sample. The obvious suggestion at the outset of discovery was that they represented two tails of a normal distribution of responses.

After an analysis of the data, however, it appears that the propensity to be symbol-oriented tends to be a less generally distributed trait in the general public than does the tendency to be word-oriented. It may well be that this is a rational adaptation by the majority, where reading and word-interpreted reality tends to be a dominant factor of life in work (where white-collar occupations are increasing in number) and even in recreation (where the sheer number of magazines targeted for narrow audiences continues to expand each year).

3. ADDRESSING RESEARCH OBJECTIVES

RESEARCH OBJECTIVE ONE: Identify the degree to which the 99 Iowa counties perceive a current or potential problem exists in terms of current signing at uncontrolled intersections.

This objective was addressed indirectly throughout the survey of Iowa county engineers (reported in Section 4.4, Detailed Documentation). The comments received indicate that there is significant concern on the part of the county engineers. The county engineers want to properly sign the roads for which they are responsible. At the same time they do not want to install signs excessively or unnecessarily. They realize that it is expensive to establish and maintain an inventory of traffic control devices, and that, due to the critical nature of signing, resources are likely to be diverted from other areas to meet signing needs. They also realize that the geographical size of the road system limits their ability to respond quickly to the problem of damaged signs.

RESEARCH OBJECTIVE TWO: Identify the variety of measures being used by the other 49 states to sign for local uncontrolled intersections.

The survey of the other 49 states (as reported in Section 4.1, Detailed Documentation) indicated that officials in other states who were responsible for policy regulating signing on local roads were largely applying the MUTCD to satisfy driver communication needs. Several notable exceptions are in progress, such as the attempt by the Kansas Department of Transportation to implement a policy adopting a

"Handbook of Traffic Control Practices for Low Volume Rural Roads" [8]. It is not clear that these policy efforts are sufficiently supported at this time by traffic operations research to be directly transferable to Iowa.

RESEARCH OBJECTIVE THREE: Establish exactly what message is communicated to drivers upon encountering the standard CROSS ROAD sign in advance of entering an uncontrolled local road intersection.

Traffic control practitioners have questioned the effectiveness of current symbol signs [9,10]. The meaning of the CROSS ROAD sign to drivers approaching an uncontrolled local road intersection has to be interpreted from the simulation survey data and from comments made by respondents during the course of the research. The simulation survey addressed this objective by identifying a significant subgroup of the sample for whom the CROSS ROAD sign distinctly indicated a warning of an upcoming intersection and of the need to approach that intersection cautiously. However, during the data gathering of the simulation survey, a number of persons expressed reactions to the CROSS ROAD sign which implied that they had little or no understanding of its intended message. This objective was addressed further in the validation survey performed at a regional shopping mall to sample Iowa driver interpretation of a variety of standard signs. While most drivers were able to demonstrate an understanding of the general meaning of the CROSS ROAD sign, some drivers thought it warned of a railroad crossing or other equally inaccurate message. In addressing this objective, it has become clear that for some individuals, the absence of a word legend on a sign limits their ability to assign specific and unique meaning to the message. This has particular salience where signs such as the CROSS ROAD sign are to be used.

RESEARCH OBJECTIVE FOUR: Investigate the variety of legend and symbol face combinations of sign designs based upon USA and international signing conventions to determine whether there are any other legend and symbol face combinations which may better communicate with drivers approaching local uncontrolled intersections.

During the development of sign patterns to display to the simulation survey respondent sample (as reported in Section 2.2, Detailed Documentation), the International Road Federation and the Federal Highway Administration Office of Highway Traffic Operations furnished full color brochures of the authorized standard signs used in North America, South America, and Europe. A symbol sign used in Europe to provide advance warning of crossing roads and intersecting highways was the inspiration for the "arrows" sign tested in the simulation. It was the professional judgment of the researchers that this was the only non-USA international sign with potential applicability to the problem outlined here. Analysis of the simulation survey data (as reported in Section 5, Detailed Documentation), did not suggest that this type of sign design was particularly effective in communicating a warning to drivers approaching an uncontrolled local road intersection.

RESEARCH OBJECTIVE FIVE: Identify the alternative courses of action available to any county encountering such a problem intersection on their local road system.

The recommendations emanating from this research (Section 8, Detailed Documentation) include several courses of action for county officials concerned about traffic safety and accident liability at local road intersections which may be obscured or which may have seasonal (or permanent) sight restrictions. However, the results of this research effort were such that most of the initiation of action resides with the Iowa Department of Transportation to implement the findings of Section 7, Detailed Documentation. There are several points that relate to Iowa counties which are threaded throughout this report. These may be highlighted as follows:

1) If action is deemed to be necessary before the Iowa Department of Transportation can determine whether its administrative rule-making power will be used to provide counties with some sanctioned flexibility in the use of the CROSS ROAD sign, county officials should utilize the authority of Section 2C-41 "Other Warning Signs," Manual on Uniform Traffic Control Devices, to sign for any "special conditions." These would, in this context, be associated with warning drivers of an uncontrolled local road intersection ahead for which the normal requirement to exercise due caution may be considered insufficient. This implies that, before the erection of a special condition sign, an engineering study would be made of the intersection approach and the intersection itself to ensure that erecting a sign would represent the appropriate action. It is possible that the CROSS ROAD sign could be installed under MUTCD Section 2C-41 as long as: (1) such an engineering study produced the conclusion that it was the appropriate sign; and (2) county engineering records documented that the

decision was made under this MUTCD section rather than Section 2C-11. Section 2C-41 could also be used to justify the use of a word legend sign (as some jurisdictions have already done).

2) Another alternative course of action might be to use the results of this research (indicating that a significant proportion of the Iowa drivers do not desire additional resources within the county engineering budget diverted to additional signing) as the basis for developing an educational and informational program on the topic of correct driving procedures for local uncontrolled roads.

In 1950, 34% of the Iowa population resided in cities of 5000 or more persons. In 1980 this proportion had increased to slightly over 50%. As the state becomes more urbanized, the driving exposure to rural local roads is a less routine experience. It is analogous to the need for training and education in freeway driving--only applied to very low volume roadways.

3) The final alternative course of action available to any county engineering office is to apply the MUTCD in signing local roads and to erect signs only when it is clearly required by engineering judgment and the guidelines of the MUTCD.

4. FINDINGS AND CONCLUSIONS OF THE RESEARCH

The following represent the findings of Project HR-230 as outlined in this report. First, based on an interactive simulation survey of 405 drivers, definitive estimates of the nature of driver perceptions with respect to local road uncontrolled intersections are available. Ninety-seven percent of the drivers participating in the simulation survey were of the opinion that obscured local road uncontrolled intersections need signing to warn approaching drivers of hidden intersections or those with limited sight distance. These same respondents displayed a decided preference for either a symbol sign with a graphic design (such as the standard CROSS ROAD sign) or preferred a word-legend sign with a message communicating that they were approaching a dangerous intersection or a blind intersection. Analysis of the responses and characteristics of the respondents identified a pair of subgroups within the survey sample (each containing about 10% of the sample) representing two divergent modes of preference. One subgroup was symbol-oriented, and the other was word-oriented.

Second, the results of two special surveys, conducted at the Merle Hay Mall in Des Moines, Iowa, and the Iowa State Fair, coupled with research by others, suggested that significant driver confusion exists as to the operation and meaning of many common symbol signs. This finding was verified specifically in the case of Iowa drivers.

As a case in point, when confronted with an authorized standard, but never used, symbol sign for low shoulder, the vast majority of sampled Iowa drivers erroneously and dangerously misinterpreted its meaning. When asked to explain the meaning of several standard and commonly used symbol signs, a disturbingly large number of a second sample of Iowa drivers significantly misinterpreted the "Yield" and "Keep Right" signs. Many drivers do not easily acquire nor retain an understanding of the meaning and intent of symbol signs.

Third, a computer-generated questionnaire following the simulation survey revealed that most persons sampled do not know very much about the operation of county government. They generally think the county does a pretty good job of planning their activities. Importantly, the sample tended to place expending funds to install new signs and traffic control devices on a priority just behind repairing the road surface and making bridge safety inspections or else they considered installation of new traffic control devices as one of the least important activities in the county engineering budget. Thus, the responses tended to reflect some polarization of opinion. Also, it should be pointed out, they considered the county engineering program as the most or the least important activity of the county budget as presented in the sample. This, too, reflects some polarization in opinion.

Fourth, the successful development of a simulation survey experiment utilizing a microprocessor computer and a remotely controlled video tape player indicated that a new technology exists with which traffic engineering and transportation policy issues can be efficiently and effectively analyzed.

5. RECOMMENDATIONS

Conduct of this research, analysis of the data obtained, and interpretation of those data combined with professional judgment has resulted in the following recommendations.

1) If a county wishes to erect the standard CROSS ROAD or the standard SIDE ROAD symbol signs as an advance warning on the approach to an obscured intersection on an uncontrolled local road intersection, it is recommended that a policy be adopted such that when these signs are used on a through highway approach to an intersection (side road or cross road traffic is controlled by a "Stop" sign or a "Yield" sign), the through highway direction is shown in a wider line on the symbol than the side or cross road. For those persons identified by this research and research by others as able to quickly respond correctly to totally abstract symbols, this would provide an additional cue about the two different uses of these warning signs.

2) Legal clarification should be sought as to the meaning of "through highway" with respect to the MUTCD guidelines in Section 2C-11 (and similar sections) and its relationship to Iowa Code 321.1(53) defining "through highway." This research was conducted under the varying interpretations of what constitutes the relationship between pertinent MUTCD sections and the Iowa Code. It is evident that implementations of this research would be more effective if this definition was

clarified. Several avenues of action are available, such as requesting an MUTCD interpretation from the Federal Highway Administration as to whether the guidelines in the MUTCD were intended to permit application of these signs to uncontrolled highways (i.e., did the FHWA intend "through" to mean "Stop" or "Yield" sign controlled?). Another possible avenue of action is to request an Iowa Attorney General opinion on the meaning of the term "through highway" in the MUTCD with respect to the Code of Iowa. Pursuance of the preferred alternative is left to the administrative judgment of the Iowa Department of Transportation.

3) It is recommended that the Iowa Department of Transportation and the Iowa County Engineers Association work through the Federal Highway Administration, the National Association of County Engineers, and the American Association of State Highway and Transportation Officials to instigate a study of the need for supplementary word legend plates with all pure symbol signs. This research has identified word-oriented drivers and symbol-oriented drivers in significant proportions of the driving public. Perhaps all signs should be combined word-symbol messages. The resolution of this issue discovered in the conduct of this research was beyond the scope of this project.

It is not possible to identify one best sign to communicate with drivers approaching an uncontrolled local road intersection which is obscured or has restricted sight distance conditions. This research identified that the standard CROSS ROAD sign and a sign with the legend "Dangerous Intersection" communicated equally well with the driver population as a whole and communicated much better with subsets of the driving population that were word-oriented or symbol-oriented. Furthermore, the "Blind Intersection Ahead" sign communicated almost as effectively as the "Dangerous Intersection" sign and, therefore, if a word legend sign is to be used, it is recommended over the "Dangerous Intersection" sign since it implies the need for driver attention due to sight restrictions. If a single sign is desired for optimum communication in the interest of uniformity in traffic control, further research beyond the scope of this project must be undertaken.

4) It is recommended that the Iowa Department of Transportation not adopt any special handbook on traffic control practices for low volume roads, as the State of Kansas has done, until research has been conducted on what are the appropriate levels of traffic control for low volume roads in Iowa which are consistent with driver information needs. Literature research, surveys of other states, and communication with other researchers during the conduct of this research does not indicate any general direct transferability to Iowa of any policy adopted elsewhere to date.

DETAILED DOCUMENTATION

1. INTRODUCTION

In the following sections, the authors describe the methods used in Project HR-230 activities and detail the findings and recommendations arising from the research effort. The report is divided, consistent with these goals, into several parts. Sections 1 and 2 contain a description of methods, sampling procedures, and techniques employed in this project. Sections 3, 4, and 5 contain a detailed analysis of the data gathered in the project as well as some interpretation of the data. This leads logically to Sections 6, 7, and 8 wherein the authors offer their recommendations based on the data gathered and the analysis performed. (An overview of all parts has been given in the previous sections.)

1.1. Background

Project HR-230 began at the behest of the Iowa Department of Transportation. Research personnel outlined a problem relating to increasing concern about tort claims against Iowa counties resulting from accidents at uncontrolled county road intersections.

Iowa D.O.T. personnel were asked by some county engineers to consider the problem of signing such intersections where significant limitations to driver sight distance, either permanent or temporary, may exist. When asked to comment, the response of Iowa State University traffic engineering faculty was that the standard CROSS ROAD sign (W2-1, Section 2C-11, Manual on Uniform Traffic Control Devices) [1] appeared to be adequate and appropriate. However, further communication with local governments revealed that some county officials and county traffic engineers did not consider this a complete treatment of a rather complex question. Iowa State University was asked to develop a formal research response. In the past, personnel of the Civil Engineering Department and Engineering Research Institute have been active in assisting both the Iowa Department of Transportation and the various counties in developing engineering solutions to certain aspects of these problems. The present research project appears consistent with this long-standing pattern of cooperation in the study of local transportation problems. This project is the result of that process.

1.2. Problem Researched

Iowa counties have been experiencing significant tort claim liability due to the signing of local roads. One such problem is relative to the real or alleged need for signing at uncontrolled intersections of local roads. Traffic engineering faculty at Iowa State University have, in the past, taken for granted the adequacy of the guidelines and criteria contained in the 1978 Manual on Uniform Traffic Control Devices (MUTCD) [1]. Thus, it has been assumed that the standard CROSS ROAD sign, which calls for a yellow diamond with a black cross, was sufficient to provide the necessary warning that a driver may be approaching an intersection which requires special precautionary driving attention. Some county attorneys advised that the MUTCD guidance to apply the CROSS ROAD sign on a through highway conflicted with the legal status of the local county road. In several states this sign is used for warning purposes on local roads.

Section 2C-11 of MUTCD states that, "The CROSS ROAD sign is intended for use on a through highway to indicate the presence of an obscured intersection." Chapter 321 of the Iowa Code defines a through highway as one "...at the entrances to which vehicular traffic from intersecting highways is required by law to stop before entering or crossing...." Therefore, a legal conflict would appear to exist with regard to engineering intent, enforcement, and usage. The problem is further compounded by the fact that some counties have placed stop signs on one of two roads at all local road intersections, while other counties have a policy of using stop or yield signs to control only designated through routes. For a driver crossing county lines, especially at night, this could lead to some misinterpretation as to how right-of-way is assigned from one intersection to the next.

In light of this situation, it seemed worthwhile to know the extent to which uncontrolled local road intersections were perceived as a potential liability problem; the degree to which the standard CROSS ROAD sign communicated to the driver the message a county engineer wanted at these local road intersections; and whether there were any better signing alternatives available to communicate this hazard to the driver in this situation.

Such information could then become the basis of a request for legislative change in Code Chapter 321, or the basis for a county board of supervisors developing a documented policy on signing of uncontrolled intersections. In the most extreme case, the information was seen as a possible basis for an Iowa Department of Transportation request to the Federal Highway Administration for permission to conduct a new sign field test for possible incorporation into the MUTCD.

This research has recognized the previous research conducted by Dr. R. L. Carstens under Iowa D.O.T. Highway Research Board Contract HR-204 under the direction of the Iowa Highway Research Board. All research conducted was accomplished using as a guideline the eight recommendations contained in the final report of Project HR-204.

1.3. Objectives of this Research

In order to research the problem outlined above, a research plan was directed toward satisfying the following objectives:

1) Identify the degree to which the 99 Iowa counties perceive a current or potential problem exists in terms of current signing at uncontrolled intersections.
2) Identify the variety of measures being used by the other 49 states to sign for local uncontrolled intersections.
3) Establish exactly what message is communicated to drivers upon encountering the standard CROSS ROAD sign in advance of entering an uncontrolled local road intersection.
4) Investigate the variety of legend and symbol face combinations of sign designs based upon USA and international signing conventions to determine whether there are any other legend and symbol face combinations which may better communicate with drivers approaching local uncontrolled intersections.

5) Identify the alternative courses of action available to any county encountering such a problem intersection on their local road system.

close-up shots of the actual signs used (photographed from a fixed position for the short interval where they must appear stationary on the final edited video tape).

Second, the video tape was edited (using the facilities of the Iowa State University Film Production unit) in such a way as to permit control over the following variables:

- the order in which the respondent views either words or symbols first (in order to eliminate the possibility that seeing one or the other kind of signs first might inordinately bias the respondents)
- the order in which the respondent sees the standard CROSS ROAD sign first or last
- the order in which the respondent sees the entire approach shot to the intersection or a more abbreviated drive-up to the intersection
- the actual order of the sign presentation was mixed, so that there were actually twenty-four versions of the sequence presented.

The mixing of the order was done for several reasons: (1) the possibility that one respondent might oversee another in the process of going through the simulation (and would get a different sequence even if he or she went through as the next person), (2) to permit statistical controls on order of presentation, and (3) delete the traditional bias of presentation-order found in pencil-and-paper surveys.

The third step was to place on the final edited versions of the video tape a reference number (frame numbers corresponding to sixty-frames per second) which the Cavri computer/video tape interface would use to display to the respondent the desired approach shots, establishing shots, and signs in a predetermined but complex sequence.

The fourth step entailed the writing of a rather complex computer program which would simultaneously serve as the controller for the video tape display (overseeing the order of presentation synchronized with individual frame numbers), storing each individual answer from the respondent, giving appropriate responses, and finally transferring the resultant data onto a computer disk at the conclusion of the session.

In step five the equipment (consisting of computer, video tape machine, and monitor for viewing) was taken to the Iowa State Fair where it served dually as a portion of the Iowa Department of Transportation display in the Hall of Transportation as well as a device to gather a sample of representative respondents. The display and equipment unit was manned throughout the entire period of the operation of the Iowa State Fair (August 13, 1981 to August 23, 1981 inclusive) by no fewer than two persons at any time and by as many as four persons during peak times.

In step six, the data from the simulation survey were transformed (again by a program on the Apple II computer) into BCD card format for analysis on the mainframe computer at Iowa State University. Data were input directly from the Apple computer to the Itel AS/6 computer from which permanent records (card backup) and hard-disk storage was utilized. Statistical analysis was performed on the mainframe computer.

Finally, the results were studied by the authors and the final report prepared.

2.2. Development of Sign Patterns

An array of nine signs was created to incorporate into the simulation. This test set of signs was developed from three sources:

(1) Contacting selected county engineers about their ideas for signs to provide warning at obscured uncontrolled local road intersections;

(2) Review of all officially authorized and adopted warning signs in the Manual on Uniform Traffic Control Devices;

(3) Review the international symbol system of signs as used in North and South America;

(4) Review the international symbol system of signs used in Europe;

(5) Conduct a pretest of sign meaning to a selected set of engineering faculty, social science faculty, and general university students.

One symbol signing concept used in Europe that appeared to have promise was the use of crossing arrows of different widths to indicate advance warning of intersecting roadways and the relative priority of the roadways. Thus, in response to research objective 4 (Section 1.3), a sign variation of the standard CROSS ROAD sign was tested which incorporated arrow heads on the cross symbol (hereafter referred to as the "arrows" sign).

The CROSS ROAD sign and a word sign legend ("Dangerous Intersection") were selected because these two were in use to some limited degree in Iowa and in some jurisdictions outside Iowa. The pretest sample suggested that some graphic symbol relating to collison potential would be promising. Therefore, a silhouette of cars colliding, one into the side of another, was included in the sign set (hereafter referred to as the "crashing cars" symbol).

The remaining signs were word legends from signs warning of obscured sign distance and potential traffic conflicts on urban street systems and primary highway systems. These variations were selected to test signs that might be suitable in transfer of association of meaning. (Refer to Table 28 for a list of the test sign set.) Figure 1 illustrates the patterns used in this research.

2.3. Why Survey by Simulation?

Policy studies and the social sciences have frequently pursued the same sorts of goals using very similar methods. These methods include observation, secondary data (information already gathered by others), and some form of primary data collection. Of the latter, the most popular method developed in the past 100 years has been the survey--either by personal (or telephone) interview or questionnaire. Given that the policy researcher is not interested in what happened last year (or possibly even last week), obviously some form of survey is called for. The limitations of the use of traditional surveys in policy (and specifically in transportation) have been discussed for

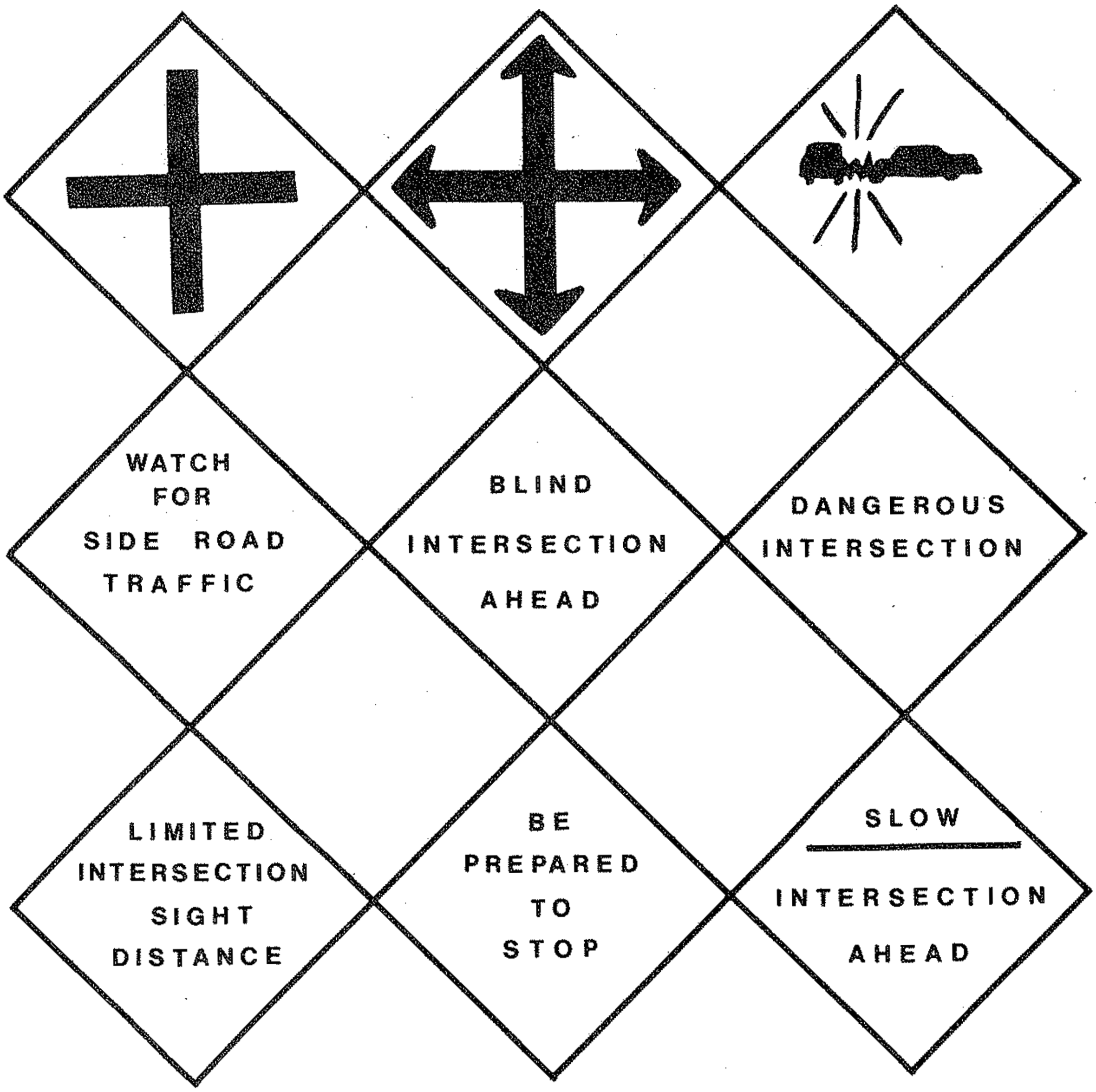

Figure 1. Sign patterns tested in this research.

decades. In brief, what the critics argue is that the traditional survey tends to distort resulting data for numerous reasons. The reading level of the respondent, coupled with the representativeness of the sample, may result in findings which reflect only a small segment of the population. Telephone surveys generate bias in favor of (1) telephone owners and (2) those who happened to be at home when the interviewer called. Finally, there are technical problems such as response sets (the tendency for respondents to fall into a pattern of answers) or reliability problems caused by the order, proximity, or wording of questions.

Yet, for transportation policy researchers, none of these weaknesses cover the most frequent problem encountered. Transportation researchers often refer to this as the "would you ride a bus if it came to your door" syndrome. This tendency is often manifested in surveys containing "what if" questions wherein respondents are asked to project and predict their own behavior in the future. The researcher who asks respondents whether they would utilize a bus which picked them up at their front door when they called for the bus will almost invariably find the respondents answering in the affirmative. More than once demand bus systems have been set up based on such data only to operate mostly empty.

The reason for this is not that the public was lying when they responded to the question in the survey. Rather, the problem lies in the manner in which the survey was conducted. That is, the survey omitted a number of very salient variables from the questions relating to the decision to ride or not ride the bus. For example, what would the respondent have said if the interviewer also said that it might take 40 minutes for the bus to arrive and then it might drive all over town dropping off other people before taking the individual to work? What if the interviewer asked about the presence of rain? What about the look and condition of the bus? In other words, the respondent was asked to declare a behavior in the future based on an ideal assumption. Unfortunately, real life decisions do not happen in that environment. In order to most effectively ask respondents how they might behave in such a situation, the best method would be to simulate for the respondent what the experience would be like, in as great a detail as is possible. Then, in light of a simulated experience with the phenomenon, the respondent could be asked to render a decision.

In the case of the problem posed by the authors, the issue of how effectively a sign warned drivers of an obscured intersection could only (we argue) be understood by simulation. In the simulation, respondents were not asked to imagine an uncontrolled local road or the amount of crop or weed material growing beside the highway. Using color video tape, the respondents were shown a specific intersection and asked which sign most effectively warned them. Further, to prevent contamination of other respondents, no two consecutive respondents saw the same intersection (there were six in all). Other controls were included in order that statistical manipulation would reveal bias and the effects of site (there were none) or of order of sign presentation (with some important qualifications there were none). It would seem, based on the quality of the data generated and the comments by the individual respondents, that the simulation survey method is warmly received by the public. It may be that several generations of television watching and the current fad of video arcade and television games makes it less exotic to respond to a survey via videotape and computer. For whatever reasons, however, the experiment in method appears to have been a genuine success.

2.4. Randomness of Methods Used

The theories of probability normally used in the design and analysis of survey data (e.g., having to do with normally distributed errors) are also applicable to simulation survey methods. There has developed, as a consequence of modern survey procedures, a concern bordering on a fetish with the need for randomness in the sampling frame of a survey. Part of the reason for this concern deals with the simple need for validity and generalizability of findings. Yet randomness (the theoretical condition wherein each member of a population has an equal opportunity to be included in the sample drawn) is not an absolute necessity for numerous kinds of surveys. For example, surveys targeted for specific subgroups in a population (i.e., diesel automobile owners, train commuters, and the like) would be unlikely to do a general population survey. Rather, the designers would likely seek out and interview or administer questionnaires to these specific groups. Moreover, the expenses in both time and money are so great today that availability samples (taken where the respondents are--on commuter trains, waiting rooms, public places, and the like) are becoming increasingly common. Under conditions of availability sampling, it is virtually impossible to approach randomness in sample selection. More to the point, randomness is not only not needed but can be dispensed with when the target population has known characteristics. National polling organizations such as Gallup, Roper, Harris and others do not use random samples. They use stratified samples selected specifically because they can represent the characteristics of the known population of the United States (known because the U.S. Census Bureau publishes the results of each census plus updates and estimates). It is not uncommon for a sample drawn for a national polling organization to number no more than 1800 persons (drawn to represent 250 million). Randomness would not be advantageous in this circumstance.

In this research, a moderate position between an absolute demand for randomness in sample selection and elimination of it as a factor was taken. This research, it is argued, does not demand randomness in the selection of the sample population for several reasons. First, policy questions are often aimed at rather specific questions relating to some phenomenon affecting most members of the population. From this perspective, a random sample would be of no particular value. Second, randomness refers to the mode of selection of sample members. There is no need for surveys to be random unless there is the assumption that the survey will locate traits randomly distributed in the population. Thus, the researcher would want to assure that any single sampling did not contain an inordinate number of persons from one tail of the normal distribution or the other. However, this concern can be of little significance when statisticians point out that samples in excess of 125 tend to look very much alike (i.e., to approach a normal distribution).

Finally, and most importantly, there would be little merit in conducting a simulation survey merely to ascertain the traits or characteristics of a population (such as, how widespread is the use of aspirin in the adult public). The simulation survey is useful where there exists an underlying structure or process, the nature of which the researcher wishes to understand. For example, in a policy issue relating to signing, the decision processes of the public were the focus of the simulation survey--not as crystallized attitudes toward signs, but as dynamic choices of which sign best communicates hazards and whether an additional sign would be desirable (not in an ideal environment, but where tax dollars pay for signs and displace some other worthy end).

In this light, the need for randomness is seen as a possibly desirable, but by no means essential, aspect of this research. For this reason, no major effort was made to insure a random sample. Rather, the adult driving population of Iowa was sampled where they were found (in this case at the Iowa State Fair), and the issue of the decisions going into sign need and selection were made not by sheer numbers of respondents check-marking pencil-and-paper surveys, but by respondents responding to conditions at uncontrolled local road intersections with their selections of signs.

2.5. Statistical Procedures

The procedures used for statistical analysis were largely conventional; that is, percentages, correlation, and cross-tabulation of variables were used throughout. In addition, where applicable, (stepwise) multiple regression was used. As might be anticipated, the lower power statistical tools were used when descriptive and sorting tasks were called for. Regression and factor analysis were used at later times, as more specific answers were called for.

2.6. Generalizability of Findings

As mentioned earlier, the goal of simulation survey research is to probe the nature of some underlying processes or structures. There exists no reason to suspect that the decision-making and interpretation processes are unevenly distributed in the general population (with the exceptions noted later, relating to factors such as age, sex). Therefore, there also exists no particular reason to interpret these findings as applicable only to subgroups in the population. Stated another way, there is every reason to suspect that the findings detailed here are applicable to the general population of drivers in the state of Iowa.

2.7. Supplementary Methods (Additional Surveys)

At two points in the research process, the need for definitive answers to questions led the researchers to conduct traditional pencil-and-paper surveys. In the first instance, as the research project was getting under way, a pilot study was conducted to ascertain the extent of understanding a sample group would demonstrate to the standard signs used for hazard warning. This survey was very useful in the actual design of the simulation survey. From this point of view, it could be seen to function as a survey pretest. What it permitted was a more succinct presentation of the alternatives and a more finely directed approach to the question. Later, after the simulation survey had been conducted and much of the data analyzed, it became obvious that an additional and external verification would be helpful. Thus, an additional pencil-and-paper survey was conducted wherein respondents were asked very specific questions relating to the meanings of signs. This survey, too, could have been seen as a verification device for the simulation survey procedure. The additional survey conducted after the larger study tended to shed some critical light on the meanings derived from signs, as well as to help the researchers to interpret some of the anomalous findings.

2.8. Survey of Iowa County Engineers

Questionnaires were sent to all 99 county engineers in Iowa in an effort to solicit the extent to which they perceived these signing matters constituted a problem in their specific county. The final report recommendations included in Project HR-204 conducted by Professor R. L. Carstens [2] were used as guidelines during this phase.

Of the 99 questionnaires sent out to Iowa county engineers, 86 (87%) with usable information were returned. Some information called for in the survey form may not have been readily available to the county engineer or may have been maintained in such a manner that it would have been prohibitively expensive to produce. In any case, some of the most crucial of this information was obtainable from other sources in the state of Iowa (including expenditures on certain categories of traffic devices, e.g.). What the authors chose to do was to include the non-respondents using data available from public sources in order to improve the validity of the findings. Thus, on some tallies of this data set, all 99 counties are listed as responding. The response rate of 87% was high enough on the attitudinal and other items to render the data very useful.

2.9. Survey of State Departments of Transportation

The 49 states other than Iowa were contacted with a brief survey to assess the perception of the need to improve signing and driver communication at uncontrolled local road intersections in other jurisdictions. Responses were received from 41 states with one state obtaining replies from 10 of its county engineers. The analysis sections (Sections 4 and 5) give details on the response to this questionnaire.

2.10. Additional Surveys Conducted

Near the conclusion of the analysis of the simulation survey data, it became obvious to the researchers that there were two unanswered questions not posed by the earlier studies. These related to the meaning attached to the various signs by the respondents and to the extent of understanding shown relative to symbol/word legend signs. In order to more fully explore these matters, the researchers carried out an additional survey.

In this survey the authors attempted to ascertain the extent of understanding shown by respondents to specific signs only. For the purposes needed, it was not seen as imperative that any degree of randomness be the goal. As a consequence, samples were gathered on an availability basis--the researchers simply went where the people were. In two instances this included class members at the Iowa State University College of Engineering, in another the sample came from visitors to an Iowa State University athletic event, and finally, shoppers at the largest shopping mall in Des Moines were solicited for responses. In all, this small sample totaled 350. It tended to be more representative of age and sex distributions in the overall Iowa population than was the more intensively gathered simulation survey sample from the Iowa State Fair.

The detailed analysis of all of these studies is to be found in the following section of this report.

3. DESCRIPTIVE STATISTICS (Simulation Survey Sample)

The total sample numbered 405. No cases were omitted for any reason (an interesting by-product of a survey method which does not rely on pencil-and-paper methods). However, background information (i.e., age, sex, county of residence) was not gathered on all of the 405 respondents. The gathering of these data were not commenced until the third day of data gathering (out of 12 days). There is no evidence whatsoever from the extant data that the individuals from which data were gathered differed in any way from those from which the data were not gathered.

Respondents represented 68 (69%) of Iowa's 99 counties. Table 1 shows the distribution of the sample according to the six Iowa Department of Transportation Districts. The preponderance of respondents residing in District One is clearly due to geographic proximity to the

Table 1. Respondents by Iowa D.O.T. district.

Iowa D.O.T. District	Percent	No. of Responses
District One	56.8%	155
District Two	4.8%	13
District Three	4.4%	12
District Four	9.2%	25
District Five	19.4%	53
District Six	5.5%	15
Missing: 132 (32.6% of total)		

Iowa State Fair site where the simulation was set up. The Fairgrounds on which the State Fair operates is in the midst of District One. Such a bias was probably unavoidable, but also tends to reflect the demographic fact that the city of Des Moines represents the largest concentration of population in the state of Iowa.

The ages of the respondents ranged from 14 years (the youngest age with a valid driver's permit) to 65 years. Table 2 displays the distribution of respondent's ages. Note that an effort was made to construct categories in such a way as to represent equal proportions of age groups surveyed. It is also important to note that age, sex, and county of respondent data were not gathered on 122 (30.1%) of the 405 individuals in the sample. In some cases, two individuals elected to respond to the survey, and the age of the second person was also recorded. Although these second respondents numbered only sixteen, their ages ranged from 17 to 65 years. The ages represented in the sample give an excellent representation of all age groups found in Iowa.

The sample turned out to be predominantly male. Males represented 70.2% of the sample, as contrasted with females who represented only 24.2% of the sample for which such data were gathered. These percentages can be compared with those for the general driving public of Iowa as a whole. Some 51.3% of licensed drivers are male, while 48.7% of drivers are female. Thus, our sample does display a bias in this regard. It is important to note, however, that in every category of analysis where contrasts were drawn, the variable of sex was either not a factor or tended to demonstrate little statistical relationship to other variables being considered.

Table 2. Ages of respondents by grouped categories.

Age Range	Percent	No. of Responses
14-19 Years	23.7%	67
20-26 Years	25.8%	73
27-35 Years	26.1%	74
40-65 Years	24.4%	69

Missing: 122 (30.1% of total)

4. ANALYSIS OF THE DATA

The traditional approach to the study of signing problems has been to identify the information needs of the driver. (King and Ludenfeld [11] is frequently used as a starting point.) These needs are thought to represent a hierarchy of information needs for drivers. Doughty [12] elaborates:

> Information needs occur throughout the entire driving task and they fall into a hierarchy relative to satisfying those needs. The highest order of needs are those associated with the two main tasks of tracking and speed control, followed by the needs for obstacle avoidance and maintenance of the most efficient and safe course in the traffic stream. The lowest order of needs are those associated with trip preparation and direction finding.

From this perspective, the imperative which should guide the transportation engineer in the placement of signs should be to reduce the need for the driver to concentrate on information gathering when tracking and speed control are required.

The standard reference in such matters, of course, is the <u>Manual on Uniform Traffic Control Devices for Streets and Highways</u> [1].

This seemingly simple task is complicated by the fact that the <u>MUTCD</u> cannot possibly cover all possible contingencies which might arise. The problem area discussed here falls logically into this category. It was, in fact, at the behest of the county engineers of Iowa that this study was instigated. Being much closer to the problems and anomalies associated with signing, county engineers were moved to note the difficulty they experienced in warning motorists about the potential problems of a specific intersection. In a technical sense, this is an easy problem, especially where the need for warning occurs on a through road or highway, for the standard CROSS ROAD sign is obviously (and legally) called for. However, the county engineers asked, what signing is called for when the roads intersecting are low-volume, usually unpaved county highways? In this situation, the use of the CROSS ROAD sign was seen by many engineers as a questionable option for two reasons. First, some expressed some doubt as to the nature of public understanding of the meaning of the sign. Second, (and more important) the use of the sign on two uncontrolled local roads would run counter to the guidelines of the MUTCD, for the CROSS ROAD sign strictlycalls for communicating to the driver who would see such a sign only when approaching a road intersection wherein they will be on a through highway having the right of way. Therein lies one of the central problems on which this research problem has turned--should this sign be used in this circumstance or should some other sign be used to communicate this warning? Secondary to this matter was the extent to which the public understands the meaning of the standard CROSS ROAD sign and likes it as a warning device. Our research yielded some interesting findings along this line.

In order to pursue these questions, the information from four surveys of different kinds is analyzed in this section. First will be the survey of state Departments of Transportation, followed by analysis of the data gathered in the survey of Iowa county engineers, the simulation survey conducted in the late summer of 1981, and the follow-up availability survey conducted in late fall of 1981. A detailed analysis of these findings is to be found in the succeeding pages of this section.

4.1. Analysis of Data from State Departments of Transportation

During the course of this research all 49 states other than Iowa were contacted to obtain an assessment of the degree to which they were concerned about driver communication at uncontrolled local road intersections. In order to maximize the probability of receiving a response, the questionnaire was reduced to a single page printed on both sides. The respondents were given a brief introductory letter identifying the contract and its purpose.

The eight recommendations resulting from project HR-204, "Construction and Maintenance Practices to Minimize Potential Liability by Counties From Accidents" were presented to each respondent with instructions to evaluate each one on two scales. First, the respondent was asked to rank the importance of each of the eight HR-204 recommendations as they pertained to the local road system in their state. The most important recommendation was given a rank of one (1), and so on through a rank of eight (8) for the least important. Second, each recommendation of HR-204 was rated for applicability to the particular state's local road system with five possible ratings varying from "not applicable" to "complete implementation in our county systems".

Table 3 indicates the results of the 37 usable responses from other states on the importance of the eight recommendations of Project HR-204.

From the table it is obvious that a general consensus existed that it is most important to strictly apply the MUTCD in the use of warning signs, and that these states generally agreed that written agreements to delineate the responsibility for county line roads were least important. However, in order to determine whether the aggregate ranking of these eight policy recommendations from previous research was statistically significant, a coefficient of concordance was computed. The frequencies in Table 3 yielded a coefficient of concordance of 0.3785 with an associated chi-square of 98.04. Since a chi-square with seven degrees of freedom at the 0.9995 level of significance is 26.0, the null hypothesis that no agreement exists among the states responding as to the order of importance of these recommendations is rejected.

The statistically significant order of importance of the policies shown in Table 3 is indicated according to the summed rankings in Table 4.

As can be seen in Table 4, strong agreement existed that it was important to follow the MUTCD in use of warning signs on county road systems. There was also strong agreement that it was of lesser importance to use a ball bank indicator to establish advisory speed signing on curves and to develop written agreements delineating responsibilities for county line roads. The remaining five policies were separated with aggregate sum rankings which were statistically significant in their differences, but at the same time, they were all grouped close together

Table 3. Frequency of ranking by states outside Iowa of each of eight recommendations from HR-204 (N=37).*

Project HR-204 Recommendation in Order of Listing on Questionnaire	Rank of Importance							
	1	2	3	4	5	6	7	8
Follow strictly the provisions of the <u>Manual on Uniform Traffic Control Devices</u> in the use of warning signs	26	5	1	2	1	0	0	2
Establish a coherent and carefully documented policy governing the use of stop signs	5	7	5	7	2	3	7	1
Establish a continuing sign inventory process	2	5	7	4	4	4	6	5
Establish written agreements covering county (parish) line roads that clearly delimit responsibilities	0	1	1	3	1	2	10	19
Develop procedures to assure timely notification of accidents on roads under county (parish) jurisdiction	4	8	6	4	10	3	2	0
Use a ball bank indicator to establish advisory curve speeds	1	1	5	3	5	11	7	4
Establish a program to document conditions surrounding accidents on roads under county (parish) jurisdiction	2	3	6	8	7	7	2	2
Establish a road and sign inspection program	4	8	7	8	5	4	1	0

*41 states and the District of Columbia replied. However, the replies from Illinois, Delaware, Pennsylvania, and New Jersey were incomplete for this portion of the questionnaire. Also, California replied by having the county engineers in 10 counties respond, so that state's response is presented separately.

Table 4. Statistically significant rank orderings of HR-204 policy recommendations by 36 states and D.C.

HR-204 Policy Recommendation	Summed Rankings
Strictly follow MUTCD for warning signs	68
Establish road and sign inspection program	129
Timely notification of accidents on county roads	136
Establish policy on the use of stop signs	147
Document conditions at accidents on county roads	165
Establish continuing sign inventory process	175
Use ball bank indicator to set advisory curve speeds	202
Written agreements on county line roads	256

because a wide variation existed among the ranks assigned to any one policy. The results of surveying states on the importance of these policies in dealing with safety on local roads support the concerns of Iowa county engineers: there is a difference in the importance of these recommended policies. Therefore, implementation must proceed according to each jurisdiction's needs.

Table 5 contains the frequency distribution of the applicability ratings for each of the eight policy recommendations of Project HR-204. It is evident from these data that states outside Iowa regard as "not applicable" or "not feasible" those policies for which the aggregate ranking of importance was low (see Table 4 for two least important policies). It is also clear from comparing the data in Tables 4 and 5 that the policies ranked as more important were those for which

Table 5. Frequency of applicability of HR-204 policy recommendations by states (N=37).*

Project HR-204 Policy Recommendation	Rating of Applicability to States Outside Iowa** A	B	C	D	E
Follow strictly the provisions of the <u>Manual on Uniform Traffic Control Devices</u> in the use of warning signs	0	3	4	18	12
Establish a coherent and carefully documented policy governing the use of stop signs	2	0	17	8	10
Establish a continuing sign inventory process	0	4	16	14	3
Establish written agreements covering county (parish) line roads that clearly delimit responsibilities (***)	14	5	9	1	7
Develop procedures to assure timely notification of accidents on roads under county (parish) jurisdiction (****)	1	0	7	7	21
Use a ball bank indicator to establish advisory curve speeds	1	8	10	13	5
Establish a program to document conditions surrounding accidents on roads under county (parish) jurisdiction (****)	1	3	10	7	15
Establish a road and sign inspection program	0	4	11	15	7

*Replies were received from 41 states and the District of Columbia. Replies from Delaware, Pennsylvania, Kansas, and New Jersey did not contain a response to this question. (California replied by having 10 county engineers respond, so these are presented separately).

**Applicability rating code is defined as follows:

A: Not applicable to our county (parish) systems.
B: Not feasible to implement in our county (parish) systems.
C: Feasible but no action has been taken to implement in our county (parish) systems.
D: Implementation in our county (parish) systems has not been completed.
E: Implemented in our county (parish) systems and completed.

***Minnesota did not rate this policy.

****Florida did not rate this policy.

implementation was either completed or underway. State officials outside Iowa have apparently expended their administrative efforts to implement local road policies for which there was significant administrative agreement about the importance of the policy. This implies that there is great value to be derived in discussing safety related policy issues through broadly based organizations for transportation administrators such as the American Association of State Highway and Transportation Officials (AASHTO). Unresolved issues with respect to the focus of this research (HR-230) might be appropriate topic material for selected AASHTO committees.

The next question presented to the state respondents required an assessment of the extent to which the potential for collisions and the need for signing at uncontrolled local road intersections was a problem on their state's county (parish) systems. The results are shown in Table 6. As the data indicate, most of the officials responding were uncertain of the extent to which there was a problem at uncontrolled local road intersections. Thirty of the 34 responses were in the "probably", "probably not", or "don't know" categories. If this is a result of state level offices being too remote from local road situations to be fully cognizant of traffic needs, then it behooves officials responsible for local roads to communicate safety and traffic related problems to higher levels of administration. It is also possible that the question was misinterpreted.

The last question required rating the respondent's degree of concern about four common signing problems on local road systems.

Table 6. Assessment of problem presented by need for signing in collision prevention by states (N=34).*

Assessment of Problem	No. of Responses
Definitely is a serious problem	2
Probably is some problem	15
Don't know, can't say, does not apply	3
Probably not much of a problem	12
Definitely not a problem at all	2

*Replies were received from 41 states and the District of Columbia. Massachusetts, Delaware, Arkansas, Pennsylvania, Oklahoma, New Jersey, and North Carolina did not respond to this question. California's response was completed by 10 county engineers and is tabulated later in this report section.

From Table 7, which contains these results, it is apparent that states outside Iowa were quite concerned about being able to respond to damaged signs in a timely manner and about the expensive nature of maintaining a complete inventory of traffic control devices. These data support concerns expressed by Iowa county engineers. Since these concerns appear to be universal, it is imperative that any policy change requiring additional signing on the local road system be adopted only when adequate research and sound engineering judgment suggests that an appropriate return may be expected in reduced accidents, or in increased driver efficiency, or in reduced litigation.

Table 7. State officials' concern for selected local road signing problems (N=35).*

Statement of Signing Problem	No. of Responses** A	B	C	D	E
A complete inventory of traffic control devices is expensive, both in time and money	10	19	5	1	0
There tends to be resistance on the part of the driving public to the removal of existing signs	0	1	22	12	0
There frequently exists public pressure to install signs for the wrong reasons (e.g., stop signs for speed control, low speed limit signs to curb reckless driving)	5	19	11	0	0
There frequently exists a problem in the inability to be aware of and to respond quickly to vandalism and other damage to signs	13	16	6	0	0

*Replies from Delaware, Pennsylvania, Nebraska, Georgia, Oklahoma, and New Jersey did not contain responses to this question. (California replied by having 10 county engineers respond. Responses are reported later in this section.)

**A. The most serious of the problems listed here.
B. A major concern but not the most serious.
C. A minor concern.
D. Not a source of concern at all.
E. Not applicable for some reason, no opinion, don't know, etc.

4.2. State of California Response to Survey

The state of California chose to have selected county engineers within the state respond on behalf of the state. Therefore, those responses are reported separately in the remainder of this section. Table 8 contains the California county engineers' assessment of the importance of the eight HR-204 recommendations to minimize potential liability by counties from accidents.

With such a small number of persons ranking these policy recommendations, it is not obvious from the data in Table 8 whether the responses of these California county engineers were parallel to or divergent from the state level responses previously reported. A coefficient of concordance was again computed yielding a value of 0.3104. The null hypothesis that no agreement existed among the sample respondents as to the true ranking of these policies was tested. A chi-square of 19.56 was calculated for the sample as compared to theoretical chi-square of 18.5 for seven degrees of freedom at the 0.99 level of significance. Therefore, the null hypothesis is rejected with less than one chance in 100 that there really is no agreement on the ranking of the policies.

The statistically significant ranking of the policies is shown in Table 9. Note that the order of ranking of the policies shown in that table is the same as that produced by analysis of the responses from the states outside Iowa (see Table 4). This suggests that for agencies outside Iowa that have responsibility for policy related to local roads, the perception of the importance of safety and liability related policies is consistent between the state-level and county-level officials.

Table 10 indicates the California county engineers' ratings of the applicability of each of the Project HR-204 policy recommendations. It is apparent by comparing Table 10 to Table 5 (other states) that the

Table 8. Frequency of ranking by nine California county engineers of HR-204 recommendations regarding construction and maintenance practices.

Project HR-204 Recommendations in Order of Listing on Questionnaire	Rank of Importance							
	1	2	3	4	5	6	7	8
Follow strictly the provisions of the <u>Manual on Uniform Traffic Control Devices</u> in the use of warning signs	4	2	1	0	0	0	0	2
Establish a coherent and carefully documented policy governing the use of stop signs	0	3	1	1	2	2	0	0
Establish a continuing sign inventory process	2	0	0	1	3	2	0	1
Establish written agreements covering county (parish) line roads that clearly delimit responsibilities	0	0	0	0	0	1	4	4
Develop procedures to assure timely notification of accidents on roads under county (parish) jurisdiction	1	0	3	2	1	2	0	0
Use a ball bank indicator to establish advisory curve speeds	0	1	1	1	1	1	3	1
Establish a program to document conditions surrounding accidents on roads under county (parish) jurisdiction	1	1	1	3	0	0	2	1
Establish a road and sign inspection program	1	2	2	1	2	1	0	0

Questionnaires were returned by county engineers for San Diego, Monterey, Los Angeles, Lassen, Butte, Sacramento, Fresno, Sonoma, Humbolt, and Yolo Counties. Monterey County did not respond to this question.

Table 9. Statistically significant rank ordering of the importance of the eight policy recommendations of HR-204 as reported by nine California counties.

HR-204 Policy Recommendations	Summed Rankings*
Strictly follow MUTCD for warning signs	27
Establish road & sign inspection program	31
Timely notification of accidents on county roads	35
Establish policy on the use of stop signs	35
Document conditions at accidents on county roads	40
Establish continuing sign inventory process	41
Use ball bank indicator to set advisory curve speeds	49
Written agreements on county line roads	66

*Ties in the summation of the ranks assigned to policies are separated according to the summation of the square of each rank [13].

selected California counties have completed the implementation of these eight policies to a much larger degree than have other states as a group. Since there was no difference in the priority of these policies between the two groups, the variance in status of implementation is interpreted to be associated with differing allocation of road system responsibilities among the states and differing levels of resources available among the states with which to implement such policies.

Table 11 contains the California counties' responses in assessing the extent to which the need for signing at uncontrolled local road intersections is a problem. The responses of these selected county

Table 10. Frequency of applicability of Project HR-204 policy recommendations on construction and maintenance by ten California counties.*

Project HR-204 Policy Recommendations	Rating of Applicability by California Counties†				
	A	B	C	D	E
Follow strictly the provisions of the <u>Manual on Uniform Traffic Control Devices</u> in the use of warning signs	1	0	0	2	7
Establish a coherent and carefully documented policy governing the use of stop signs	0	0	1	0	9
Establish a continuing sign inventory process	0	0	1	0	9
Establish written agreements covering county (parish) line roads that clearly delimit responsibilities	2	2	1	0	5
Develop procedures to assure timely notification of accidents on roads under county (parish) jurisdiction	0	0	0	0	10
Use a ball bank indicator to establish advisory curve speeds	0	0	1	2	7
Establish a program to document conditions surrounding accidents on roads under county (parish) jurisdiction	0	1	1	1	7
Establish a road and sign inspection program	0	0	1	1	8

*Replies were received from San Diego, Monterey, Los Angeles, Lassen, Butte, Sacramento, Fresno, Sonoma, Humbolt, and Yolo Counties.

†Applicability rating code is defined as follows:
- A: Not applicable to our county (parish) systems.
- B: Not feasible to implement in our county (parish) systems.
- C: Feasible but no action has been taken to implement in our county (parish) systems.
- D: Implementation in our county (parish) systems has not been completed.
- E: Implemented in our county (parish) systems and completed.

engineers in California as shown in Table 11 are nearly identical to the responses of the state officials as shown in Table 6 previously.

Table 12 contains the results of selected California county engineers rating the degree to which concern existed about four signing problems which are common for Iowa counties.

These county engineers expressed concern about signing problems differently than did the state officials. The California county engineers were far more concerned about public pressure to use signs for the wrong reasons and were much less concerned about the cost of traffic control device inventories than the state officials. This is interpreted to be a result of a county engineer being much closer to the public complaints and criticisms. State officials have a more formidable bureaucracy between the citizen and themselves than the county engineers. Consequently, changes in signing policies for local road systems must be made with full recognition of these differences in pressures at the two different administrative levels.

4.3. Symbol Sign Identification Contest

In conjunction with the simulation survey done at the 1981 Iowa State Fair, Professor Brewer was given permission to undertake, at his expense, a traditional contest format survey. The objective was to obtain another measure of driver understanding of symbol signs for comparison to the effect of simulation survey, which was at that time unknown.

Table 11. Assessment by nine California counties of signing needs as a problem in county road system.

Assessment of Problem	No. of Responses
Definitely is a serious problem	0
Probably is some problem	5
Don't know, can't say, does not apply	0
Probably not much of a problem	4
Definitely not a problem at all	0

*Replies were received from San Diego, Monterey, Los Angeles, Lassen, Butte, Sacramento, Fresno, Sonoma, Humbolt, and Yolo Counties. Lassen County did not respond to this question.

Table 12. Concern for selected local road signing problems as rated by nine California county engineers*.

Statement of Signing Problem	No. of Responses†				
	A	B	C	D	E
1. A complete inventory of traffic control devices is expensive, both in time and money	0	2	5	2	0
2. There tends to be resistance on the part of the driving public to the removal of existing signs	0	3	5	1	0
3. There frequently exists public pressure to install signs for the wrong reasons (e.g., stop signs for speed control, low speed limit signs to curb reckless driving)	4	3	2	0	0
4. There frequently exists a problem in the inability to be aware of and to respond quickly to vandalism and other damage to signs	1	4	3	1	0

*Replies were received from San Diego, Monterey, Los Angeles, Lassen, Butte, Sacramento, Fresno, Sonoma, Humbolt, and Yolo Counties. Sacramento County did not respond to this question.

†Degree of concern response is coded as follows:
- A: The most serious of the problems listed here.
- B: A major concern but not the most serious.
- C: A minor concern.
- D: Not a source of concern at all.
- E: Not applicable for some reason, no opinion, don't know, etc.

A questionnaire was constructed on an 8.5 by 11-inch sheet with a black and white image of the low shoulder symbol sign. A blank was provided to state what the sign meant. Spaces were provided to indicate the entrant's name, address, age, and whether the person had a valid driver's license. An instruction was printed on the form to deposit the questionnaire in the box available and that all those persons correctly identifying the sign would receive a prize after the fair.

Professor Brewer purchased fast-food chain gift certificates and mailed one to each of the 22 correct respondents along with a letter explaining the response and contest results. The small prize was used as an inducement to encourage as many persons as dared to attempt to figure out a purely graphic symbol sign which was authorized by the Federal Highway Administration, but to the best of the researchers' knowledge had never been used on the public highways of the USA prior to August 1981. A total of 350 entry forms were completed and submitted. The results are shown in Table 13.

As is indicated in Table 13, 6% of the contestants exactly correctly identified the sign and another 7% expressed a meaning to the sign which incorporated the essence of a low shoulder warning. The next five categories of responses in the table encompass 27% of the contestants and cover a range of meanings that are related to shoulder condition warnings. One interesting pattern is that the group interpreting the sign as meaning "soft shoulder" is significantly more rural than all contestants, while the group interpreting the sign to mean "no shoulder" is significantly more urban than all contestants. This suggests that unfamiliar symbol signs may be interpreted within the context of driving experience. If this implication is true, then symbol signs should be studied from a sociological context for potential misinterpretations prior to introducing a new symbol.

The last five categories in the table contain 59% of the contestants and represent completely erroneous interpretations. For this

Table 13. Interpretation of the low shoulder symbol sign by contest entrants and their self-designated characteristics.

Symbol Interpretation	Percent That Resides In: Small Town or Rural	Percent That Resides In: Urban	Percent Entrants' Age By Group*: 1	2	3	4	?	Percent Sex: M	F	?
Total entries (N = 350)	48.9	51.1	22.9	24.9	25.1	24.9	2.3	49	45	6
Low shoulder (N = 22)	45.5	54.5	18.2	31.8	31.8	18.2	4.5	59	36	5
Similar to low shoulder (N = 26)	42.3	57.7	23.1	15.4	38.5	19.2	3.8	39	46	15
General idea of hazard warning in low shoulder (N = 41)	51.2	48.8	12.2	34.1	36.6	17.1	0.0	56	37	7
Soft shoulder (N = 23): similar meaning but unique sign exists	69.6	30.4	17.4	47.8	21.7	13.0	0.0	65	22	13
General idea of warning but error is significant (N = 3)	66.7	33.3	100.0	0.0	0.0	0.0	0.0	67	33	0
Recognized shoulder hazard but assigned prohibitive meaning not intended (N = 4)	25.0	75.0	50.0	25.0	25.0	0.0	0.0	0	100	0
No shoulder (N = 23): meaning wrong but hazard location correctly placed	39.1	60.9	17.4	21.7	26.1	30.4	4.3	52	44	4
Resurfacing drop off between highway lanes (N = 74)	41.9	58.1	21.6	27.0	27.0	24.3	0.0	49	47	4
Bump in road or rough road (N = 26)	46.2	53.8	11.5	15.4	11.5	57.7	3.8	19	73	8
Curb or median ahead and warning of parking or driving over curb (N = 75)	57.3	42.7	32.0	25.3	18.7	22.7	1.3	49	49	2
Road or street narrows or curve or hill ahead (N = 19)	42.1	57.9	31.6	5.3	31.6	31.6	0.0	58	42	0
Wild and strange interpretations (N = 14)	50.0	50.0	21.4	7.1	21.4	50.0	0.0	50	36	14

*1 = 17 years and under; 2 = 18-23 years; 3 = 24-33 years; 4 = 34 years and older; ? = insufficient information combined group the male to female percentages are 46:50 as compared to the total contestant group being 49:45. This raises an unanswered question as to whether new and unfamiliar signs are more of a problem for women drivers than for men. If further study should verify this possibility, then perhaps driver education and communication programs for signing need to take into consideration the increasing number of women active in driving.

Since the persons entering the sign contest were able to study the questionnaire as long as they wished and confer with companions, it is particularly disconcerting that 59% of the persons entering the contest grossly misinterpreted the sign. Therefore, we can expect that a significant number of drivers traveling a highway encountering a new or unfamiliar symbol sign will most likely never know what message was intended to be communicated until the driver is in the midst of the traffic situation.

4.4. Iowa County Engineer Survey Results

A survey was conducted wherein questionnaires were sent to all county engineers in Iowa. The information solicited dealt with the extent to which the engineers in each county perceived that a problem in signing uncontrolled local roads existed, as well as how great a problem in their specific county it was thought to be. Among the kinds of information solicited was a ranking and assessment of the applicability of the recommendations contained in Project HR-204 conducted by Carstens [2]. These eight recommendations call for practices intended to minimize potential liability to counties from accidents. These include:

- Following strictly the provisions of the Manual on Uniform Traffic Control Devices in the use of warning signs.
- The establishment of a coherent and carefully documented policy governing the use of stop signs.
- The establishment of a continuing sign inventory process in the county.
- The establishing of written agreements covering county line roads wherein clearly delimited responsibilities are laid out.
- The use of ball bank indicator to establish advisory curve speeds where needed.
- The establishing of a road and sign inspection program.
- The establishing of a program to document conditions surrounding accidents on roads under county jurisdiction.
- The developing of procedures to assure the timely notification of the county engineer when accidents have occurred on roads under county jurisdiction.

Of the 99 Iowa county engineers who were mailed questionnaires, usable responses were received from 86. Thus, the resultant data represents an 87% sample of Iowa county engineers. In Table 14 the priority ranking of the recommended items from Project HR-204 is presented. In the first step the county engineers were asked to rank these eight items as to the priority they would assign them in their own county operations.

Table 14. Responses by Iowa county engineers to queries on the priority rank given recommendations from Project HR-204.

Recommendation	*Rank 1-2	Rank 3-4	Rank 5-6	Rank 7-8	No. of Responses
Follow strictly <u>MUTCD</u> guidelines	62.6%	9.1%	6.0%	3.0%	N=80
Establish a policy on use of stop signs	28.3%	20.2%	15.2%	16.2%	N=79
Establish a sign inventory process	35.3%	25.3%	12.2%	8.1%	N=80
Set up pacts delimiting responsibility on county line roads	3.0%	19.2%	26.2%	29.3%	N=77
Use ball bank indicator to set curve speeds	3.0%	8.1%	16.2%	52.5%	N=79
Set up road and sign inspection program	27.2%	33.4%	11.1%	9.1%	N=80
Set up program to record accident conditions in county	5.0%	29.3%	36.4%	8.1%	N=78
Set up a system to get timely information on accidents	9.1%	20.2%	29.3%	20.2%	N=78

*Where 1 = Highest Priority, 8 = Lowest Priority

As the table clearly demonstrates, the highest rating went to the recommendation that county engineers strictly adhere to the <u>MUTCD</u> guidelines in the installation of signing (62.6% assigned this item a highest or second highest ranking). After that point, however, the extent to which county engineers agreed with the recommendations and gave them high scores, priority rankings were quite varied. The recommendation from HR-204 which received the lowest ranking and thus was seen as being least important to responding county engineers called for the use of the ball bank indicator for setting advisory speed limits on curves. Fully 52.5% of the respondents gave this item a seven or eight ranking (next to last and last, respectively). Between these two extremes the recommendations could be said to show varying degrees of support or ambivalence among respondents. Regrouped to reflect their relative priority ranking by Iowa county engineers, the eight recommendations would be listed as follows (from most to least support):

1) Following strictly the provisions of the Manual on Uniform Traffic Control Devices in the use of warning signs.
2) The establishing of a road and sign inspection program.
3) The establishment of a continuing sign inventory process in the county.
4) The establishment of a coherent and carefully documented policy governing the use of stop signs.
5) The establishing of a program to document conditions surrounding accidents on roads under county jurisdiction.
6) The developing of procedures to assure the timely notification of the county engineer when accidents have occurred on roads under county jurisdiction.
7) The establishing of written agreements covering county line roads wherein clearly delimited responsibilities are laid out.
8) The use of ball bank indicator to establish advisory curve speeds where needed.

Next, county engineers were asked to assess either the feasibility of these recommendations or the extent to which these policies had been implemented in their counties. Table 15 reveals the results of this query. The table shows that there is again considerable variation to be found in the extent to which Iowa counties follow these policy guidelines as recommended by HR-204. Looking first at the policy recommendations seen as least applicable or feasible, it can be seen that, again, the use of the ball bank indicator was seen as least applicable or feasible by respondents. The other policy recommendations, in an ascending order of popularity (relative to applicability or feasibility) were:

1) The establishment of a policy on the use of stop signs.
2) The setting up of a program to note the conditions surrounding accidents in the county.
3) The development of a system whereby timely information on accidents can be accumulated.
4) The setting up of a road and sign inspection program.
5) The following of <u>MUTCD</u> guidelines strictly and
6) The establishment of a sign inventory process.

(The last two were tied for last in the ascending order.)

At the same time, collapsing the last two categories (referring to those policies which had been implemented before 1979 and since 1979), it can be seen that strict adherence to <u>MUTCD</u> guidelines, the setting up of a sign inspection program, and the establishment of a sign inventory process were far and away the most frequently implemented policy recommendations from HR-204. In addition, despite the fact that the

Table 15. Responses by Iowa county engineers to queries on the applicability of HR-204 recommendations.

Recommendation	Not Appl.	Not Feas.	Implementation: Begun Incomplete	Implementation: Since 1979	Implementation: Before 1979	No. of Responses
Follow strictly MUTCD guidelines	2.4%	2.4%	39.0%	4.9%	51.2%	N=82
Establish a policy on use of stop signs	8.8%	7.4%	35.3%	11.8%	36.8%	N=68
Establish a sign inventory process	2.4%	2.4%	42.7%	18.3%	34.1%	N=82
Set up pacts delimiting responsibility on county line roads	5.4%	2.7%	50.0%	8.1%	33.8%	N=74
Use ball bank indicator to set curve speeds	11.0%	21.9%	24.7%	16.4%	26.0%	N=73
Set up road and sign inspection program	1.2%	8.6%	35.8%	14.8%	39.5%	N=81
Set up program to note accident conditions	5.6%	9.7%	41.7%	18.1%	25.0%	N=72
Develop system to get timely info on accidents in county	7.1%	7.1%	50.0%	10.0%	25.7%	N=70

policies calling for the setting up a program for noting accident conditions in the county and development of a system for getting timely notification to the county engineer when accidents occur were rated lowest and next lowest among those implemented before or since 1979, fully 50% of the respondents reported that two policies (setting up of agreements to delimit responsibility on county line roads and development of a timely system of information of accidents in the county) were implemented but not complete.

Respondents were also queried as to their responses to common problems relative to signing on county roads. In one question they were asked to respond to the statement that the inventory of signing devices is expensive in both time and money. Table 16 displays the results of that question. The table shows considerable consensus among the respondents on at least two items. First, as to the statement that "there tends to be resistance on the part of the driving public to the removal of signs," fully 53% responded that this was a minor concern, while another 28.9% indicated that it was not a concern at all. Second, at the opposite extreme, the statement "there frequently exists a problem in the inability to be aware of and to respond quickly to vandalism and other damage to signs," 45.8% indicated that this was the most serious of the concerns listed, while another 37.3% listed it as a major concern, even though not the most important. There was considerably less consensus as to the other two items. Both suggest, however, that county engineers in Iowa see these as important factors, but are uncertain as to how significant they tend to be. The first of these was the item which asked for a response to the statement, "there frequently exists public pressure to install signs for the wrong reasons, (i.e., stop signs for speed control, low speed limit signs to curb reckless driving)." Identical proportions of the sample (43.4%)

Table 16. Responses by Iowa county engineers to queries on the expense, resistance, and problems of signing.

Response	Most Serious	Major Concern	Minor Concern	Not Concern	Not Appl.	No. of Responses
Inventory is expensive (time, $)	21.7%	38.6%	27.7%	9.6%	2.4%	N=83
Public resists the removal of signs	1.2%	12.0%	53.0%	28.9%	4.8%	N=83
Signs wanted for wrong reasons	4.8%	43.4%	43.4%	7.2%	1.2%	N=83
Hard to know of vandalism and other sign damage	45.8%	37.3%	14.5%	2.4%	0.0%	N=83

responded that this factor constituted either a major or a minor concern on their part. Less emphatic was the response to the statement, "a complete inventory of traffic control devices is expensive, both in time and money." While 21.7% of the respondents answering this question rated it a matter of most serious concern, 12.4% of the respondents responded that it was either not a concern or not applicable to their county. Meanwhile, 38.6% listed it as a major concern and 27.7% listed it as a minor concern.

What this set of responses tends to show is that county engineers in Iowa see the day-to-day concerns of replacing worn-out and vandalized signs and keeping up with what signs are in place as the major concerns of their signing programs. At the same time, the more abstract matters, relating to public acceptance or resistance to signing, were seen as clearly secondary. Given the magnitude of the first two problems in most Iowa counties, it is reasonable to interpret these as pragmatic responses.

These data from the survey of Iowa county engineers were compared to the data obtained from agencies outside Iowa (see Section 4.2). Officials outside Iowa placed a significantly more important ranking on strictly following the MUTCD in the use of warning signs and on developing timely notification of accidents on roads under county jurisdiction than did Iowa county engineers. At the same time, officials outside Iowa were significantly more likely than Iowa county engineers to assign a very low importance to establishing a continuing sign inventory and to developing written agreements for county line roads. These officials from outside Iowa were also much less likely than Iowa county engineers to assign a low importance to use of the ball bank indicator to establish advisory speed curves. Since the responses of both officials outside Iowa and the Iowa county engineers on the acceptability and applicability of these policies is almost identical, the perception of different degrees of importance attached to the policies suggests that the local road signing problem in Iowa has unique characteristics that must be recognized and dealt with.

Officials outside Iowa and Iowa county engineers agreed on the importance of the four signing problems. Both groups considered the inability to respond to damaged signs as the most serious of the four problems presented, and a close second was the cost of a complete traffic control device inventory. Therefore, any policy or program resulting from this research must recognize these two administrative concerns in order for the policy to be effective. A universal call to erect signs may not result in any overall net gain in safety to the motoring public if the reallocation of resources and effort to deal with the problems of sign damage and inventory are excessively aggravated.

4.4.1. Tort Claim Information

Iowa county engineers were asked to report the level and frequency of tort claims against their counties in a previous research study conducted by Carstens [2]. There was found to be an enormous variation in reported tort claims. Table 17 reports the results of these questions.

4.4.2. Regression Analysis

At a certain point in the analysis, different statistical approaches seemed to be in order. It was obvious that certain kinds of questions were related most directly to the relationship between tort claims (size, frequency, etc.) and the attitudes held by county engineers with respect to some of the matters cited earlier (and included in the survey instrument). For this reason, a more detailed analysis was performed using stepwise multiple regression wherein the dependent variables were first the tort claim items (size, frequency, and others) and the independent variables attitudinal items and queries relating to implementation of these policy items. Table 18 summarizes some of these findings.

The most important factor to note in Table 18 is that while structural factors were included in the list of independent variables (such

Table 17. Responses by Iowa county engineers to queries regarding county tort claims for 1973-1978 [2].

	Smallest	Largest	Mean	N=
Average tort claims ('73-'78)	$239	$992,833	$109,688	N=55
Total tort claims ('73-'78)	$1436	$5,957,000	$658,133	N=55
Highest tort claims ('73-'78)	$942	$3,800,000	$506,884	N=55
Average tort claims settled ('73-'78)	$67	$75,806	$6,053	N=34
Total tort claims settled ('73-'78)	$402	$454,834	$36,316	N=34

as population of county, money spent on traffic devices) it was the attitudinal factors which were predictive. In this case, it was the attitude of the county engineers toward the idea of a thorough sign inventory along with the perception that members of the public desire the installation of signs for improper reasons which entered the equation first and third, respectively. Also coming to bear were the feasibility or actions taken vis-a-vis the setting up of written agreements with other counties (entering second) and the total expenditures for traffic service/control devices for 1975 (which entered the equation fourth).

The importance of Table 19 is that our data clearly suggest a link between the attitudes held by county engineers in Iowa and the

Table 18. Stepwise regression results using as dependent variable average tort claims per year (1973-1978) with policy questions as independent variables.

Order of Entry		Beta Weight*	Explained Variation
First	Complete inventory of signs is expensive in time and money	0.27	0.074
Second	Feasibility or action relating to setting up written agreements	-0.19	0.108
Third	Perceived public pressure to put up signs for the wrong reasons.	-0.24	0.147
Fourth	Traffic service/control expenses for 1975	-0.18	0.168

*Standardized regression coefficient with regression through the origin.

average size of tort claims against their respective counties. Exactly why this exists is not clear. It appears that the attitude of the county engineer comes to be reflected in the attention given to thorny signing problems and to the liability of the county.

As Table 19 indicates, the most salient variable in predicting the magnitude of spending on traffic control devices (1973-1978) was the population of the county. Simply put, the larger the county population, the more money was spent on traffic control devices. This should come as a surprise to very few observers. Interestingly, however, another variable (the ranking given by the county engineer to the recommendation calling for the timely notification of the county engineer's

Table 19. Stepwise regression results using as dependent variable county spending on traffic control devices (1973-1978).

Year	1st Variable to enter the equation	2nd Variable to enter the equation	3rd Variable to enter the equation	Variation Explained as Third Step
1973	Pop. (0.648)	Notif. (-0.287)	Inventory (0.155)	0.517
1974	Pop. (0.659)	Notif. (-0.308)	Inventory (0.152)	0.543
1975	Pop. (0.554)	Notif. (-0.235)	Inventory (0.261)	0.414
1976	Pop. (0.775)	Notif. (-0.249)	Inventory (0.102)	0.668
1977	Pop. (0.721)	Notif. (-0.203)	FeasNOTIF (0.140)	0.576
1978	Pop. (0.687)	Notif. (-0.244)	INVEXPEN (-0.170)	0.555
1979	Pop. (0.477)	Doc of Acc. (-0.306)	Agreements (0.218)	0.330
1980	Pop. (0.782)	Doc of Acc. (-0.187)	FeasNOTIF (0.120)	0.657

Key: Pop. = Population of the county
Notif. = Rank given to the policy recommendation calling for timely notification of accidents within the county.
Doc of Acc. = Rank given to the policy recommendation calling for the careful documentation of the circumstances surrounding accidents.
Inventory = Rank given to policy recommendation calling for a complete inventory of signs in the county.
Agreements = Rank given to the policy recommendation calling for drawing up of agreements with adjacent counties on responsibility for county line roads.
FeasNOTIF = Assessment of the feasibility of setting up a system for timely notification of accidents within the county.
INVEXPEN = Assessment of the factor of cost in recommending a thorough inventory of signs in the county.

office when accidents occur in the county) was the second strongest variable for the years 1973 through 1978. For the years 1979 and 1980, the second most important variable represented the rank given the surveyed county engineer to the need for careful documentation of accidents and the conditions surrounding them. The researchers believe that positive action has been taken to address this issue that our analysis has further highlighted.

4.4.3. Perceived Priorities of County Engineering Activities by Simulation Survey Respondents

Each sample respondent was given a computer display which listed the following county engineering budget categories in this order.

1) Fix potholes and road surface
2) Build new roads and bridges
3) Blade and drag gravel roads
4) Repair bridges and culverts
5) Plow snow and control ice
6) Mow grass and clear brush
7) New signs and traffic lights
8) Fix and replace existing signs
9) Bridge safety inspections

These categories were obtained from the annual reports submitted to the Secondary Roads Office of the Iowa Department of Transportation by each county. Each category was assigned a descriptive name that the general public would understand. The nine budget categories are listed in descending order according to the average amount of funding allocated to each activity by a typical Iowa county in 1980. The 1980 state-wide average county expenditure as reported to the Iowa Department of Transportation was displayed by the computer to the right of each category. Each person was asked to assign a priority number to each activity as if that person were the county engineer by placing a one (1) in front of the activity he or she perceived to be the most important activitiy in the county engineering office operation, and to continue for all nine activities. In this manner, an estimate of public perception of the importance of installing additional signing was developed.

It is recognized that budget expenditure is not equivalent to priority as some activities are more expensive per unit of work. Also, a small expenditure per year may cover one activity, while millions of dollars annually may not satisfy the need in another activity. However, since respondents were being asked later to test their priority of activities in the expenditure of additional resources and were initially required to prioritize activities for budget reductions, a knowledge of average budgets had to be provided to the respondents. Therefore, the respondents' assessment of priority is a joint measure of priority preference and preference in allocation of resources.

If all respondents in the sample had selected the same activity as the most important, it would have received a total summed rank of 405 (405 persons assigning a rank of first), and conversely, if all sample respondents had selected the same activity as the least important, it would have received a summed rank of 3645. Table 20 indicates the summed ranks for the nine activities and lists them in the order of preference for the total respondent sample.

Table 20. Rank order of priorities assigned to county engineering activities where first (number one) is most important N=405).

County Engineering Activity	Respondent Preference Order	Summed Ranks	1980 Spending Order
Fix potholes & road surface	1	1076	1
Bridge safety inspections	2	1411	9
Fix & replace existing signs	3	1602	8
Plow snow & control ice	4	2001	5
New signs & traffic lights	5	2073	7
Repair bridges & culverts	6	2260	4
Blade & drag gravel roads	7	2582	3
Build new roads & bridges	8	2594	2
Mow grass & clear brush	9	2626	6

In order to estimate the statistical significance of the priority rankings assigned these county engineering activities by the sample respondents, a coefficient of concordance was computed. A value of 0.2250 was obtained where zero would imply that the rankings are so random that no real and significant preference exists among the persons ranking the activities. A coefficient of concordance equal to one would result from everyone agreeing on the exact same ranking.

The sample rankings yielded a chi-square value of 826.28 to test the significance of a coefficient of concordance of 0.2250. Such a large chi-square indicated that the null hypothesis that no true preference existed among the respondent sample should be rejected. Therefore, it was assumed that the priority order of the ranked activities based on the summed ranks represented a valid measure of the preference among the activities.

Note that allocating resources to new signs and traffic lights was the middle priority category of nine. In the original list shown the respondents on the computer, this category was seventh, so the overall effect within the sample response was to raise its priority two places. This suggested that the respondents placed a stronger emphasis on new signs than did the computer display given each respondent. However, there was a possibility that the type of preference study being conducted on signing might have caused people to place a higher priority on new signs than they would have under other circumstances. A validity check for this potential respondent bias was developed. The computer displayed a forced-choice paired-comparison set to test the consistency of each person's priority ranking with respect to installing new signs.

Each activity was reworded into a positive action statement. For instance, the budget category "new signs and traffic lights" became "installing more signs to enhance intersection safety." The computer presented each category of activity opposite the "new signs" action alternative (installing more signs...) in the order in which the person prioritized the categories. Thus, a choice was presented for each person to choose in spending a new allotment of additional resources between his or her first priority category and new signs. After choosing to which of the two activities additional resources would be devoted, the second highest priority category would be presented opposite new signs and the choice would be repeated. Theoretically, if a person was consistent in his or her priority assignment, then when forced to choose between two activities for additional resources, any item ranked above new signs should have resulted in a choice away from new signs. When a category appeared for which a priority had been assigned lower than new signs, then new signs should have been the choice. Table 21 indicates the priorities assigned to new signs as a category. Note that the most common priority assigned to new signs was four (4).

Table 21. Frequency of assigned priorities to county engineering activity of installing new signs.

Priority Assigned	Number of Respondents	Percent Frequency
1	9	2.2
2	25	6.2
3	43	10.6
4	160	39.5
5	35	8.6
6	4	1.0
7	26	6.4
8	63	15.6
9	40	9.9
Total N=405		

The respondents were analyzed for the character of their paired-comparison choices with respect to the distribution of the assignment of priority to new signs as given in Table 21. This analysis was to test the possibility that persons ranking new signs with a high priority might have some bias different from those ranking it low.

The first characteristic of the response pattern examined involved all respondents with perfect consistency in rating the importance of installing new signs and in making forced-choices in allocating additional resources. If a person always rejected new signs when it was shown next to an activity which had been previously ranked with a priority above new signs, and also always selected new signs when it was shown next to an activity which had been previously ranked below new signs, then that person was perfectly consistent in rankings and choices. Table 22 lists the distribution of the 14 respondents who were completely consistent between ranking activities and making forced-choice comparisons.

Table 22. Respondents consistent in ranking of county engineering categories and in forced-choice of county engineering activities against new signs (N=405).

	Priority Rank of "New Signs & Traffic Signals"								
	1	2	3	4	5	6	7	8	9
Number of Respondents	2	1	0	0	1	0	1	4	5

The most disappointing thing shown in this table is that so few persons were consistent in their ranking and their choices about how to allocate resources between competing activities. Only 14 of 405 persons is a very small fraction. In designing this experiment, it was hoped that a significant proportion of the respondents would be able to maintain continuity of preference between the two methods of estimating preferences. However, it has been suggested by a very experienced survey researcher that the number of items may have been too long for people to retain a strong sense of their ordered preferences. It does indicate that the persons who gave erecting new signs a low priority rank were significantly more likely to be consistent in their choices about how to allocate resources among competing pairs of activities. This implies that persons who dislike excessive signing have strong preferences about installing signing. Resistance to additional signing may be more difficult to overcome than attempting to persuade persons wanting more signing that it is not needed.

This analysis was followed with an examination of the responses to determine how many persons were totally inconsistent (i.e., completely reversed their priority rankings with respect to their forced-choice paired comparisons between activities). Only one person completely reversed their priorities. This suggests that the intended meaning of the forced-choice test was clear to the respondents. If confusion had existed as to the intent of the forced-choice paired-comparison test, the number of respondents reversing their priority rankings with respect to their forced-choices should have been nearly equal to the number of respondents who were perfectly consistent.

Another characteristic of interest in the forced-choice response pattern was the degree to which a respondent always chose new signs in the paired comparisons or never chose new signs. If persons with such a response pattern on the forced-choice paired-comparison test were primarily individuals who assigned a priority rank of first or ninth (last) to the new signs budget category, then these persons could be assumed to be reflecting strong preferences. Alternatively, if these persons were scattered throughout the distribution of rankings given new signs (as shown in Table 21), then it may be assumed these persons were only a measure of chance variation in personal decision processes. Table 23 contains the distribution of respondents always or never selecting "erect new signs" in choosing to allocate resources between competing activities.

Table 23. Respondents always or never selecting "erect new signs" in forced-choice comparison test against other county engineering activities (N=405).

	Priority Rank of "New Signs & Traffic Signals"								
	1	2	3	4	5	6	7	8	9
Number of Respondents	2	1	4	8	1	0	3	3	5

It was hypothesized that the distribution of responses shown in the above table was the same as the distribution of priority rankings assigned to "new signs" by the total respondent sample in Table 21.

That is, it was assumed that Table 23 displays chance variation in decision making by individuals. This null hypothesis was tested statistically using the Kolmogorov-Smirnov goodness-of-fit test [14]. Since the test was not significant at any available level of test significance, the hypothesis could not be rejected. Thus, it is interpreted to mean that it is extremely unlikely that persons who indicated that resources should always be allocated to erecting new signs, or that resources should never be allocated to erecting new signs, did so because of any rational analysis of budget preferences.

One further analysis was made of the paired-choice data with respect to the priority ranking of the county engineering budget activities. The pattern of choices among those activities ranked above erecting new signs and the pattern of choices for those activities ranked below erecting new signs were compared to a uniform response distribution. If the pattern of responses people made were not statistically different from a uniform response distribution (i.e., equal number in each possible choice cell), then a random number process could have yielded the same results as the paired-choice survey test method. Table 24 contains the results for all respondent paired-comparison choices with respect to county engineering activities ranked above erecting new signs.

The similar data for the pattern of selections within the paired-choice comparison process for activities ranked lower than erect new signs is shown in Table 25.

Table 24. Response pattern of paired-comparison choices for county engineering activities ranked above "erect new signs" and significance as tested by Kolmogorov-Smirnov [14] (N=405).

Rank of "Erect New Signs"	Number of times "erect new signs" was selected when compared to an activity which had been ranked above it in priority									Ho Test	Total No.
	0	1	2	3	4	5	6	7	8		
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	9
2	12	13	NA	NA	NA	NA	NA	NA	NA	CR	25
3	20	17	6	NA	NA	NA	NA	NA	NA	0.10	43
4	42	71	40	7	NA	NA	NA	NA	NA	0.01	160
5	9	11	12	3	0	NA	NA	NA	NA	0.01	35
6	0	1	1	1	1	0	NA	NA	NA	CR	4
7	4	4	10	6	1	1	0	NA	NA	0.01	26
8	7	10	16	16	7	7	0	0	NA	0.01	63
9	5	5	10	10	5	3	1	1	0	0.01	40

Ho: Null hypothesis that the selection of alternative actions to which resources were to be allocated was governed by random chance.

NA: Not applicable.

CR: Cannot reject hypothesis Ho at any level of significance for which a test was available.

0.01: Hypothesis Ho is rejected at the 0.01 level of significance, i.e., there is a less than one in a hundred chance that this selection pattern was the result of random choices.

0.10: Hypothesis Ho is rejected at the 0.10 level of significance, i.e., there is less than one in ten chance that this selection pattern was the result of random choices.

Table 25. Response pattern of paired-comparison choices for county engineering activities ranked below "erect new signs" and significance as tested by Kolmogorov-Smirnov [14] (N=405).

Rank of "Erect New Signs"	Number of times "erect new signs" was selected when compared to an activity which had been ranked below it in priority									Ho Test	Total No.
	0	1	2	3	4	5	6	7	8		
1	0	1	1	1	2	1	1	0	2	CR	9
2	0	5	2	4	6	3	3	2	NA	CR	25
3	3	8	9	15	3	2	3	NA	NA	0.01	43
4	15	37	46	39	18	5	NA	NA	NA	0.01	160
5	3	10	8	9	5	NA	NA	NA	NA	CR	35
6	0	2	2	0	NA	NA	NA	NA	NA	CR	4
7	10	11	5	NA	NA	NA	NA	NA	NA	CR	26
8	19	44	NA	NA	NA	NA	NA	NA	NA	0.05	63
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	40

Ho: Null hypothesis that the selection of alternative actions to which resources were to be allocated was governed by random choice.
NA: Not applicable.
CR: Cannot reject hypotehsis Ho at any level of significance for which a test was available.
0.01: Hypothesis Ho is rejected at the 0.01 level of significance, i.e., there is a less than one in a hundred chance that this selection pattern was the result of random choices.
0.05: Hypothesis Ho is rejected at the 0.05 level of significance, i.e., there is less than one in twenty chance that this selection pattern was the result of random choices.

Persons who assigned a priority rank of 1, 2, and 6 (38 respondents or 9% of the sample) to new signs selected one of the two alternative choices given them in the paired-choice comparison test in an essentially random manner. Persons who assigned a priority rank of 3, 4, 8, and 9 (306 respondents or 76% of the sample) to new signs had a statistically significant skew to their choice pattern. These persons tended to not select erect new signs when it was compared to an activity to which they had assigned a higher priority, and they tended to select erect new signs when it was compared to an activity to which they had assigned a lower priority. Thus, persons who assigned new signs a priority rank of 3, 4, 8, or 9 were statistically more consistent. Individuals who ranked erect new signs at these four levels of priority were more certain of their preferences. Thus, two levels of agreement existed about the priority for erect new signs. One was favorable (3 or 4) and one was opposed to the activity (8 or 9). The latter represents a public resistance to signing that must be recognized in adopting any new policy.

In summary, the overall summed ranks placed the county engineering budget category containing the activity erect new signs in fifth place. The most common priority given the new signs budget category was fourth place (40% of the sample). The persons providing statistically consistent tendencies in their paired-choice test results with respect to their priority rankings were those persons ranking new signs 3 or 4, or persons ranking it 8 or 9. Of those persons whose paired-choice test results were perfectly consistent with their priority ranking, 9 or 14 (64%) ranked new signs either 8 or 9. Thus, the statistically valid priority given the budget activity associated with erecting more new signs is appropriate. Sixty-seven percent of the sample ranked it as the fifth priority or higher budget category of the nine categories shown, with most people rating it right behind fixing potholes and repairing the road surface and making bridge safety inspections. This indicates a strong general public opinion and preference base to allocate additional resources to roadway signing. However, the data do indicate that a smaller but significant group (103 or 25% of the sample) are strongly opposed to diverting additional resources into additional roadway signing on the county highway system. These data suggest that in order to consider public funding priorities and preferences, any new signing considered for adoption should be implemented within a selective application policy and not an overall system-wide application policy.

Upon completion of the forced-choice paired-comparison items on county engineering budget activities, each respondent was presented a list of nine major total county budget items with typical 1980 spending levels (local funds). Table 26 illustrates the display shown.

Table 26. Computer display of county budget items.

County Budget Items	Local Dollars Shown
Board of Supervisor salary	$56,000
Auditor office operations	$73,000
Treasurer office operations	$163,000
Recorder office operation	$67,000
County Attorney office operation	$135,000
Sheriff budget and jail costs	$500,000
Social services and welfare	$37,000
Courthouse operation	$205,000
Engineering and road operation	$2,000,000

Each respondent was required by the computer to assign a rank of one (1) through nine (9) to each county budget item. A rank of one was the most important to the respondent in the event of reduced county funding, and so on through nine. Thus, the priority assigned was to represent a measure of how the respondent wanted local county funds allocated in periods of reduced resources. Table 27 indicates the pattern of rankings given the budget items.

Note that in Table 27 the respondents appeared to have a preference for the county budget items in the reverse order in which the items were displayed. This response pattern was consistent with the exception of the engineering and road operations budget. Two peaks in the distribution of ranks assigned to engineering and road operations are evident in Table 27, one at rank equal one and one at rank equal seven. This bimodal response to engineering and road operations suggests that the public client group served by the county engineering function has two distinct and radically differing perceptions of the value of this public service. The larger segment of the public is very strongly in support of the county engineering function. However, there is a sizable proportion of the public that places an extremely low priority on the county engineering function. These data are interpreted to suggest that it is important to utilize fully the channels available to the county engineering office to publicize the alternatives considered in each policy action. Because a significant proportion of the public identified a low priority to county engineering, it would be a good idea to provide advance notice of any engineering or operating policy change being considered and do so in a manner intended

Table 27. Respondent ranking of county budget items with one being the most important item (N=405).

County Budget Item	Priority Assigned to Budget Item									Sum of Ranks
	1	2	3	4	5	6	7	8	9	
Board of Supervisor Salary	14	0	2	0	2	5	5	7	370	3481
Auditor office operations	11	6	2	6	3	48	33	284	12	2967
Treasurer office operations	13	6	13	9	26	100	208	29	1	2527
Recorder office operations	27	17	16	25	86	214	16	3	1	2068
Attorney office operations	32	24	42	78	207	12	0	8	2	1707
Sheriff and jail	35	44	101	181	19	7	5	11	2	1428
Social service and welfare	38	102	185	40	11	5	13	6	5	1226
Courthouse operations	92	175	34	30	31	4	10	29	0	1145
Engineering and road operations	143	31	10	36	20	10	115	28	12	1676

to inform the public of the engineering management basis of the desired direction of change. Such a public communication effort and citizen participation process would not be directed to those persons giving a high priority to the county engineering function. Those persons generally support the county engineering process already. The informational program should be directed to those persons who are not currently favorably disposed to support the county engineering system.

In the context of competitive games, the county engineer can seek to either maximize gain (winnings in a gambling sense) or minimize losses. The public information approach suggested above is conservative and is based on the competitive game concept of minimizing losses. A county engineering office pursuing this type of public information program would probably never be outstandingly popular. On the other hand, it is unlikely that a citizen group opposed to some policy change would be able to successfully legally challenge the prerogatives of exercising engineering judgment. If a signing system change was undertaken to provide new driver communication at obscured uncontrolled local road intersections, future liability for any publicly perceived undesirable aspects of this signing change could be minimized by an informational program outlining the basis of the change.

The validity of the rankings provided by the sample respondents was tested with the coefficient of concordance. A null hypothesis that no statistical significance existed in the sample rankings was tested with chi-square and rejected. The coefficient of concordance was 0.5338 yielding a chi-square value of 1729.4 which indicates that the rankings given the county budget items have less than five chances in 10,000 of occurring by random probability. Thus, the ranking for the county engineering program (which is different from the pattern of the other rankings) is a significant indicator of public perception of the worth of the program. Since the statistical analysis conducted in this research did not indicate a significant association with locational variables, the priority ranking among county budget items can be assumed to be generally valid across the state. This suggests that funding needs for the jail, courthouse maintenance, and welfare administration are the types of budget categories that have competitive public support for additional resources the county engineer may seek.

5. SIMULATION SURVEY DATA

5.1. Analysis of Simulation Survey Data

The most obvious place to begin the analysis was to see how the overall sample (N=405) rated the nine signs shown them in the simulation survey. The mean scores appear in Table 28. Bear in mind that for the mean scores presented, the range of scores was from one to five

Table 28. Mean ratings for signs for the total sample of respondents*.

Sign Shown	Mean	Variance	Rank
CROSS ROAD	2.33	1.10	1
Watch for Side Road Traffic	3.14	1.59	8
Blind Intersection Ahead	2.68	1.61	3
Limited Intersection Sight Distance	3.12	1.63	7
Be Prepared to Stop	3.06	1.77	6
Slow--Intersection Ahead	2.71	1.41	4
Arrows symbol	2.91	1.71	3
Crashing cars symbol	3.19	1.75	9
Dangerous Intersection	2.45	1.23	2

*N=405.

with one equaling a strong liking for the particular sign and a five representing a strong dislike for the sign. Remember, also, that in each case the sign was evaluated after the respondent had seen a simulated approach to a specific intersection and that each subsequent sign was evaluated after seeing a video reference to the same intersection.

In Table 28, it can be seen clearly that the two most favored signs by the entire sample were the CROSS ROAD and "Dangerous Intersection" signs. The least liked signs were the signs reading "Watch for Side Road Traffic" and the symbol sign bearing the image of two cars crashing into one another. The two most popular signs also demonstrated the least shifting of opinion as measured by the variance figures (1.10 and 1.23 respectively). The sign around which there was the largest shifting of opinion was the sign reading "Be Prepared to Stop" as this sign had a variance of 1.77.

5.2. Analysis by Site Tested

In the next analysis, a contrast was drawn between the evaluation of each sign and the site shown to the respondent. It was presumed that there might be some bias introduced by virtue of which site was presented to the respondent. Some sites were representative of flat terrain, some rolling or undulating hills, while one site represented the steep, twisting driving environment of Eastern Iowa along the Mississippi River. It was thought that the background of the respondent might somehow affect their response to the simulation. This contrast appears in Table 29.

Table 29. Mean ratings for signs by site used where 5=most disliked and 1=most liked and rank and average ranking by site.

	Site Number						
Sign Shown	Site-1 (N=73)	Site-2 (N=67)	Site-3 (N=71)	Site-4 (N=64)	Site-5 (N=66)	Site-6 (N=64)	Rank
CROSS ROAD	2.23	2.26	2.60	2.46	2.19	2.20	
Rank	(1)	(1.5)	(2)	(3)	(1)	(1)	(1)
Watch for Side Road Traffic	2.95	3.37	3.01	3.37	3.00	3.18	
Rank	(6)	(8)	(7)	(8)	(6)	(6.5)	(9)
Blind Intersection Ahead	2.38	2.50	2.63	2.82	2.36	3.46	
Rank	(2)	(4)	(3.5)	(5)	(3)	(8)	(3)
Limited Intersection Sight Distance	3.37	3.40	2.90	2.37	3.72	2.53	
Rank	(8)	(8)	(5)	(1)	(9)	(4)	(5.5)
Be Prepared to Stop	2.86	2.62	3.59	3.56	2.95	2.81	
Rank	(5)	(5)	(9)	(9)	(5)	(5)	(7)
Slow--Intersection Ahead	2.41	2.37	2.63	2.95	2.31	3.67	
Rank	(3)	(3)	(3.5)	(6)	(2)	(9)	(4)

Table 29. (Continued).

Sign Shown	Site Number						
	Site-1 (N=73)	Site-2 (N=67)	Site-3 (N=71)	Site-4 (N=64)	Site-5 (N=66)	Site-6 (N=64)	Rank
Arrows symbol	3.17	3.11	2.94	2.57	3.37	2.23	
Rank	(7)	(7)	(6)	(4)	(8)	(2)	(5.5)
Crashing cars symbol	3.87	2.26	3.40	3.32	3.01	3.18	
Rank	(9)	(1.5)	(8)	(7)	(7)	(6.5)	(8)
Dangerous Intersection	2.54	2.79	2.12	2.40	2.57	2.29	
Rank	(4)	(6)	(1)	(2)	(4)	(3)	(2)

Statistical Significance:
Sign 3 ($F = 7.53$, $\alpha = < 0.001$)
Sign 4 ($F = 17.47$, $\alpha = < 0.001$)
Sign 5 ($F = 6.78$, $\alpha = < 0.001$)
Sign 6 ($F = 14.48$, $\alpha = < 0.001$)
Sign 7 ($F = 7.45$, $\alpha = < 0.001$)
Sign 8 ($F = 12.78$, $\alpha = < 0.001$)
Sign 9 ($F = 3.07$, $\alpha = < 0.05$)

In Table 29 it can be seen that there was clearly a variation across sites in terms of the evaluation of respondents. Yet, the importance of this fact is not that the sites engender different evaluations by the respondents, but that the relative ranking of the signs did not change across sites, with only a couple of exceptions. The variation by site is likely due to the extent to which each site exhibits different amounts of risk and obscurement. It may well be that the selection of some signs at one site and some at another site may reflect the strength of the warning on a particular sign.

5.3. Analysis by Word or Symbol Presentation Order

In Table 30, the contrast is drawn between the ratings of signs as seen by mean score evaluations and the effect of having been shown either symbol signs first (using the CROSS ROAD sign) as opposed to the "Dangerous Intersection" sign. In the table the effect of having shown the two most popular signs was included as a statistical control, and the mean scores show the differences which accrued as a result. Most of the differences were quite small (such as 2.68 and 2.69), while the largest mean difference was 3.11 and 3.28. None of the mean difference shown were statistically significant at even the 0.05 level of significance.

The next section will detail results of a test made to ascertain the effect of the presentation of an establishing shot at the outset of the simulation or the conclusion of the simulation.

Table 30. Mean ratings for signs by kind of first exposure (word or symbol) with CROSS ROAD and "Dangerous Intersection."

Sign Shown	First Exposure: Symbol (N=222)	First Exposure: Word-Legend (N=183)
CROSS ROAD	2.26	2.40
Watch for Side Road Traffic	3.16	3.12
Blind Intersection Ahead	2.68	2.69
Limited Intersection Sight Distance	3.13	3.12
Be Prepared to Stop	3.05	3.08
Slow--Intersection Ahead	2.74	2.67
Arrows symbol	2.96	2.85
Crashing cars symbol	3.11	3.28
Dangerous Intersection	2.42	2.49

Note: All statistical relationships not statistically significant.

5.4. Analysis by Establishing Shot Order

Table 31 contrasts between the mean evaluation of each sign as affected by: (1) the use of the establishing shot at the outset of the simulation; or (2) the establishing shot at the conclusion of the simulation experience. Note that all respondents saw an approach to the intersection prior to evaluating each sign so that only the fixed, out-of-vehicle establishing shot differentiated sample subgroups in this regard.

Table 31. Mean ratings for signs by order of establishing shot presentation.

	Establishing Shot Placement	
Sign Shown	First (N=242)	Last (N=163)
CROSS ROAD	2.26	2.42
Watch for Side Road Traffic	3.04	3.29
Blind Intersection Ahead	2.64	2.75
Limited Intersection Sight Distance	3.14	3.10
Be Prepared to Stop	3.10	3.01
Slow--Intersection Ahead	2.67	2.76
Arrows symbol	2.91	2.92
Crashing cars symbol	3.14	3.26
Dangerous Intersection	2.43	2.49

Note: All statistical relationships not statistically significant.

According to Table 31, the variation between the evaluation of any individual sign when the respondent was shown the establishing shot first or last was small. In some cases, the mean evaluations were nearly identical (2.68 and 2.69) and in some cases they were larger (with the largest difference being 3.11 and 3.28). Note that in no case were any differences large enough to achieve statistical significance at the 0.05 level using t-tests. Under these circumstances, using a new and experimental method of research, analysis of this sort was necessary despite the fact that the probability of its having any appreciable effect was slight.

A casual examination reveals that the last two tables (Tables 30 and 31) are strikingly similar. That is, there was little effect discovered as a consequence of exposure to either word sign first ("Dangerous Intersection") or symbol sign first (CROSS ROAD). Likewise, there was little or no effect demonstrated when respondents were shown a long approach shot of the intersection as opposed to a short approach and an establishing shot at the end. What is important here is that there is clearly little effect of methodology present, and the structure of the presentation contributed no discernible variation to the results obtained. In fact, the contamination by method was very likely less than what is commonly found in traditional pencil-and-paper surveys due to the fact that the simulation survey does away with response sets and other difficult phenomena of surveys. This sort of test was important to do in light of the fact that simulation survey research techniques have not been reported in the literature as used before.

5.5. Regression Using Total Sample

From the preceding analysis, it was obvious that:

1) There was little or no variation introduced by the simulation survey method utilized.
2) There was little or no effect generated by exposing respondents to either word signs ("Dangerous Intersection") or symbol sign (CROSS ROAD) at either the beginning or the end of the simulation.
3) There was little or no effect generated by exposing respondents to an establishing shot at either the beginning or the end of the simulation.
4) There was found to be some site-generated effect, but the relative overall rankings of signs across sites changes only slightly.
5) The decision by the researchers to use the CROSS ROAD and "Dangerous Intersection" signs for statistical control purposes was fortuitous as there was found to be a need to focus on these signs. This is because they were selected by respondents as the two most communicative signs. From Table 20 it can be seen that the two signs were singled out by the respondents as having greater importance than the other signs used.

For this reason, greater attention will be focused on these two signs in the following section, wherein the statistical techniques of correlation and multiple regression are brought to bear on this question.

Prior to initiating a regression analysis, the results of the respondents' answers to the survey questions were considered. As previously reported, the respondents selected three signs as the dominant preference for best sign to use for the sample intersections. These were in order of preference: CROSS ROAD, "Dangerous Intersection," "Blind Intersection Ahead." Preference for worst sign was dominated by two signs: "Limited Intersection Sight Distance" and the crashing cars symbol sign. The arrows symbol sign (the CROSS ROAD sign symbol with arrow heads on each corner) is the next sign in order in both the best and worst categories. If there is any relationship among the sign responses and the sample characteristics that regression would be expected to reveal, it would appear that this significant preference must be considered. Thus, the first regression analysis presented results from examining the respondent's evaluation of each sign tested with the total respondent sample.

In each case the dependent variable was the evaluation of a sign ranging from very good to very bad with respect to the intersection shown the respondent. The list of independent variables entered into the computer for possible inclusion in the solution were:

1) Degree of certainty or uncertainty the respondent had about the way the county conducts its business.
2) Degree of knowledge the respondents thought they had about the financial condition of the county.
3) Whether the establishing shot (video view of the actual intersection with a vehicle passing through it) was seen before evaluating the signs or after the signs had all been evaluated.

4) Whether the respondent saw a symbol sign (CROSS ROAD sign) first or a word sign ("Dangerous Intersection" sign).

5) The evaluation score of each of the signs excluding CROSS ROAD and "Dangerous Intersection."

6) A weighted measure of the degree to which a person selected as best sign a sign seen first or near the beginning of the sign sequence.

7) A weighted measure of the degree to which a person selected as worst sign a sign seen last or near the end of the sign sequence.

8) Counties grouped according to the size of the largest city in the county as a measure of the effect of urbanization on sign preferences.

9) Age of the respondent grouped into four categories which provided about 25% of the sample in each category.

10) Age of a second person if the primary respondent was assisted by someone with this age also grouped to provide four equal sample categories. (The age breaks were nearly identical with the previous variable.)

11) Counties grouped by Iowa Department of Transportation District.

12) County rank by absolute population according to the 1980 U.S. Census report.

13) Counties grouped by five population groups.

Since the preferences for best and worst signs indicated both word legend and symbol face signs, the initial direction of the analysis was to examine the regression results for all signs, cutting off the regression when four independent variables had been introduced into the stepwise solution. This level was selected because for all regressions the amount of additional variance explained by adding another variable to the solution diminished sharply after step four. The results appear in Table 32.

Table 32. Regression results using as dependent variable sign reading "Watch for Side Road Traffic" (N=405).

Regression Step	Variable Entering the Regression Solution	Beta Values of Solution	Explained Variance (%)
1	Limited Intersection Sight Distance	0.32	10
2	Blind Intersection Ahead	0.23,0.23	15
3	Slow--Intersection Ahead	0.19,0.21,0.15	17
4	Be Prepared to Stop	0.17,0.20,0.13,0.09	18

It is interesting to note that the first variable to enter the solution was the evaluation of "Limited Intersection Sight Distance" sign. Since the beta coefficient was positive, persons liking the "Watch for Side Road Traffic" sign were associated with favorably evaluating "Limited Intersection Sight Distance." Liking a sign with a word legend such as "Watch For Side Road Traffic" could be expected on the basis of familiarity with similar legends that are encountered to warn of entering truck traffic in the vicinity of truck haul roads. However, since the "Limited Intersection Sight Distance" legend is technical and was strongly disliked when persons were asked to select the worst sign, for a person favorable to the legend "Watch For Side Road Traffic" to be associated with being favorable to "Limited Intersection Sight Distance" implies that a communication relationship exists among word legends.

At this point in the analysis, it is worth noting that the remaining variables contained in the four in the regression equation were all positive associations with other word legend signs. One of them, "Blind Intersection Ahead" was a very popular word-sign choice for best sign. Since a popular choice for worst and best sign were the first and second variables to enter the regression and all word-legend signs, the suggestion noted above that certain drivers may prefer word-based communication regardless of the complexity of the message is reinforced.

Table 33 shows that respondent evaluation of a "Blind Intersection Ahead" sign could be predicted by a four variable regression equation containing two of the sign variables in the previous equation (Table 32). "Blind Intersection Ahead" and "Watch For Side Road Traffic" were seen to exchange places in their respective equations indicating a consistency in respondent preferences. The fourth variable represented a negative association with the arrows symbol sign. Thus, a favorable reaction to the "Blind Intersection Ahead" sign was predicted by a positive

Table 33. Regression results using as dependent variable sign reading "Blind Intersection Ahead" (N=405).

Regression Step	Variable Entering the Regression Solution	Beta Values of Solution	Explained Variance (%)
1	Limited Intersection Sight Distance	0.35	13
2	Watch For Side Road Traffic	0.28,0.22	18
3	Be Prepared To Stop	0.23,0.20,0.15	20
4	Arrows symbol	0.25,0.19,0.15,-0.08	20

Table 34. Regression results using as dependent variable sign reading "Be Prepared to Stop" (N=405).

Regression Step	Variable Entering the Regression Solution	Beta Values of Solution	Explained Variance (%)
1	Limited Intersection Sight Distance	0.37	14
2	Slow--Intersection Ahead	0.28,0.26	20
3	Blind Intersection Ahead	0.23,0.24,0.15	22
4	Dangerous Intersection	0.21,0.22,0.15,0.08	23

association with three other word-legend signs and a negative with a symbol-legend sign and, therefore, is a consistent example of individuals displaying a preference for a type of communication (as previously noted above).

Examination of the four variable estimation equations shown in Table 34 for "Be Prepared to Stop" revealed that the first three variables were the same three variables found in the "Watch For Side Road Traffic" regression. The fourth variable to enter was the "Dangerous Intersection" sign. Thus far no variables defining geographical or social/economic factors have been seen to enter into the solution in the initial four steps.

Table 35. Regression results using as dependent variable sign reading "Slow--Intersection Ahead" (N=405).

Regression Step	Variable Entering the Regression Solution	Beta Values of Solution	Explained Variance (%)
1	Be Prepared To Stop	0.35	13
2	Limited Intersection Sight Distance	0.26,0.23	17
3	Watch For Side Road Traffic	0.24,0.19,0.13	19
4	Dangerous Intersection	0.22,0.17,0.12,0.11	20

Table 35 indicates an estimation equation for the "Slow--Intersection Ahead" sign constructed from another combination of the previously discussed variables. In this and the previous three tables, the dependent variables and the first three independent variables in the regression solutions are all elements of a common set. While it added nothing new to the previous evidence, the response pattern was seen to remain consistent.

Table 36. Regression results using as dependent variable sign reading "Limited Intersection Sight Distance" (N=405).

Regression Step	Variable Entering the Regression Solution	Beta Values of Solution	Explained Variance (%)
1	Be Prepared To Stop	0.37	14
2	Blind Intersection Ahead	0.29,0.27	21
3	Slow--Intersection Ahead	0.22,0.24,0.19	24
4	Arrows symbol	0.21,0.25,0.17,0.15	26

The first three variables to enter into the estimation equation for the evaluation of "Limited Intersection Sight Distance" were positive associations with word-signs, as shown in Table 36. Thus, liking or disliking (which was more common), the "Limited Intersection Sight Distance" sign was associated with correspondingly liking (or disliking) three other word-signs. This again reinforces the previously stated interpretation of these data that persons who preferred a word-legend liked it (even when the communication value of the sign with respect to uncontrolled local roads was perceived as bad) as a means of driver communication. This continues to support the possibility that a sign type and communication preference exists. However, the fourth variable entering the regression relation was a positive association with the evaluation of the arrows symbol sign. Why liking (or disliking) the "Limited Intersection Sight Distance" sign should have been associated with liking (or disliking) the arrows symbol sign is not clear.

Table 37. Regression results using as dependent variable sign reading "Dangerous Intersection" (N=405).

Regression Step	Variable Entering the Regression Solution	Beta Values of Solution	Explained Variance (%)
1	Limited Intersection Sight Distance	0.28	7
2	Slow--Intersection Ahead	0.22,0.16	10
3	Establishing Shot Order	0.22,0.16,-0.11	11
4	Be Prepared to Stop	0.18,0.13,-0.12,0.11	13

The four variable estimation equations for the evaluation of the "Dangerous Intersection" sign (Table 37) presented some departure from the previous patterns. The first or second variable brought into the stepwise regression solution for the previous equations was the evaluation of a sign for which the dependent variable was the first independent variable. In other words, to a large extent the evaluations previously noted were estimating each other. It is true that "Dangerous Intersection" appeared in the four variable solution for "Be Prepared To Stop" and "Slow--Intersection Ahead," but it was the fourth variable to enter. Also, "Dangerous Intersection" was not in the equation to estimate the evaluation of "Limited Intersection Sight Distance." This is the first time the variable representing whether the respondent saw the establishing shot first or not has entered the solution. Since the beta value is negative (establishing shot order) and the data were coded with 1 = viewing the intersection establishing shot before seeing the signs and 2 = viewing the intersection after evaluating the sign set, seeing the intersection first was associated with evaluating "Dangerous Intersection" more highly as a good sign. However, reviewing the regression equations in detail beyond the four variable solutions indicated that seeing the intersection before evaluating the signs was generally associated with increasing the degree to which any sign was evaluated as good. Table 37 does indicate that the "Dangerous Intersection" sign which was popular as a best sign among word-legend signs was associated differently to the regression variables than the other signs examined thus far. This uniqueness may be related to the uniqueness of respondent preference for it as an appropriate style of sign to provide advance warning to drivers approaching a hidden, obscured, or sight-restricted local road intersection.

Table 38. Regression results using as dependent variable the arrows symbol sign (N=405).

Regression Step	Variable Entering the Regression Solution	Beta Values of Solution	Explained Variance (%)
1	CROSS ROAD symbol	0.25	7
2	Crashing cars symbol	0.27,0.25	13
3	Limited Intersection Sight Distance	0.27,0.23,0.18	16
4	Establishing Shot Order	0.27,0.24,0.18,-0.11	18

Regression analysis in Table 38 indicates the first factor associated with a respondent evaluation of the arrows symbol sign was the evaluation of the CROSS ROAD symbol sign. That was particularly encouraging since the arrows sign is the CROSS ROAD sign with arrow heads added to the cross. Respondent preferences were consistently associated among these symbol signs.

The next two variables which entered the regression solution were the crashing cars symbol and "Limited Intersection Sight Distance." It is somewhat puzzling why the evaluation of the arrows sign was closely associated with the overall most popular sign for best sign, i.e., the CROSS ROAD sign, and simultaneously closely associated with the two most often cited signs for worst sign, i.e., crashing cars and "Limited Intersection Sight Distance." The authors attribute this to the almost equally divided preference for the arrows symbol as a best and as a worst sign. This type of symbol sign appears to generate an ambivalent response. Perhaps the fact that this was a sign never seen before created an uncertainty in the response. The results of the contest to identify the low shoulder symbol sign (see Section 4.3) suggests that this may be the case here.

Table 39. Regression results using as dependent variable the crashing cars symbol sign (N=405).

Regression Step	Variable Entering the Regression Solution	Beta Values of Solution	Explained Variance (%)
1	Arrows symbol	0.23	5
2	CROSS ROAD symbol	0.26,-0.13	7
3	Rating Sign Seen Last as Worst	0.26,-0.13,-0.09	8
4	Slow--Intersection Ahead	0.27,-0.13,-0.09,-0.09	9

The crashing cars symbol was selected as the worst sign with almost the same frequency as "Limited Intersection Sight Distance." The regression equation used in Table 39 indicated that persons liking the crashing cars sign were associated with liking the arrows sign and disliking the CROSS ROAD sign. This suggests that persons preferring symbol signs assign unique communication value to a symbol sign and do not just prefer symbols as a general matter.

The negative beta value for "rating seen last as worst" means that persons liking the crashing cars sign were associated with a tendency to select as worst sign one of the signs they viewed early in the video tape sequence. This was most likely a result of disliking the CROSS ROAD sign which was the first sign viewed for half the respondent sample.

Table 40. Regression results using as dependent variable sign indicating CROSS ROAD symbol (N=405).

Regression Step	Variable Entering the Regression Solution	Beta Values of Solution	Explained Variance (%)
1	Arrows symbol	0.25	6
2	Crashing cars symbol	0.28,-0.13	8
3	Seeing a Symbol or Word Sign First	0.28,-0.13,-0.10	9
4	Limited Intersection Sight Distance	0.30,-0.13,-0.10,-0.08	10

The regression equation to estimate the respondent evaluation of the CROSS ROAD (symbol) sign in Table 40 was associated with liking the arrows symbol sign, with disliking the crashing cars symbol, with liking the CROSS ROAD sign more if it was the first sign seen, and with disliking the "Limited Intersection Sight Distance" sign. This is consistent with the previous discussion on the communication preferences noted in the above tables. It is indicative of a respondent group which identified with symbol signs, in contrast to a previously noted respondent group which strongly identified with word-legend signs.

It was originally assumed that persons seeing the CROSS ROAD symbol sign first liked it because the experimental design presented the signs in a sequence such that one-half of the respondent sample viewed the CROSS ROAD sign first. However, detailed examination of the evaluations of the CROSS ROAD sign revealed that persons who liked it and thought it was best were among both those who saw it first and those who saw it last. Those who disliked it and thought it was worst were also found among persons seeing it first and persons seeing it last.

The effect of seeing the CROSS ROAD symbol on the response to the individual sign evaluation was examined since the general usage of this sign on the primary highway system might have had a biasing effect on the respondents. Table 41 contains the results of this analysis.

The only sign evaluation for which a significant effect of seeing the CROSS ROAD sign first was in evidence was the CROSS ROAD sign itself. As previously noted this is considered to be a result of the circumstance of the sequence of the video tape editing. Since no

Table 41. Response effect of seeing the CROSS ROAD (symbol) sign first (N=405).

Sign	Effect on Number of Persons Rating it Good or Better	Chi-square Test Significance Level
CROSS ROAD	Increased	0.0268
Dangerous Intersection	Increased	0.1467
Watch For Side Road Traffic	Decreased	0.1611
Crashing Cars symbol	Increased	0.3421
Blind Intersection Ahead	Decreased	0.5090
Be Prepared To Stop	Decreased	0.8874
Slow--Intersection Ahead	Decreased	0.9070
Arrows symbol	Increased	1.0000
Limited Intersection Sight Distance	No Effect	1.0000

circumstance of the sequence of the video tape editing. Since no effect carried over to the arrows symbol sign, which is a derivative of the CROSS ROAD sign and for which regression analysis indicated a strong evaluation correlation with the CROSS ROAD sign, this effect is presumed to be trivial.

The preceding analysis has shown a strong tendency for the respondent sample to divide itself into persons strongly preferring word-legend signs and another group strongly preferring symbol-legend signs. Following sections of the report will examine this aspect of the research in more detail. The existence of word-oriented and symbol-oriented persons in the driving population would have important ramifications in signing for local roads.

5.6. Interpretation of Findings of Sign Data

The most significant finding of the response to evaluating nine different signs in the context of local uncontrolled intersections is that there are drivers with strong preference for symbol-legend signs while other drivers have a strong preference for word-legend signs. Data in this research suggested that these two strong preference groups are each probably about 10% of the driving population. Since other research in experimental psychology has shown that persons recognize and interpret word messages more quickly than abstract symbols in the perception-intellection phase of the perception-intellection-emotion-volition (PIEV) process [3,4,5], these data from this research suggest that any new sign developed to be applied as a warning for an uncontrolled local road intersection should be word-based. Conversely, if there is an overriding reason to use a symbol-based sign, then a supplementary word message plate should be devised and used. Research sponsored by the American Automobile Association has shown (with a highly selective and perhaps biased sample) that several commonly used standardized symbol signs such as "Yield" and "Keep Right" signs are misinterpreted by the majority of drivers [6,7].

A second interpretation that can be made of these data is that when a sign's message is a totally graphic symbol, consideration should be given to adding a word legend supplementary plate. This principle would apply to all warning sign installations, not just to uncontrolled local intersections. Engineering judgment should be exercised if a person or agency were to adopt this principle, however. In situations where the warning symbol can be associated with the additional need for driver attention through driving experience in general, rather than driving experience specific to local road systems, engineers responsible for local roads should not place supplementary word legends on symbol signs unless the same practice were to be applied to higher functional classifications of roads. Uniformity in driver expectancy should be encouraged.

The responses to the question of which sign is best for the uncontrolled local road intersection can obviously be interpreted to mean that no one sign was perceived as best. Beyond that surface observation is the implication that drivers want a sign to tell them something specific. Some of the resistance to the CROSS ROAD sign (most popular best sign) centered around the reaction of a number of respondents that "it does not tell me anything about the intersection." In the opinion of the researchers, this desire on the part of the driver for specific guidance is related to the preference expressed for the "Dangerous Intersection" and "Blind Intersection Ahead" signs (second and third most popular best sign). Any attempt to consider this interpretation on a broad scale in signing practice could result in conflict with the long accepted principles of uniformity in signing. This interpretation is not a stone upon which to construct a path to erecting a singularly unique sign at every intersection requiring signs. However, this does suggest that symbol-graphic signs are difficult to design so that the sign communicates (see Section 4.3 on the independent survey of sign interpretation). Further research needs to be conducted to establish the validity of a hypothesis that has arisen as a result of this research: most symbol-graphic signs communicate only by a learned and continually reinforced response. If this hypothesis has any validity, then word-oriented drivers are constantly in the process of learning, forgetting, and relearning the meaning of symbol signs. Therefore, symbol signs should be used sparingly and always for the same and consistent traffic purpose.

When asked to evaluate the intersection shown in the establishing shot with respect to whether it needed a sign, 73% of the respondents indicated it definitely did and another 23% said it probably did. No one was undecided and the remainder of the respondents indicated the intersection probably or definitely did not need a sign. On the surface, this suggests that the sample was strongly of the opinion that local roads in Iowa with some type of sight restriction need warning signs placed at them. However, when these same persons were required to evaluate the priorities of county engineering activities and to decide on the allocation of additional resources with respect to erecting more signing, a far different pattern emerged (see Section 4.3). It is the opinion of the researchers that the resulting responses on whether the intersection needed a sign is related to the previously noted interpretation that the sample drivers expressed a concern for specific guidance in carrying out their driving task. This response is a little like the answer to the old question in urban areas "Would you ride a bus if it came to your door?" for which the answer is always yes. What people really mean is "maybe" or "since you want me to say yes I will cooperate" or "under certain conditions." When people were forced to be specific about their interest in adding signs to the local road system they were much less interested.

The selection of which sign was the worst to be applied to these types of local road intersections produced an almost equally strong response for the "Limited Intersection Sight Distance" and the crashing cars symbol signs. While a number of persons verbally indicated that the legend "Limited Intersection Sight Distance" was too many words, two other signs had one more word. It does contain the most characters and is the most technical; hence, it requires the most concentration to interpret for possible evasive action. Again, since the previous interpretation suggested that drivers prefer positive action guidance in signing, then this legend tells them about the situation but does not tell them what to do, i.e., slow down, keep right. The crashing cars symbol created the reaction among a number of persons that it implied that if you drove through the intersection you would, in fact, have a collision. This is much the same frustration drivers associate with the word legend, "Men Working Ahead" or "Road Work Ahead," and when driving through the area finding nothing they can consider as road work occurring. The symbol apparently communicated event certainty, not probable hazard of the event. The implication of this is (as above) that for many people symbols do not communicate a clear meaning with respect to driver action, unless the process of learning and reinforcement is continuous. Hence, symbol signs as a general traffic control and driver communication policy need to be coordinated with a program of driver communication education (preferably not the school of hard knocks). (Refer also to Section 4.3.)

5.7. Site as a Factor in Respondent Evaluation

When the respondent's choice of best sign was factored by intersection site, a slight effect of site was noted. As shown in Table 42, sites 1, 5 and 6 had no effect; site 2 appears to be more word-legend dominated; site 3 appears to be more symbol-legend dominated; and site 4 appears to have a mixed effect. The chi-square statistical test for table variation has a 0.148 significance level which is above the usual critical level of 0.10. However, a bit of further investigation was conducted to develop further confidence that the intersection sites did not prevent generalization of the data across all sites.

Regressions were conducted to obtain an equation to estimate the survey participant evaluation of the following signs:

1. CROSS ROAD (symbol)
2. Dangerous Intersection (word legend)

Table 42. Four most popular "best sign" choices cross-tabulated with intersection site (N=298)--frequency of response (N=405).

Best Sign	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
CROSS ROAD symbol	21	13	20	16	20	17
Arrows symbol	9	4	14	2	7	8
Blind Intersection Ahead	14	12	6	14	13	10
Dangerous Intersection	16	17	9	8	15	13
Total by Site:	60	46	49	40	55	48

3. Crashing cars (symbol)

4. Limited intersection sight distance (word legend)

These are the most frequent choices across all six sites for best sign and worst sign for the symbol and word legend signs, respectively. If any significant site variation creates problems in the analysis, it would be most critical with respect to these signs.

The explained variance went up by a factor of 50 to 400% depending upon which sign and which site was examined. Such a large increase in explained variance for certain sites could be indicative that the data are almost totally site dependent. Each regression was examined at the four-step-level solution as was done in Section 5.5. For the four signs examined, the same four variables which entered the four-step solution for each sign with the total sample dominated the individual site specific regressions with two exceptions. At site two for the crashing cars symbol sign, none of the four variables in the total sample regression entered the regression solution at the end of the fourth step. At site four for the "Limited Intersection Sight Distance" sign, the same abnormality occurred.

The variables common to both the total sample regressions and the individual site regressions entered the regression solution for the individual sites first in 17 of 24 cases. In four of the seven cases where a total sample regression variable did not enter first, on the second step such a variable did enter the site specific regression solution. In all cases, when variables associated with the total sample solution entered a site specific regression solution, a sign and coefficient consistent with the total sample regression existed. The other variables which intervened on the site specific solution varied randomly across the four signs at any one site. Within any one sign across all sites, there was some commonality of intervening variables. However, since the intervening variables that entered at the four-step solution were different among the signs, the researchers concluded that analysis by site only changed the order in which variables entered the regression solution for specific signs at specific intersection sites. Thus, the random variation in choice and preference by the respondents appears to be the primary source of different regression equations to estimate a person's evaluation of a sign at any one of the individual test intersections.

5.8. Regression Analysis to Further Isolate Subsamples

It was obvious from the preceding analyses that there were dynamics at work in the data set which were neither anticipated nor understood in the early examinations of the data. What began to emerge was evidence that the sample represented a far from homogeneous aggregation. This knowledge posed questions related to the selection of approaches for triangulating the nature and magnitude of the subsample differences.

One of the first means used was to use multiple stepwise regression to ascertain the order of entry into the regression equation of various independent variables thought to have a determining effect on the selection of one sign over the other. Table 43, which shows the results of that analysis, highlights a number of very interesting features. First, there was a striking consistency to the patterns of

Table 43. Order of entry of independent variables using signs as dependent variables (N=405).

Sign	Order of Variable Entry				
	First Entered	Second Entered	Third Entered	Fourth Entered	R-Squared Total
CROSS ROAD	Arrows (0.303)*	Crashing Cars (-0.136)	Sym/Word Order (-0.105)	Limited Sight (-0.085)	0.100
Watch For Side Road Traffic	Limited Sight (0.171)	Blind Inter. (0.200)	Slow (0.120)	Be Prepared (0.091)	0.177
Blind Inter-Section Ahead	Limited Sight (0.254)	Watch For (0.195)	Be Prepared (0.159)	Arrows (-0.086)	0.203
Limited Inter-section Sight Distance	Be Prepared (0.217)	Blind Inter. (0.258)	Slow (0.178)	Arrows (-0.086)	0.263
Be Prepared to Stop	Limited Sight (0.216)	Slow (0.227)	Blind Inter. (0.151)	Danger (0.085)	0.226
Slow--Inter-section Ahead	Be Prepared (0.355)	Limited Sight (0.199)	Watch For (0.136)	Danger (0.116)	0.202
Arrows symbol	CROSS ROAD (0.272)	Crashing Cars (0.251)	Limited Sight (0.187)	Est. Shot Order (-0.114)	0.176
Crashing cars symbol	Arrows (0.273)	CROSS ROAD (-0.132)	Neg-Value Sight** (-0.097)	Slow (-0.114)	0.089
Dangerous Intersection	Limited Sight (0.189)	Slow (0.134)	Est. Shot Order (-0.121)	Be Prepared (0.118)	0.129

*Beta Weights in parentheses

**Negative Value-Controlling for Order of Sight sign entry into the regression equations for the two most popular signs (CROSS ROAD and "Dangerous Intersection"). For the CROSS ROAD sign, it should be noted that the first two signs to enter were symbol signs (arrows and crashing cars). For the "Dangerous Intersection" sign, the first two signs to enter into the equation were word-legend signs ("Limited Intersection Sight Distance" and "Slow--Intersection Ahead"). It is very important to note that the "Limited Intersection Sight Distance" sign was the least popular sign of the nine offered the respondents for evaluation. This was one of the first suggestions from the data that the two groups may, in fact, represent two opposite kinds of response orientations from a normally distributed population. Also, it should be observed that the R-Squared values for the CROSS ROAD and the "Dangerous Intersection" signs were at the lower end of the nine calculated. In fact, the CROSS ROAD sign was the second lowest of the nine (0.100). It seemed that there were clearly other factors yet to be explained, and different approaches to understanding the data appear later.

Continuing in the analysis of the last table, it can be seen that on four of the word signs, the "Limited Intersection Sight Distance" sign was the first to enter into the equation, despite its being the least popular sign generally. Further, the "Limited Intersection Sight Distance" sign was either first or second on all six word signs, a strong hint as to the different kinds of responses given to word versus symbol signs. In order to more fully understand this, the researchers examined the sample for those individuals who tended to respond in classically consistent patterns (liked only symbol signs or only word signs). This yielded the first comparison shown in Table 44. The significance of this information can be seen in the table, wherein the best/worst ratings given to the nine signs is contrasted first for the population as a whole and then for the two subsamples.

The analysis of Table 44 tends to suggest a number of things. First, the likes and dislikes of the word and symbol subgroups tend, up to a point, to reflect the overall population. For example, all respondents tended not to like the "Limited Intersection Sight Distance" and crashing cars symbol signs very much. However, the most salient point to note is that there were patterns to the loadings of responses on certain signs. Later analysis will suggest that this represents more than simply a generalized preference for some signs.

Next, a similar stepwise regression series focused on the preferences of the sample for some signs over others. Specifically, the focus was on the affinity of some in the sample for signs using word messages as opposed to other signs bearing only symbol messages. An analysis of the overall percentages and the regressions done earlier indicated that two such signs were clearly chosen more often and with greater fervor than were any others. These signs were the CROSS ROAD sign (a purely symbol representation) and the word sign reading "Dangerous Intersection." Further, it began to appear, as the preference for these two signs was used as a starting point, that some kinds of differences separated or distinguished these two groups which transcended mere attitudinal predisposition. Specifically, as the group preference for either the word sign ("Dangerous Intersection") or the symbol sign (CROSS ROAD) was more finely drawn out, the two groups

Table 44. Percentage of sample and subsample rating for all signs used (N=405).

Sign	Group and Rating of Sign			
	"Best" Rank (N=405)	"Worst" Rank (N=405)	"Worst"* Rank (Word)	"Worst"* Rank (Symbol)
CROSS ROAD	26.4(1)	6.2(4)	22.5(2.5)	--
Arrows symbol	10.9(4)	11.4(3)	22.5(2.5)	--
Crashing cars symbol	8.4(5)	34.3(2)	55.0(1)	--
Watch For Side Road Traffic	3.0(8)	2.5(7)	--	4.1(3.5)
Blind Intersection Ahead	17.0(3)	1.2(8)	--	4.1(3.5)
Dangerous Intersection	19.3(2)	1.0(9)	--	
Limited Intersection Sight Distance	1.2(9)	36.5(1)		83.7(1)
Be Prepared to Stop	7.7(6)	4.0(5)	--	6.1(2)
Slow--Intersection Ahead	6.2(7)	3.0(6)	--	2.0(5)

*The criteria for inclusion into each sub-sample precludes some responses. More is said of the two group traits presently.

appeared to more markedly differ from each other. Just as important, they appeared to increasingly display patterns of response and preference which differed from the total sample.

The process of isolation of the group preferring word signs from the group preferring symbol signs was accomplished as follows. When the first frequencies printouts were used, there appeared to be little to suggest such a division. The reason was that taking each sign one at a time or taking the entire sample's responses did not suggest that the composition of each set of preferences was significant. However, the use of cross-tabulations of responses by sign and independent variables suggested some anomalies which could not easily be explained. For example, the group which selected the CROSS ROAD sign with the greatest frequency tended to reject word-signs with uncommon consistency. Similarly, those selecting the "Dangerous Intersection" sign were shown to similarly reject the symbol signs (crashing cars, CROSS ROAD, and the embellished CROSS ROAD sign containing arrows to accentuate the intersection). What was clearly needed, it appeared, was a more distinct picture of these two groups (dubbed the "word-oriented" and the "symbol-oriented" subsamples). Through successive iterations, the computer breakdowns of responses were refined until the purest sets of responses of each category were isolated. Essentially, the traits used as the criteria for inclusion in the two groups were as follows:

- Word-Oriented Respondents: These respondents were identified as having selected the "Dangerous Intersection" sign as either a good or very good sign, while at the same time rating the "Dangerous Intersection" sign as the best sign shown (in the overall comparison); and simultaneously rating one of the symbol signs used as the worst signs shown. To the researchers very great surprise, 40 persons fell into this consistent response group (representing some 9.87% of the total sample of 405).

- Symbol-Oriented Respondents: These respondents were identified as having selected the CROSS ROAD sign as a good or very good sign, while at the same time rating the CROSS ROAD sign as the best sign shown (in the overall comparison); and simultaneously rating any of the six word-legend signs as the worst shown. Forty-nine persons were found to fall into this response group (representing some 12.09% of the total sample of 405).

It was obvious that a small bias existed in the criteria for inclusion into the symbol-oriented as opposed to the word-oriented group. That is, while the criteria were otherwise identical, the symbol group could improve their chances of being included by rating six word-legend signs as worst while word-oriented respondents could select from only three symbol-message signs which could earn a worst rating. This imbalance in offerings of word as opposed to symbol signs had not been thought of as important in any way during the design of the research. There existed no reason to suspect that the need would arise to compare subsample groups on symbol versus word criteria. Thus, in light of this fact, the two groups can be thought of as almost identical equivalents in proportion of the total sample. The obvious suggestion at the outset of discovery was that they represented two tails of a normal distribution of responses. It seemed important, then, to further detail the characteristics of these two sample subgroups.

5.8.1. Description of the Word-Oriented and Symbol-Oriented Subgroups

The first step in understanding these two groups appeared to be to gain some understanding of how they differed from the general sample as well as from each other. Table 45 shows the results of the initial comparison.

As Table 45 demonstrates, there were some striking similarities and striking differences between the two groups. For example, the mean age of the two groups differed very little (merely 3.3 years). Most important, it can be seen that while the ages appear to exhibit some differences, the mode and standard deviation are similar enough to suggest that the differences are in the range of normal variation. Note that for the word-oriented subgroup there is an important caveat in that the gathering of age and residence information did not begin until the third day of the simulation survey. For reasons to be discussed later, the preponderance of the word-oriented subgroup came during the early part of the demonstration. Some of the differences in the recoded ages contrast can, it would appear, be explained by this same factor. However, the word-oriented group would appear to be slightly skewed toward the older respondents.

One of the most interesting comparisons was that relating to the question of whether the intersection shown actually needed a sign to be safe. In the opinion of the respondents, all of the symbol-oriented group indicated that the intersection did not need a sign for safety reasons (fully 65.3% said "Definitely"). A nearly identical proportion of the word-oriented group indicated the same opinion. This differs

Table 45. Characteristics of word-oriented, symbol-oriented, and total sample (N=405).

Independent Variable	Group Under Examination		
	Word-Oriented	Symbol-Oriented	Total Sample
Age			
(Mean)	32.0	28.7	30.4
(Mode)	30.0	30.0	30.0
(Standard Deviation)	11.1	12.1	0.7
	(N=23)	(N=41)	(N=405)
Age Recoded			
14-19 years	8.7%(2)	26.8%(11)	23.7%(67)
20-26 years	21.7%(5)	24.2%(10)	25.8%(73)
27-35 years	47.8%(11)	29.3%(12)	26.1%(74)
40-65 years	21.7%(5)	19.5%(8)	24.4%(69)
	(miss=17)	(miss=8)	
Intersection Need Sign?			
Definitely Does	67.5%(27)	65.3%(32)	73.3%(297)
Does	25.0%(10)	34.7%(17)	23.5%(95)
Probably	0.0%(0)	0.0%(0)	0.0%(0)
Does Not	5.0%(2)	0.0%(0)	3.0%(12)
Definitely Does Not	2.5%(1)	0.0%(0)	0.2%(1)
Uncertainty:			
Very Predictable	7.5%(3)	10.2%(5)	8.9%(36)
Predictable	27.5%(11)	28.6%(14)	25.7%(104)
No Opinion	37.5%(15)	30.6%(15)	34.1%(138)
Unsettled	17.5%(7)	26.5%(13)	27.2%(110)
Very Unsettled	10.0%(4)	10.0%(4)	4.2%(17)
Knowledge of Financial Info?			
Know Nothing	5.0%(2)	4.1%(2)	6.4%(26)
Very Little	35.5%(14)	38.8%(19)	37.3%(151)
Can't Say	12.5%(5)	18.4%(9)	15.3%(62)
General Idea	35.0%(14)	26.5%(13)	30.9%(125)
Great Deal	12.5%(5)	12.2%(6)	10.1%(41)
County of Residence by Size of Largest City			
50k and up	55.0%(11)	37.5%(15)	38.1%(104)
25-49k	10.0%(2)	20.0%(8)	16.5%(45)
10-24k	0.0%(0)	10.0%(4)	6.6%(18)
<10k	35.0%(7)	32.5%(13)	38.8%(106)

substantially from the opinions offered by the total sample where 96.8% answered either that it definitely does or does not need a sign.

Examination of the two sections dealing with questions relating to the perceptions of environmental uncertainty and knowledge about county financial and political affairs demonstrated little variation. Finally, the examination of the county of residence as coded by the population of the county's largest city revealed that the two subgroups differed only in that again, 50% of the word-oriented group was missing due to the first-day factor mentioned earlier, and further, with that size of lost subsample numbers, it would not be out of reason to see the 55% to 37.5% difference in the largest city category as a function of sample size and missing data. However, one comment is due. This small difference, coupled with the researchers' observations on site and the word-group's preponderance during the first three days of the Iowa State Fair, suggests that at least some of these respondents represented Des Moines business persons and other exhibitors who were on the grounds for reasons other than recreation. The importance of this will be discussed later.

Next, to ascertain the nature of the two group's differences relative to the two most important signs tested (CROSS ROAD and "Dangerous Intersection"), stepwise multiple regression was used to identify the most salient independent variables. The results are described in the following two tables. In each, one of the two signs was used as a dependent variable, and then stepwise multiple regressions were calculated using the total sample (N=405) and the two subsamples being studied.

In Table 46, the depiction is of the order of entry into the stepwise regression equation of independent variables where the dependent variable is the CROSS ROAD sign. What is immedately obvious in this table is the strength of the beta weights shown for each variable. Specifically, it is clear that the symbol and word groups are independent variables (for example, the beta weights for the first two independent variables to enter for the word group). By comparison, for the total population the beta weight for the first variable was a mere 0.255. Clearly, the independent variables were far more predictive of choices for the symbol group than from the word group, as well as for either the word or the symbol group than for the total sample. Furthermore, the total amount of explained variation (R-squared) for the total population, symbol, and word groups were 0.110, 0.505, and 0.546, respectively. Thus, the eight independent variables used were salient enough to explain merely 11% of the variation in the total sample, while the eight variables to enter first into the equation were able to explain 50.5% for the symbol group and 54.6% of the variation in the CROSS ROAD for the word group.

Two things should be pointed out relative to this finding. First, in normal social science and marketing preference research, an explained variation for a single dependent variable in the range of 50% is very high when using merely eight variables and a straightforward regression without a causal model. Second, the amount of explained variation for the CROSS ROAD sign was, overall, at first glance higher than for the "Dangerous Intersection" sign in a subsequent table. However, a

Table 46. Order of entry of independent variables using CROSS ROAD sign as dependent variable (N=405).

Entry Order	Order of Variable Entry		
	Total Sample	Symbol Group	Word Group
First	Arrows (0.255)	Ages Rec. (0.423)	Arrows (0.384)
Second	Crashing (-0.133)	Sym/Word (0.433)	Limited (-0.373)
Third	Sym/Word (-0.107)	Danger (0.288)	Slow (0.347)
Fourth	Limited (-0.085)	Arrows (0.216)	NEGVAL (-0.204)
Fifth	Slow (0.055)	Watch For (-0.217)	Crash (-0.221)
Sixth	Be Prepared (-0.051)	Est. Shot (-0.099)	Danger (-0.175)
Seventh	Age Rec. (-0.046)	Crash (-0.091)	Be Prepared (0.220)
Eighth	IDOT Dist (-0.058)	Co$Info (0.101)	Est. Shot (0.160)
R-Squared	0.110	0.505	0.546

Key: Age Rec: Respondent ages grouped into five categories for convenience (see earlier tables).
Sym/Word: Order of initial presentation of either a symbol sign or word sign.
IDOT Dist: Residence of respondent by Iowa Department of Transportation district.
NEGVAL = Negative value, controlling for the effects of order of sight. (See Appendix A for a thorough explanation of this variable and its calculation.)
POSVAL = Positive value, controlling for the effects of order of sight. (See Appendix A for a thorough explanation of this variable and its calculation.)
Est. Shot = Indicates the use of establishing shot at outset of simulation presentation where 1 = establishing shot at beginning, and 2 = establishing shot at end.

more important finding is involved in this contrast and is highlighted in Table 47.

Table 47. Explained variation at eighth step for CROSS ROAD and "Dangerous Intersection" signs as dependent variables.

Sign Shown	Total Sample	Symbol Group	Word Group
CROSS ROAD	0.110	0.505	0.546
Dangerous Intersection	0.146	0.527	0.395

Notice first, in Table 47, that the explained variation for the total sample rises from 0.110 for the CROSS ROAD sign to 0.146 for the "Dangerous Intersection" sign. Note that there were six word signs and only three symbol signs from which respondents could choose, which may help to explain the differences in column one (between CROSS ROAD and the "Dangerous Intersection" sign).

Regarding the symbol-oriented subsample, it was clear that as the question moved from a symbol sign they knew about to a word sign that they by and large did not like, the amount of variation increased (from 0.505 to 0.527, respectively). This was, it would seem, due to the fact that where the CROSS ROAD sign was the dependent variable, the pervasiveness of this sign in the symbol subgroups consciousness was tempered by a fondness for the arrows symbol and less fondness for the crashing cars symbol signs.

By contrast, the word-oriented subgroup displayed a similar pattern with lower explained variation for the word sign than for the most favored symbol sign (0.395 and 0.546, respectively). There is one logical explanation for the fact that the lowest explained variation of the symbol/word group was for the word subgroup using the word sign as the dependent variable. This would appear to be that some "noise" was introduced into the analysis by virtue of two things. First, there existed six word signs as opposed to three symbol signs from which to choose. Second, there was not an overwhelming distinction between the preferences for the "Dangerous Intersection" sign as opposed to the "Blind Intersection" sign (the similarities being obvious).

The significance of this table is that it more clearly points out the tendency for the two word and symbol subgroups to appear as reflections of each other.

Finally, it should be pointed out that the appearance of the "Limited Intersection Sight Distance" sign in the above table is of considerable importance. First, it should be remembered that this was the least popular sign presented to the sample respondents. Next, it should be noted that while it appears as the first variable to enter into the equation for both the total sample and the word subsample (both with positive beta weights of 0.281 and 0.345, respectively), it entered at the seventh step for the symbol sub-group and the beta value was negative (-0.264). This tends to underline the suggestion that the symbol subgroup differs materially from the general sample as a whole and from the word subgroup as well.

Table 48. Order of entry of independent variables using "Dangerous Intersection" sign as dependent variable (N=405).

	Order of Variable Entry		
Entry Order	Total Sample	Symbol Group	Word Group
First	Limited (0.281)	Be Prep. (0.457)	Limited (0.345)
Second	Slow (0.168)	Uncert. (-0.250)	Co$Info (0.290)
Third	Est. Shot (0.114)	CROSS ROAD (-0.210)	Est. Shot (0.203)
Fourth	Be Prep. (0.118)	POSVAL (-0.270)	Arrow (0.194)
Fifth	Sym/Word (-0.081)	AbsPop (-0.198)	CROSS ROAD (-0.187)
Sixth	Watch for (0.074)	Watch for (0.236)	Crashing Cars (-0.145)
Seventh	Blind (0.062)	Limited (-0.264)	Sym/Word (-0.164)
Eighth	POSVAL (-0.054)	Crash (0.123)	POSVAL (-0.729)
R-Squared	0.146	0.527	0.395

Key: NEGVAL = Negative value, controlling for the effects of order of sight. (See Appendix A for a thorough explanation of this variable and its calculation.)
POSVAL = Positive value, controlling for the effects of order of sight. (See Appendix A for a thorough explanation of this variable and its calculation.)
Uncert = Perceived uncertainty about county financial condition.
Co$Info = Reported knowledge about county financial affairs.
AbsPop = Absolute county population (not recoded).

Other important distinctions which must be drawn include the following. For both the word and symbol subgroups, the second variable to enter into the equation was one relating to knowledge or attitudes about the political or economic environment. For the symbol subgroup, this variable was an item which asked for the amount of perceived political and economic uncertainty present in their counties. For the word subgroup, this variable consisted of an item which asked for the amount of information relative to economic and political matters in their county of residence. The negative beta value for the environmental uncertainty factor (-0.250) relates to the direction of the responses where one equals very predictable, and five equals very unpredictable. Thus, a stronger preference for the "Dangerous Intersection" sign by the symbol-oriented subgroup was paralleled by a stronger feeling that the political and economic environment was more unpredictable or uncertain and vice versa.

Some evidence from Table 48 tends to suggest that there are some parallels between the total sample and the word subgroup. For example, one-half of the first eight variables to enter into the equations were seen in both the total sample and the word subgroup. These were (along with their total/word subgroup beta weights shown respectively): "Limited Intersection Sight Distance" (0.281 and 0.345 both first); the order of the establishing shot (0.114 and 0.203 with both entering third); the order of symbol or word presentation (-0.081 and -0.164 appearing fifth and seventh, respectively); finally, positive value, controlling for the effects of order of sight (-0.054 and -0.729 with both entering eighth). While there were also three non-sign independent variables entering into the equation for the symbol subgroup, two of these did not enter into the total or word-oriented subgroups in the first eight steps. The one identical variable was POSVAL; the two different variables were the perception of environmental uncertainty discussed earlier and the absolute population of the respondent's county of residence.

It would appear, then, that there exist some striking similarities and some equally striking distinctions between the total population and the symbol-oriented subgroup. Thus, at a very preliminary stage, it would appear that the propensity to be symbol-oriented tends to be a less generally distributed trait in the general public than does the tendency to be word-oriented. It may well be that this is a rational adaptation by the majority, where reading and word-interpreted reality tends to be a dominant factor of life in work (where white-collar occupations are increasing in number) and even in recreation (where the sheer number of magazines targeted for narrow audiences continues to expand each year).

6. ADDRESSING RESEARCH OBJECTIVES

RESEARCH OBJECTIVE ONE: Identify the degree to which the 99 Iowa counties perceive a current or potential problem exists in terms of current signing at uncontrolled intersections.

This objective was addressed indirectly throughout the survey of Iowa county engineers reported in Section 4.4. The comments received indicate that there is significant concern on the part of the county engineers. The county engineers want to properly sign the roads for which they are responsible. At the same time they do not want to install signs excessively or unnecessarily. They realize that it is expensive to establish and maintain an inventory of traffic control devices and that, due to the critical nature of signing, resources are likely to be diverted from other areas to meet signing needs. They also realize that the geographical size of the road system limits their ability to respond quickly to the problem of damaged signs.

RESEARCH OBJECTIVE TWO: Identify the variety of measures being used by the other 49 states to sign for local uncontrolled intersections.

The survey of the other 49 states (as reported in Section 4.1 of this report) indicated that officials in other states who were responsible for policy regulating signing on local roads were largely applying the MUTCD to satisfy driver communication needs. Several notable exceptions are in progress, such as the attempt by the Kansas Department of Transportation to implement a policy adopting a "Handbook of Traffic Control Practices for Low Volume Rural Roads" [8]. It is not clear that these policy efforts are sufficiently supported at this time by traffic operations research to be directly transferable to Iowa.

RESEARCH OBJECTIVE THREE: Establish exactly what message is communicated to drivers upon encountering the standard CROSS ROAD sign in advance of entering an uncontrolled local road intersection.

The meaning of the CROSS ROAD sign to drivers approaching an uncontrolled local road intersection has to be interpreted from the simulation survey data and from comments made by respondents during the course of the research. (Traffic control practitioners have questioned the effectiveness of current symbol signs [9,10].) The simulation survey addressed this objective by identifying a significant subgroup of the sample for whom the CROSS ROAD sign distinctly indicated a warning of an upcoming intersection and of the need to approach that intersection cautiously. However, during the data gathering of the simulation survey, a number of persons expressed reactions to the CROSS ROAD sign which implied that they had little or no understanding of its intended message. This objective was addressed further in the validation survey performed at a regional shopping mall to sample Iowa driver interpretation of a variety of standard signs. While most drivers were able to demonstrate an understanding of the general meaning of the CROSS ROAD sign, some drivers thought it warned of a railroad crossing or other equally inaccurate message. In addressing this objective, it has become clear that for some individuals, the absence of a word legend on a sign limits their ability to assign specific and unique meaning to the message. This has particular salience where signs such as the CROSS ROAD sign are to be used.

RESEARCH OBJECTIVE FOUR: Investigate the variety of legend and symbol face combinations of sign designs based upon USA and international signing conventions to determine whether there are any other legend and symbol face combinations which may better communicate with drivers approaching local uncontrolled intersections.

During the development of sign patterns to display to the simulation survey respondent sample (as reported in Section 3.2), the International Road Federation and the Federal Highway Administration Office of Highway Traffic Operations furnished full color brochures of the authorized standard signs used in North America, South America, and Europe. A symbol sign used in Europe to provide advance warning of crossing roads and intersecting highways was the inspiration for the arrows symbol sign tested in the simulation. It was the professional judgment of the researchers that this was the only non-USA international sign with potential applicability to the problem outlined here. Analysis of the simulation survey data as reported in Section 5 did not suggest that this type of sign design was particularly effective in communicating a warning to drivers approaching an uncontrolled local road intersection.

RESEARCH OBJECTIVE FIVE: Identify the alternative courses of action available to any county encountering such a problem intersection on their local road system.

The recommendations emanating from this research (reported in Section 8) include several courses of action for county officials concerned about traffic safety and accident liability at local road intersections which may be obscured or which may have seasonal (or permanent) sight restrictions. However, the results of this research effort were such that most of the initiation of action resides with the Iowa Department of Transportation to implement the recommendations of Section 7. Oglesby [15] has suggested that low-volume rural roads should not have unnecessary investment. There are several points that relate to Iowa counties which are threaded throughout this report. These may be highlighted as follows:

1) If action is deemed to be necessary before the Iowa Department of Transportation can determine whether its administrative rule-making power will be used to provide counties with some sanctioned flexibility in the use of the CROSS ROAD sign, county officials should utilize the authority of Section 2C-41 "Other Warning Signs", Manual on Uniform Traffic Control Devices, to sign for any "special conditions." These would, in this context, be associated with warning drivers of an uncontrolled local road intersection ahead for which the normal requirement to exercise due caution may be considered insufficient. This implies that, before the erection of a special condition sign, an engineering study would be made of the intersection approach and the intersection itself to ensure that erecting a sign would represent the appropriate action. It is possible that the CROSS ROAD sign could be installed under MUTCD Section 2C-41 as long as: (1) such an engineering study produced the conclusion that it was the appropriate sign; and (2) county engineering records documented that the decision was made under this MUTCD section rather than Section

2C-11. Section 2C-41 could also be used to justify the use of a word-legend sign (as some jurisdictions have already done).

2) Another alternative course of action might be to use the results of this research (indicating that a significant proportion of the Iowa drivers do not desire additional resources within the county engineering budget diverted to additional signing) as the basis for developing an educational and informational program on the topic of correct driving procedures for local uncontrolled roads. In 1950, 34% of the Iowa population resided in cities of 5000 or more persons. In 1980 this proportion had increased to slightly over 50%. As the state becomes more urbanized, the driving exposure to rural local roads is a less routine experience. It is analogous to the need for training and education in freeway driving, only applied to very low volume roadways.

3) The final alternative course of action available to any county engineering office is to apply the MUTCD in signing local roads and to erect signs only when it is clearly required by engineering judgment and the guidelines of the MUTCD.

7. FINDINGS AND CONCLUSIONS OF THE RESEARCH

The following represent the findings of Project HR-230 as outlined in this report. First, based on an interactive simulation survey of 405 drivers, definitive estimates of the nature of driver perceptions with respect to uncontrolled local road intersections is available. Ninety-seven percent of the drivers participating in the simulation survey were of the opinion that obscured uncontrolled local road uncontrolled intersections need signing to warn approaching drivers of hidden intersections or those with limited sight distance. These same respondents displayed a decided preference for either a symbol sign with a graphic design (such as the standard CROSS ROAD sign) or preferred a word legend sign with a message communicating that they were approaching a dangerous intersection or a blind intersection. Analysis of the responses and characteristics of the respondents identified a pair of subgroups within the survey sample (each containing about 10% of the sample) representing two divergent modes of preference. One subgroup was symbol-oriented and the other was word-oriented.

Second, the results of two special surveys, conducted at the Merle Hay Mall in Des Moines, Iowa, and the Iowa State Fair, coupled with research by others, suggested that there exists significant driver confusion as to the operation and meaning of many common symbol signs. This finding was verified specifically in the case of Iowa drivers.

As a case in point, when confronted with an authorized standard, but never used, symbol sign for low shoulder, the vast majority of sampled Iowa drivers erroneously and dangerously misinterpreted its meaning. When asked to explain the meaning of several standard and commonly used symbol signs, a disturbingly large number of a second sample of Iowa drivers significantly misinterpreted the "Yield" and "Keep Right" signs. Many drivers do not easily aquire nor retain an understanding of the meaning and intent of symbol signs.

Third, a computer-generated questionnaire following the simulation survey revealed that most persons sampled do not know very much about the operation of county government. They generally think the county does a pretty good job of planning their activities. Importantly, the sample tended to place expending funds to install new signs and traffic control devices on a priority just behind repairing the road surface and making bridge safety inspections or else they considered installation of new traffic control devices as one of the least important activities in the county engineering budget. Thus, the responses tended to reflect some polarization of opinion. Also, it should be pointed out, they considered the county engineering program as the most or the least important activity of the county budget as presented in the sample. This, too, reflects some polarization in opinion.

Fourth, the successful development of a simulation survey experiment utilizing a microprocessor computer and a remotely controlled video tape player indicated that a new technology exists with which traffic engineering and transportation policy issues can be efficiently and effectively analyzed.

8. RECOMMENDATIONS

Conduct of this research, analysis of the data obtained, and interpretation of those data combined with professional judgment has resulted in the following recommendations.

1) If a county wishes to erect the standard CROSS ROAD or the standard SIDE ROAD symbol signs as an advance warning on the approach to an obscured intersection on an uncontrolled local road intersection, it is recommended that a policy be adopted such that when these signs are used on a through highway approach to an intersection (side road or cross road traffic is controlled by a "Stop" sign or a "Yield" sign), the through highway direction is shown in a wider line on the symbol than the side or cross road. For those persons identified by this research and research by others as able to quickly respond correctly to totally abstract symbols, this would provide an additional cue about the two different uses of these warning signs.

2) Legal clarification should be sought as to the meaning of "through highway" with respect to the MUTCD guidelines in Section 2C-11 (and similar sections) and its relationship to Iowa Code 321.1(53) defining "through highway." This research was conducted under the varying interpretations of what constitutes the relationship between pertinent MUTCD sections and the Iowa Code. It is evident that implementations of this research would be more effective if this definition was

clarified. Several avenues of action are available, such as requesting an MUTCD interpretation from the Federal Highway Administration as to whether the guidelines in the MUTCD were intended to permit application of these signs to uncontrolled highways (i.e., did the FHWA intend "through" to mean "Stop" or "Yield" sign controlled?). Another possible avenue of action is to request an Iowa Attorney General opinion on the meaning of the term "through highway" in the MUTCD with respect to the Code of Iowa. Pursuance of the preferred alternative is left to the administrative judgment of the Iowa Department of Transportation.

3) It is recommended that the Iowa Department of Transportation and the Iowa County Engineers Association work through the Federal Highway Administration, the National Association of County Engineers, and the American Association of State Highway and Transportation Officials to instigate a study of the need for supplementary word-legend plates with all pure symbol signs. This research has identified word-oriented drivers and symbol-oriented drivers in significant proportions of the driving public. Perhaps all signs should be combined word-symbol messages. The resolution of this issue discovered in the conduct of this research was beyond the scope of this project.

It is not possible to identify one best sign to communicate with drivers approaching an uncontrolled local road intersection which is obscured or has restricted sight distance conditions. This research identified that the standard CROSS ROAD sign and a sign with the legend "Dangerous Intersection" communicated equally well with the driver population as a whole and communicated much better with subsets of the driving population that were word-oriented or symbol-oriented. Furthermore, the "Blind Intersection Ahead" sign communicated almost as effectively as the "Dangerous Intersection" sign and, therefore, if a word legend sign is to be used, it is recommended over the "Dangerous Intersection" sign since it implies the need for driver attention due to sight restrictions. If a single sign is desired for optimum communication in the interest of uniformity in traffic control, further research beyond the scope of this project must be undertaken.

4) It is recommended that the Iowa Department of Transportation not adopt any special handbook on traffic control practices for low volume roads, as the State of Kansas has done, until research has been conducted on what are the appropriate levels of traffic control for low volume roads in Iowa which are consistent with driver information needs. Literature research, surveys of other states, and communication with other researchers during the conduct of this research does not indicate any general direct transferability to Iowa of any policy adopted elsewhere to date.

9. REFERENCES

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APPENDIX A

INTERPRETATION OF THE POSVAL AND NEGVAL VARIABLE

A concern existed about the degree to which persons might have assigned (either consciously or unconsciously) an image of best to the sign seen first and worst to the sign seen last when they were participating in the simulated survey to evaluate the nine signs. Conversely, it was thought to be possible that participants might assign best to the last sign because it was the freshest in their memory. In order to check for any possible bias in the sample with regard to these factors, two separate variables were created.

Each sign was given a weight according to the order in which a respondent viewed the sign sequence (there were 24 different sequences as outlined previously). When the selection of best sign was considered, the sign seen first was given a weight of +1 and so on to the sign seen last being given a +9 weight. When the selection of worst sign was considered, the sign seen first was given a weight of -9 and so on to the sign seen last being given a weight of -1. The positive valued weighting variable is associated with best sign selection and the negative valued weighting variable is associated with worst sign. Table A1 demonstrates some of the results.

Table A1. Frequency of positive valued weighting for bias in selecting the first sign seen as the best (N=405).*

Bias Level	Value	Frequency	Percent
Last sign as best	+9	55	13.7
Eighth sign as best	+8	26	6.5
Seventh sign as best	+7	35	8.7
Sixth sign as best	+6	31	7.7
Fifth sign as best	+5	20	5.0
Fourth sign as best	+4	21	5.2
Third sign as best	+3	56	13.9
Second sign as best	+2	39	9.7
First sign as best	+1	119	29.6

*Three responses are missing.

Table A2 presents the results of the negative valued tabulations using the same criteria.

Table A2. Frequency of negative valued weighting for bias in selecting the last sign seen as the worst (N=405).*

Bias Level	Value	Frequency	Percent
Last sign as worst	-1	12	3.0
Eighth sign as worst	-2	76	18.8
Seventh sign as worst	-3	43	10.6
Sixth sign as worst	-4	40	9.9
Fifth sign as worst	-5	54	13.4
Fourth sign as worst	-6	82	20.3
Third sign as worst	-7	24	5.9
Second sign as worst	-8	56	13.9
First sign as worst	-9	17	4.2

*One response is missing

Notice that there is almost no effect of when a person saw the sign within the experimentally designed sequence of viewing on the selection of worst sign. On the other hand, the most frequent selection of best sign occurred from those signs seen first. This presents a "chicken or the egg first" problem. Only the CROSS ROAD (symbol) and the "Dangerous Intersection" (word) signs were seen first. In four of the 24 video sequences, either one of these two signs was seen last. Almost 50% of the persons selecting the "Dangerous Intersection" or the CROSS ROAD sign as best did so after having seen all the other signs. Except for this notation the variation within the choice of best sign with respect to order of viewing is as random as could be expected with a sequence of 24 pattern variations. Hence, it was concluded that the first and last order of precedence implication was not a significant factor and that the observed preference for the signs was a more a degree of familiarity and communication format than order of viewing.

APPENDIX B

The table which follows sets out the sequences used in the video tape simulation survey. The table also shows the order in which each intersection video tape sequence was edited together.

Table B1. Simulation survey video display sequences.

Respondent Sequence Number	Intersection Site	Video Tape Sequence 1	2	3	4	5	6	7	8	9	10
1	1	ES	CR	WFSRT	BIA	LISD	BPTS	SIA	A	CC	DI
2	3	ES	CR	A	SIA	BPTS	LISD	BIA	WFSRT	CC	DI
3	2	ES	CR	CC	BIA	LISD	BPTS	SIA	A	DI	WFSRT
4	5	ES	CR	WFSRT	BIA	LISD	BPTS	SIA	CC	A	DI
5	4	ES	CR	CC	WFSRT	BIA	LISD	BPTS	SIA	A	DI
6	6	ES	CR	A	CC	SIA	BPTS	LISD	BIA	WFSRT	DI
7	1	ES	DI	WFSRT	BIA	LISD	BPTS	SIA	A	CC	CR
8	3	ES	DI	A	SIA	BPTS	LISD	BIA	WFSRT	CC	CR
9	2	ES	DI	CC	BIA	BPTS	LISD	SIA	A	CR	WFSRT
10	5	ES	DI	WFSRT	BIA	LISD	BPTS	SIA	CC	A	CR
11	4	ES	DI	CC	WFSRT	BIA	LISD	BPTS	SIA	A	CR
12	6	ES	DI	A	CC	SIA	BPTS	LISD	BIA	WFSRT	CR
13	1	CR	WFSRT	BIA	LISD	BPTS	SIA	A	CC	DI	ES
14	3	CR	A	SIA	BPTS	LISD	BIA	WFSRT	CC	DI	ES
15	2	CR	CC	BIA	BPTS	LISD	SIA	A	DI	WFSRT	ES
16	5	CR	WFSRT	BIA	LISD	BPTS	SIA	CC	A	DI	ES
17	4	CR	CC	WFSRT	BIA	LISD	BPTS	SIA	A	DI	ES
18	6	CR	A	CC	SIA	BPTS	LISD	BIA	WFSRT	DI	ES
19	1	DI	WFSRT	BIA	LISD	BPTS	SIA	A	CC	CR	ES
20	3	DI	A	SIA	BPTS	LISD	BIA	WFSRT	CC	CR	ES
21	2	DI	CC	BIA	BPTS	LISD	SIA	A	CR	WFSRT	ES
22	5	DI	WFSRT	BIA	LISD	BPTS	SIA	CC	A	CR	ES
23	4	DI	CC	WFSRT	BIA	LISD	BPTS	SIA	A	CR	ES
24	6	DI	A	CC	SIA	BPTS	LISD	BIA	WFSRT	CR	ES

ES = Establishing shot of intersection
CR = Standard CROSS ROAD sign (symbol)
A = Arrows sign (symbol)
CC = Crashing cars sign (symbol)
BIA = "Blind Intersection Ahead" sign
SIA = "Slow--Intersection Ahead" sign
DI = "Dangerous Intersection" sign
LISD = "Limited Intersection Sight Distance" sign
BPTS = "Be Prepared to Stop" sign
WFSRT = "Watch for Side Road Traffic" sign