

NATIONAL CONFERENCE ON WORK ZONE SAFETY

December 5-7, 1994

PROCEEDINGS

Sponsored by the

FEDERAL HIGHWAY ADMINISTRATION
AND THE
AMERICAN ROAD & TRANSPORTATION BUILDERS ASSOCIATION

Cosponsored by the

AMERICAN ASSOCIATION OF STATE HIGHWAY & TRANSPORTATION OFFICIALS
AND THE
AMERICAN TRAFFIC SAFETY SERVICES ASSOCIATION

SECTION II

INTRODUCTION

Section II contains workshop reports for each of the five topic areas. Each describes the countermeasures selected by workshop participants as holding the most promise for short-term improvements in work zone safety.

Following each report, where applicable, are additional noteworthy points raised by the participants in the workshop discussions but not included in the facilitator's final report.

Also included in the workshop reports are action plans devised for implementing countermeasures. Constraints and obstacles that may be encountered during implementation were also discussed at the workshops, and they too are addressed.

The final item in Section II is a recapitulation of the Conference activities presented by the Moderator, Dr. Nicholas J. Garber. His remarks summarize the primary recommendations derived from the workshops.

PHILOSOPHY OF TRAFFIC CONTROL

Dr. Russell M. Lewis

Consulting Engineer

PURPOSE AND SCOPE

This workshop on the Philosophy of Work Zone Traffic Control examined two closely interrelated subjects: fundamental principles of work zone traffic control and human factors/behavior in work zones. This paper, written before the conference, contains an introduction to the subject with the objective of providing a background for the workshop participants and to guide and elicit their participation. Various concepts and common terminology are established to facilitate communication. Only selected examples taken from the paper were presented as part of the introduction and charge to participants. The remaining material was made available selectively, as appropriate, during the workshop to provoke discussion or recapitulate the group's findings.

The term "we" as used in this paper refers to the highway profession, people who exercise authority over roads and streets, and those who work on roads and streets—personnel of public agencies, utility companies, contractors, and incident management teams.

THE SYSTEM

The highway / motor vehicle system comprises three components which must perform in consonance, namely the roadway, vehicle, and driver. There are limits and differences, however, as to how much control we can exercise over each of these components. Highway agencies have a high level of control over the roads under their jurisdiction. There is a wide range of facility types from local roads and streets to freeways. Nevertheless, within each functional classification, roads throughout the country have similar design characteristics.

Likewise, there is good control over the vehicle, although this control is exercised by others: the National Highway Traffic Safety Administration (NHTSA), Interstate Commerce Commission (ICC), State Departments of Motor Vehicles (DMV), etc. Manufacturers contribute to homogeneity by providing vehicles with a relatively short life; the fleet largely turns over every decade. Again, there are vast operational differences among functional types —between motorcycles and tractor-semitrailers, for example. Yet, within each classification, the differences are relatively minor.

The motor vehicle operator is by far the most variable and difficult to control. Drivers are basically licensed for life. A half century later the change in technology is mind-boggling. The only physical characteristic that is checked, and only occasionally at that, is visual acuity. Variations among drivers are enormous. Moreover, each person's characteristics vary with time and environment. Some changes are gradual, such as the decay politely called aging. Other changes can occur minute by minute due to emotion, distraction, fatigue, etc.

Highway agencies have little opportunity to manage drivers. Such matters as driver licensing, driver education, and license suspension fall under the jurisdiction of other agencies—DMV, education, law enforcement, etc. While highway agencies should be working with these agencies in areas of common interest, their ability to effect change is very limited indeed. Other organizations working on highways, such as contractors and utility companies, have no control over drivers.

Given this broad range in driver characteristics, how can we define the critical level that we need to accommodate? Clearly we cannot utilize average values, as this would exclude half the driver population. Statisticians use a 95 to 99 percent confidence

level for the determination of statistical significance. Traffic engineers have used the 85th percentile for the establishment of speed zones. This does not mean that the other 15 percent are not afforded safeguards. In work zones, however, where normally available safety factors are reduced, it is essential to effectively communicate with *most* drivers.

System Failures

Many traffic accidents are not accidental. By definition, an accident is an event occurring by chance or arising from unknown causes. Many of these so-called accidents are predestined. Given the characteristics of the highway and the limitations of drivers, certain types of failures are predictable. The event can be anticipated; only the timing and the participant's identity are unknown. Therefore, the term "crashes" has come to be preferred within the highway safety community.

In the broader context, many of us prefer the term "systems failure," which connotes a breakdown in the roadway-vehicle-driver system. The hierarchy of system failures is shown below. Note that crashes are but a subset of these failures.

Non-catastrophic:

- Annoyed
- Delayed
- Lost
- Stranded
- Erratic maneuver
- Near miss

Catastrophic (crash):

- Property damage only
- Injury
- Fatality

The first ones in the list, while not catastrophic, may adversely alter driver characteristics. Impatience may breed anger, which can affect judgment and performance. This may result in excessive speed after an imposed delay, reckless passing, or targeting flaggers, for example.

Erratic maneuvers and near misses can provide valuable insight as to the adequacy of the traffic control system. They are indicators that crashes may be imminent—the proverbial "accident waiting to happen." Clues to such deficiencies include evasive action, excessive deceleration (brake lights), skid marks, and displaced traffic control devices.

Statisticians like to look at an accumulation of events so that they may evaluate statistically significance (i.e., show that the events are not merely random). When we evaluate and inspect traffic control zones, however, if at all possible, we do not want to wait until after catastrophic failures occur to recognize a correctable deficiency.

Special Problems in Work Zones

Drivers negotiating highways must continually address a variety of situations. When they encounter work zones, they must contend with the following additional conditions and potential hazards:

- Surprise (negative expectancy, rare event)
- Changed and unusual travel patterns
- Conflicting information and confusion
- Distractions (work activity)
- Temporary devices (closer to traveled way and relatively unstable)
- Additional hazards (fixed hazards, excavations, drop-offs)
- Workers, material and equipment in and / or adjacent to roadway
- Dirt and debris (decreased device conspicuity and increased braking distance)
- Capacity restrictions and congestion.

RELEVANT ROAD USER CHARACTERISTICS

During the past several years, many extra words have been added to Part VI of the MUTCD to expand its coverage. In many places where the word "drivers" appeared, the words "pedestrians and workers" have been added. Not only is this verbose, it still improperly excludes all parties of interest. I prefer the all inclusive terms "road users." Included in this

term are motor vehicle drivers, equipment operators, cyclists, workers, pedestrians, bystanders and any other parties in or adjacent to the right-of-way that may be of concern.

A critical attribute of temporary traffic control systems is the effectiveness with which vital information is provided to road users. Therefore, the following information taken from the human factors field is presented relative to how people acquire and utilize traffic-related information.

Acquiring Information

Before people can modify their behavior to accommodate roadway needs they must first acquire relevant information. The means available are the five human senses listed below along with their associated sensory organs.

- Sight — eyes
- Touch — skin
- Hear — ears
- Smell — nose
- Taste — tongue

Vision

Sight is the primary means of communicating with road users. Touch may occasionally supply information through changes in road texture, rumble strips, etc. There are a few audible warning devices, such as those used at railroad grade crossings and on drawbridges. Motorists, however, can often be isolated by enclosed vehicles, in-car radios, etc. Hearing is more useful for workers, where the squeal of brakes or the impact with channelizing devices can provide information that a vehicle is encroaching upon the work space. Smell has little application, except perhaps that a clutch is slipping or brakes are dragging, and we have yet to find a way to utilize taste.

Relevant attributes related to sight are the following:

- Acuity
- Color discernment
- Night vision
- Glare recovery
- Depth perception
- Reading process

Conspicuity

It may not be sufficient that a traffic sign can be seen and read. Most signs are placed peripheral to the travel path. They often must compete with other information sources present in a visually noisy background. Therefore, we are concerned with device conspicuity; that is, the extent to which something is obvious or attracts attention. This property is also referred to as target value. Conspicuity can be enhanced by:

- color,
- contrast with background, and
- motion.

Driver Behavior

The ability of drivers to effectively utilize information and perform the driving task depends upon the following human characteristics:

- Intelligence
- Knowledge
- Ability
- Emotion
- Memory

Design Driver

For decades traffic engineers have used "design vehicles" to represent the critical dimensions of the range of vehicle types and sizes that need to be accommodated on highway facilities. More recently, the concept of a "design driver" has been advocated. The design driver is not intended to represent any particular person or groups of people. It is a hypothetical aggregation of all critical characteristics, some of which could not coexist in any one individual. For example, the design driver may be so short that the forward visibility is limited by the hood and so tall that it is limited by the top of the windshield.

The objective is to meet the needs of the vast majority of all users. This does not necessarily mean that the remainder are ignored. In many instances persons who fall outside the design range use special features or techniques to achieve safe operations.

Useful characteristics for describing such a design driver follow. Consensus as to the individual traits and their quantifying values remains to be achieved.

- Limited intelligence (IQ of ?)
- Impaired condition (blood alcohol of ?; increased perception-reaction time of ?)
- Colorblind
- No depth perception (only one good eye)
- Visual acuity (20 / 40 ?)
- Limited night vision (?)
- Long glare-recovery time (? seconds)

Critical Driver

For normal traffic control situations, the unfamiliar motorist is the critical one, and the design is predicated upon the characteristics of this type of driver. In work areas, however, the familiar motorist is often the critical one. Commuters and other drivers accustomed to the road are least likely to be looking for traffic information on their route. Take, for example, the situation where a temporary runaround has been constructed in order to reconstruct a bridge. The unfamiliar driver will most likely use the temporary roadway with the least amount of conflict. In fact, if the runaround is well designed, he or she may not even realize that it is a temporary roadway. The familiar motorist, on the other hand, is the one most

likely (due to habit and inattention) to drive onto the closed bridge.

Positive Guidance

Positive guidance is a concept which combines highway engineering and human factors technologies to produce a driver information system matched to the facility characteristics and attributes of drivers. It is based upon the premise that drivers can be given sufficient information where they need it and in the form that they can best use to avoid hazardous driving situations. The application of positive guidance procedures requires an understanding of the drivers' tasks and their use of information. Decision-making failures attributable to information system deficiencies are identified as factors leading to inefficient traffic operations and crashes. The function of positive guidance is to increase safe driver performance by providing appropriate information to reduce driver-caused failures in the highway system.

Driver Performance

Driver performance consists of three levels, each having a different function. These levels are defined below, and the sources of information used in the performance of these tasks are described.

- At the *control level*, the driver exercises lateral and longitudinal positioning by means of the vehicle's controls. Information comes primarily from the vehicle itself through the driver's sensory mechanism.
- At the *guidance level*, the driver's task is the selection of speed and path along the highway. Examples include car following and passing. Information is obtained from the road, environment, other traffic and traffic control devices.
- At the *navigation level*, tasks include planning and executing a trip from its origin to its destination. Information sources include road maps, guide signs and landmarks.

Primacy

The above three levels of information are not of equal importance to the motorists. A distinct processing order exists. At the top of the primacy hierarchy is information utilized to maintain position on the roadway. Second in priority is situational or

guidance information. At the bottom of the hierarchy is navigational information. The primacy concept thus suggests that positional or control information must be processed completely before processing can begin at the situational or guidance level. Further, this level must be satisfied before navigational information can be processed. Whereas driver performance failures at the navigation level tend to result in low-severity systems failures, those at the control and guidance levels tend to be of high severity.

Worker Behavior

Many of the human characteristics described above are also applicable to those persons working on the highway. It should be recognized that a highway is one of the most hazardous workplaces that exist. By comparison, factory workers enjoy such safety benefits as controlled access to the workplace, protection from weather, controlled light, heating and air conditioning. Through constant exposure to highway conditions, however, workers may become conditioned and forget just how hazardous their workplace is.

Pedestrian Behavior

While all motorists are also pedestrians, the reverse is not true. Those pedestrians who do not drive may have little knowledge of the complexities of the driving task, thus overestimating their inability to be perceived and avoided. Similarly, stopping distances may be underestimated by non-drivers. Of particular concern are the very young and very old, because their physical and judgment capabilities may be diminished.

The fundamental differences between drivers and pedestrians is that drivers generally recognize that they are involved with a task that requires a certain amount of attention and skill. Pedestrians, on the other hand, frequently are:

- thinking about something other than their walking task,
- unaware of their local environment,
- willing to take chances, and
- very "shortest-path" oriented.

Therefore, pedestrians are less likely to notice signs. Also, they are more difficult to detour than motorists, as there is more resistance to added distance.

TEMPORARY TRAFFIC CONTROL CONCEPTS

Concept Hierarchy

In discussing the fundamental concepts of highway traffic control, it is useful to recognize a hierarchy between concepts and define a set of terms. The following set is proposed and is utilized in the discussion below:

- Laws, natural
- Principles
- Rules, imposed
- Standards
- Warrants
- Guidelines

Being an engineer, I prefer to reserve the term "law" for natural laws or laws of nature. As such, they are inherent and not subject to change. Various laws of physics apply to vehicular dynamics and traffic flow, and other laws relate to human nature and behavior.

Principles include maxims, axioms, precepts, and admonitions. As used here, principles are basic doctrines from which more detailed and specific standards and guidelines are derived. Rules are imposed and are sometimes arbitrary, such as driving on the right side of the road. Rules are generally established by statutes, ordinances, codes or regulations. Standards, warrants and guidelines, such as those set forth in the MUTCD, are engineering tools which are used to assure a consistent degree of quality and safety for road users. There is, of course, much overlap between these terms. Some States, such as Maryland, have adopted the MUTCD as part of codified law. The focus of this paper is the first two concepts listed above: natural laws and principles.

Example Laws

Several natural laws relevant to highway traffic control are presented below in boldface. These are merely examples. The list is not intended to be exhaustive, and the sequence is arbitrary.

#1. **Eventually a system failure will occur** — the essence of Murphy's First Law. The likelihood increases with exposure — time and traffic volume.

#2. **Devices are expendable and replaceable; people are not.**

#3. **Basic human behavior cannot be changed.** People must be accepted as they are. The human species has evolved over many hundred thousand years, and it is only within that time frame that basic characteristics are altered.

#4. **Human beings have free will; they can do whatever they want to do.**

#5. **People make mistakes.**

#6. **People can look at and focus on only one item at a time.**

#7. **People can process only a limited amount of information within any time interval.**

#8. **Perception-reaction time is a variable.** It can vary from a fraction of a second for a simple anticipated task to an eternity (as when the driver died before making the appropriate reaction). From a practical standpoint it varies from a few to many seconds. Note that in traditional highway design procedures, reaction time is treated as a constant (e.g., stopping site distance). Increased perception-reaction time is needed when drivers are faced with:

- unfamiliar and uncommon situations,
- multiple choices,
- distractions (such as the operation of construction equipment), and
- complex problems.

#9. **Short-term memory span is about one minute.** Motorists have a short-term memory bank in which information is constantly being updated and replaced. Information stored as short-term memory consists of items such as localized road conditions, traffic controls, and positions and speeds of other vehicles in the traffic stream.

#10. **Drivers develop expectancies that affect their responses to events or situations**, primarily as a result of experience. When expectancies are met and reinforced, they aid the driving task and performance tends to be error-free. When expectancies are violated, drivers need more time to respond, performance is poorer, and they are likely to commit errors.

#11. **Conditioned responses dictate to a large extent how people behave.** Such habits are developed as people repeatedly encounter the same situation and make the same response.

Concept Linkage

Each law may give rise to several principles. While some principles are stated in the MUTCD, others are merely implied, at best. A principle, in turn, may be implemented in several applications as standards or guidelines. For example, take Law #6, "People can look at and focus on only one item at a time." A related principle follows.

a. *Require only one action at one location.*

An implementation of this principle is specified in a typical application diagram [Figure TA-37]. It shows a double-lane closure on a multilane highway with two separate merging tapers separated by a transition distance of "2L", where "L" is the minimum length of the merging taper.

Other principles may be derived from the same law, such as the following:

b. *When channelizing devices are needed on both sides of a traffic lane, introduce them first on only one side.*

This principle is neither explained nor specifically prescribed in the MUTCD, but an example of its application can be found [Figure TA-40].

Example Principles

Provided below in italics are several temporary traffic control principles. These are merely examples intended to generate interest and discussion. Where the principle is directly derived from one of the laws previously listed, the source is so indicated.

1. *Traffic control procedures should be based on road users' needs and characteristics* (from Law #3). This is the basic principle which ties together the two subjects addressed in this workshop.

2. *"Roadway occupancy and work completion time should be minimized to reduce exposure to potential hazards"* [§6B-2d] (from Law #1). Note that this principle and numbers 3 and 4 that follow are quoted from the MUTCD. A full explanation is provided in the next section of this paper.

3. *"Reduced speed zoning should be avoided as much as practical"* [§6B-2a] (from Law #4).

4. *"Flagging should be employed only when all other methods of traffic control are inadequate to warn and direct drivers"* [§6B-3c] (from Law #2).

5. *Analyze the results of a systems failure.* As stated previously, failure probability is a function of time and volume along with traffic control quality. The types of failures that can be anticipated must also be evaluated. The justification for higher types of traffic control goes up with greater potential for catastrophes. For example, a vehicle crossing the center line into opposing traffic may be of greater concern than a single vehicle off-road crash to the right.

6. *Traffic control devices do not "control" traffic.* By themselves they do not force compliance. Barriers are a device that can control traffic, but they are not by themselves considered to be a traffic control device. It should be noted that they are designed to interact with the vehicle, not the driver. A speed limit, for example, does not control speed. A speed limit is only effective to the degree that: (1) it is consistent with people's desires, (2) it is believed to be unduly hazardous if ignored, or (3) there is fear of enforcement (from Law #4).

7. *Drivers are most likely to utilize traffic control information when it appears to be reasonable, useful and consistent with their expectations and experience.* Traffic control zones should be designed so that drivers following their natural tendencies will perform in a manner that is reasonable and safe. Effective guidance and control can be achieved when the following driver characteristics are recognized (from Law #4):

- Drivers make their own decisions.
 - Decisions are based upon the information at hand and on past experiences.
 - Traffic control procedures should be designed so that drivers recognize the desired response and consider it to be reasonable given the circumstances.
 - Merely stating that a certain action is required may not by itself be sufficient.
8. *Utilize consistency with respect to uniform traffic control devices and standard procedures.* Devices should be selected that are appropriate to the degree of hazard involved (from Law #8).
9. *Novelty is counterproductive.* It works against uniformity (from Law #8).
10. *Simplicity is desirable.* Avoid choices and non-essential information. Avoid surprises by using driver expectancy in a constructive manner (from Law #7).
11. *Minimize choices.* The best number of choices is zero; just instruct the driver as to what is required. Where choices must be given, make them binary choices. When multiple choices are necessary, separate them longitudinally along the roadway (from Laws #6 and #8).
12. *Clearly shut off closed facilities and movements so that they are not viewed as available options* (from Laws #7 and #8).
13. *Employ redundancy where appropriate.* There are many reasons why a motorist may miss a single information source. For example, a driver performing a driving maneuver may not be scanning the roadside for signs. Similarly, it is problematic whether a motorist operating in an interior lane will see ground-mounted signs placed beyond the roadway edges. One means of overcoming such information deficiencies is to utilize redundancy, as appropriate, to improve the opportunity for all motorists in the traffic stream to obtain important information and to enable the system to continue functioning even though a component is lost. For example, if a lane reduction sign is unseen or missing, channelizing devices may delineate the lane closure. If the channelizing devices along the taper are displaced, temporary pavement marking may still delineate the required merging location (from Law #6).

14. *To the extent feasible, temporary traffic control zones should incorporate self-correcting features.* Since people frequently make mistakes, traffic control zones should be designed to be forgiving and self-correcting insofar as possible. Drivers should be given information that enables them to detect that an error has been made and then have sufficient time and/or space to correct that error (from Law #5).

15. *Equivalency can be utilized when difficulties arise.* Equivalency means that if all individual requirements cannot be met, at least an equivalent level of safety should be provided. Sometimes, when adapting to field conditions, adjustments must be made that deviate from those specified. In such cases compensate by providing more than the minimum in another manner.

16. *Work vehicles and equipment should look like work vehicles.* They are units that may be stationary or mobile, in or adjacent to the traveled way. To enhance rapid recognition they need to be both conspicuous and identifiable. This can be achieved by color, color pattern, reflective elements and lighting devices.

17. *Spread highway information.* Information should be distributed such that items of low primacy are moved from areas of concentrated activity (information reception and/or required maneuvers) (from Law #6).

18. *Warnings should be repeated periodically.* Signs used in a series are generally placed at a maximum spacing of one mile for the initial warning signs, such as those warning of construction ahead, and at no more than a half-mile spacing for more definitive signs, such as those closing a specific lane. Signs warning of a continuing condition, such as those advising of a low shoulder, should be repeated every mile (from Law #9).

Evolution of Fundamental Principles In the MUTCD

It is useful to examine concepts provided in the *Federal Manual on Uniform Traffic Control Devices (MUTCD)*. A new section entitled "Fundamental Principles" first appeared in the 1978 MUTCD as §6A-5. This section comprising 2-1/2 pages is herein summarized under the following phrases. The numbers refer to numbered paragraphs, each of which

has several subparagraphs denoted by lower-case letters. The underline refers to the introduction section.

_. All traffic control devices shall conform to the MUTCD.

1. Traffic safety should be a high priority element.

2. Traffic movement should be inhibited as little as practical.

3. Motorists should be guided in a clear positive manner.

4. Inspection and monitoring should be performed.

5. Maintenance of roadside safety requires constant attention.

In 1983, words were added to the introduction of Part VI to clearly include pedestrians as part of the traveling public [Rev. 2, 12/83]. The Fundamental Principles section was again changed by Revision 5, which was first published as the 1988 MUTCD. This revision expanded the scope of this section to encompass utility operations and incident management.

A major expansion to the Fundamental Principles section, now §6B, was made in the complete revision to Part VI published 1993. The new wording emphasizes worker and pedestrian safety as well as motorist safety. Also, principles were added in the following areas:

- _. coordination with other agencies;
- _. oversized vehicles and hazardous cargo;
- 6. training (previously was §6A-8);
- 7. legislative needs; and
- 8. public relations.

A close examination of the Fundamental Principles section of Part VI using the criteria set forth earlier shows that it contains a combination of rules, objectives, principles, standards and guidelines. For those concepts listed as principles in this paper that also appear in this section, the source is cited in square brackets.

Additional points raised in workshop discussions:

Eventually, the highway system will fail. Devices are expendable; people are not. Basic human behavior cannot change. People have free will, but they can process only limited information. Perception and reaction times are variable, with short-term memory being one minute. Work zones must be designed to be self-correcting.

Governing principles suggested by the participants include the following:

1. Traffic controls should be based on road users' needs and characteristics; traffic control devices (TCDs) do not control traffic.
2. There must be consistency in devices; novelty is generally unproductive, so redundancy should be employed.
3. TCDs must be simple, limit choice, and incorporate self-correcting features.
4. Work vehicles and equipment should look like equipment.
5. Highway information should be disseminated in a systematic way, with periodic warnings.

One participant observed that if one were to design the best driver, the ideal characteristics would be low I.Q., knowledge, ability, emotion and memory. Changes in basic human behavior, however, would take hundreds of years to effect. Another disagreed, noting: "I used to feel that way about drunk drivers, that all the research and funds were going down a rat hole. But I've been proven wrong. Crashes due to alcohol are way down. The drunk driver's conduct is becoming less tolerable in today's society. The campaign against drunk driving, together with enforcement of penalties, has worked."

Other opinions and observations raised by the participants included the following:

- Impaired condition cannot be quantified. There are many kinds of abilities and disabilities, and there are functional limitations.
- There are other forces the driver must yield to; for example, the pressure of the drivers behind him, particularly when there is a significant lowering of the speed limit with little other information.

- Modern signage should be designed for higher speed. Speed variation is a big problem.
- Are drivers sometimes told more than they really need to know? Accelerating the pace of the work is safer because the workers are in the zone for a shorter period, but it is more costly. Roadways should be designed to be maintenance-free for 20 to 30 years, thereby eliminating the need for work crews to be out there at risk. At the same time the roadway is shut down, all possible work needed for the next 5-plus years should be done.
- We have the technology to identify impaired drivers, but we cannot violate privacy.
- Perhaps our goal should be to get accidents down to an acceptable range, such as 2 percent, much like an universally accepted rate of unemployment, since some hazards and damage will always be a fact of life.
- We need more restraints against impaired drivers. Barriers are the best traffic control devices, and we must increase the number of uniform traffic control devices.
- Temporary work zones are inherently unsafe. Enhancing the safety of all concerned entails cooperation among and with other agencies.
- We don't have unlimited resources to focus on safety. However, costs for rigorous enforcement are not necessarily prohibitive.
- Some research is very old, dating back to 1932. In addition, it is risky to rely too heavily on research results because there are too many variables.

Recommendations

- Consider traffic control devices not for their own sake, but in terms of how they can improve work zone safety
- Standard procedures should be developed for testing drivers. California has the best visual tests. We need to standardize definitions of what vision range is acceptable. However, tests must be realistic.

- After long-term exposure to them, people stop paying attention to traffic control devices. Work periods must be shortened, even if this is more costly. Flaggers must be trained and certified.
 - Maintenance and utility operations are performed by low-level people who can't press for change. They need management feedback and support. Writers and researchers should go into the field; too many of them draw their conclusions without worker input.
 - Consider closing down areas to shorten work time. However, if big trucks cannot be diverted, interstate coordination will be necessary.
 - By reducing exposure, we can also reduce risk. One way to accomplish this might be to increase incentives to contractors. We need more creative contracting and to educate the public as to why the money is being spent.
- More research is needed on the effectiveness of variable message signage.
 - There must be more and better training at the local level.
 - The Uniform Vehicle Code should be standardized.
 - The States should have a safety person at all pre-construction conferences.
 - There should be material on all driver's examinations dealing with work zone safety, such as Illinois now has.

John B. Moran

Director, Occupational Safety and Health
Laborers Health and Safety Fund of North America

About 40 Conference participants attended and contributed to the two "Philosophy of Traffic Control" workshops. Discussion and dialogue among the participants was extensive and broad-ranging. As a consequence, the participants felt that three specific recommendations had merit quite beyond the context of the workshop theme subject and subtopics. Those were:

1. There is a need to establish a National Clearing-house. State and local jurisdictions are taking the work zone safety matter very seriously and are approaching resolutions through a number of innovative and dynamic practices and procedures. This information, with particular regard to details of what appears to have merit and what does not, needs to be assimilated on a national basis so that it can be made available to others.
2. There is a genuine need to continue to hold conferences such as this. Such provide the only truly effective means for information exchange and networking among key players on a national basis.
3. The workshop approach used during this Conference provides a most useful approach to enhance dialogue and networking and should be continued as the framework for future such conferences.

Our two workshops addressing the "Philosophy of Traffic Control" addressed the following primary subtopics and other subtopics:

- Fundamental Principles
- Human Factors/Behavior
- Speed Management
- Training
- Positive Guidance.

The discussion which follows presents a summary of the work groups' recommendations for each of the subtopics.

FUNDAMENTAL PRINCIPLES

1. Chapter VI in the Uniform Manual regarding "principles" is generally viewed as "good."
2. The Uniform Manual is almost entirely focused on the protection of the public. As changes occur to mitigate the work zone fatality problem, we must be vigilant in assuring that such do not increase risks to workers in the work zones. Conversely, changes that reduce risks to workers must not increase risks to the motoring public.
3. Physical separation between traffic and the work zone is highly desirable and should be employed where possible.
4. There is a need to evaluate the relative risks, including the difference in risks between daytime and nighttime road work. There is an increasing trend, especially in high traffic density areas, to conduct work during low traffic density time periods.
5. There is a need to reassess construction methods and designs from a safety perspective. Disturbance of traffic flow equals high risk. Further disturbance by construction vehicles, for example, exacerbates this problem. Designs should address methods to provide construction vehicle access on other than the traffic disturbed roadway.
6. There is a need to facilitate a change in attitudes about how resources are allocated to work zone safety. Waiting until a fatal event occurs before appropriate and adequate resources are provided is not an acceptable approach.
7. There is a genuine need to gain a perspective on the true social costs associated with work zone safety incidents. Such information would aid decision makers in understanding the true value of the commitment of resources to reduce such incidents.

8. There is a need to better understand the dimensions of what is really happening "now" with regard to highway work zone safety and the measures being applied to improve safety. There is a lot going on now, as is evident in the workshop discussions during this Conference. What is working? What is not? What other problems are being created? What's "right"? Are all appropriate questions at this time.
9. Partnering, public awareness, and enforcement are viewed as key fundamental principles.

HUMAN FACTORS/BEHAVIOR

1. Credibility with the motoring public is a (if not *the*) major problem in traffic control. We need to focus our attention on this issue and attempt to recapture our credibility. Honest communication is viewed as a central theme to achieving improved credibility with the public.
2. There is need for a fresh look at what we believe characterizes human behavior. There was a general view that our understanding of human behavior based upon studies of over 20 years ago is simply no longer valid in today's world.
3. We need to focus increased attention on the training and education of drivers if we expect to "change their behavior," recognizing of course that changing driver behavior will be a very difficult process.
4. Public awareness of the hazards, to motorists and workers, of highway work zones needs additional attention. There is a need to engage the news media and others in assisting in this process.
5. Modifying driver behavior in the area of work zones is not simple. We must continue to evaluate innovative approaches such as "real time" information systems.
6. Contractor behavior needs to be addressed. SIC 161 has the highest lost time injury rate and fatality rate of any sector in the construction industry. Three issues require attention with regard to the contractor community: work zone safety compliance, standards of contractor performance, and contractor safety and health programs. With regard to the latter, it is noteworthy that several jurisdictions require contractors to have and submit safety and

health programs, that ARTBA has a model contractor safety and health program, and that OSHA has recently initiated a "Focused Inspection Program" that targets inspection to only the four leading causes of fatalities in the construction sector where a contractor has an effective safety and health program (USDL: 94-484 Press Release).

7. There needs to be a commitment from top management to work zone safety. This applies to both owners and contractors.
8. There is a potential need to change some licensing requirements, especially for older drivers. One example was vision testing, which in many states is required only at the time of procurement of the initial driver's license.
9. Some concern was expressed that current "uniform" signage has resulted in a certain degree of "desensitization" on the part of the motoring public. There is a need to consider innovative approaches such as those used in parts of Florida involving unique exit ramp signage from within the work zone.
10. We need better work zone incident data. Our current data lack the necessary detail upon which to effectively target intervention efforts to high hazard occurrences.

SPEED MANAGEMENT

1. There was general concurrence that "speed control" was not the appropriate title for this subtopical area. At best, speed in work zones can be managed, to varying degrees.
2. Speed management in work zones is of critical importance, yet achieving it is very complex, difficult, and challenging. The following were discussed as among the approaches which merit consideration:
 - Enforcement is a very important feature but it needs to have several dimensions. Some states have had a measure of success with "double fines" in work zones. It was suggested that "double points" might be an even more effective measure.
 - Police presence clearly contributes to effective enforcement, but it has limits and is expensive.

- Drone radar with a timing device has evidenced some degree of success in selected work zones.

- "Real time" message boards have proved effective; however, the messages need to be near real time and accurate or the positive effects on speed management are quickly lost.

- Measures to improve credibility with the motoring public are viewed as beneficial for speed management.

- Physical speed management approaches, such as those utilizing barriers and weaves, have been applied successfully in some circumstances.

- It is appropriate to focus on project specific speed management approaches and methods.

TRAINING

1. There is need to focus on worker training. This is evidenced by the high fatality and serious injury rates among workers with the least experience.

2. Contractors require training as noted earlier. That training should focus on work zone management and safety and health program implementation and management. In addition, participants believed that the contractor should be required to have a "work zone safety management supervisor" on the job at all active times, and this person should have

minimum defined experience and training. Certification of such individuals was suggested, although several felt this would not be viable in many jurisdictions.

Contractor and contractor employee training requirements should be part of the contract between the owner and the contractor.

3. Education and training of drivers was viewed as an important matter requiring attention. This might be accomplished through including work zone safety elements in the following:

- Driver education programs.
- State driver's license manuals.
- State driver's license examinations.
- Trucker's license tests.
- MVD mailing stuffers (with registration renewals, etc.).

POSITIVE GUIDANCE

Positive guidance is an important traffic control process which merits increased attention. Providing the driver relevant, site-specific, timely information that assists the driver in work zone decision making has substantial benefit. "Real-time" message boards, for example, are showing promise and should be pursued.

Additional points raised in workshop discussions:

Speed Management / Enforcement Issues

- Cracking down on violators can control accidents. Pennsylvania has found double fines effective, but they must use off-duty highway patrol officers to enforce the law.
- Violators comprise about 15 percent of motorists; the other 85 percent will be handled nicely through traditional traffic control methods.
- There is no guidance in Part VI of the MUCTD as to how to regulate speed. It states only that

"Normal speed should be undisturbed as much as possible." Many states set forth work zone speed limits in state law. However, the arbitrariness of such laws makes it difficult to enforce because credibility is lost.

- If a speed limit is set, it is observed for a few days and then ultimately ignored. The proper speed limit must be established in the first place. Drivers will go as fast as they think is safe anyway, but they still have a lot of accidents, so they must be told *why* they need to slow down.

- In the quest for uniformity, do we desensitize the driver to construction zones? In Pennsylvania, troopers interviewed numerous violators—speeders—in work zones and found they didn't know the fines were doubled, and they didn't even know they were in a work zone, despite all the signage. Is desensitization to standardized worker zone signs a factor in motorists' behavior?

Technology /Communications Issues

- Real-time technology is available, and it is getting cheaper. Radio messages are effective if there are people keeping it up to date.
- In Mississippi, officials send out faxes to 75 media and law enforcement organizations every day regarding what is going on in the work zone. Good communication is the most effective tool available.
- In Cincinnati and New York, traffic control reports are aired on radio, including daily updates on construction zones. Many people listen just to get construction reports.

Training Issues

Research shows that six out of every 100 workers are injured. But there are lots of companies experiencing no accidents. This kind of track record requires commitment on the part of contractors.

Planning and Contractor Issues

- Conscientious planning on the part of contractors and transportation officials is essential. If construction zones are designed properly, speed will take care of itself.
- It was suggested that incentives for traffic control be considered. It takes time to write good contracts constructed with input from engineering, but this process is worthwhile. Unit pricing also appeals to contractors. If the contractor doesn't comply, he will then have the State on his back.
- In Florida, the contract specifies that the contractor cannot do the work until he is in compliance, and, the inspector has enforcement authority. However, this approach is successful only where there is proper participation at all levels, including levels of government.

- Once the job is started, achieving effective traffic control depends on money available for the project. A certain percentage of cost should be allocated for managing and for continuous reevaluation.

- Participant observation: "It pays to listen to the people who are actually out in the field. At one time, we had lots of accidents at ramps. Finally, our maintenance employees told us that people were confused about where the ramp was. They suggested putting up new, clearer signs and barrels. So these changes weren't designed initially, during planning, but were brought in as a result of their experience. We now work this factor into contract negotiations. This experience takes account of human behavior and enables us to deal with what people are doing rather than what they are supposed to do. We need flexibility and resources to make changes when something doesn't work."
- People in upper management get out on the roadway and see what the conditions really are.
- The increasing amount of night work going on may have an adverse impact on accident and fatality trends. Studies have shown that just as many accidents occur at Xmph *under* the speed limit as the same mph *over* speed limit.
- There are instances where it makes sense to close the road: 1) it's safer, and 2) it takes much less time, which could confer a long-term benefit that could sell the temporary inconvenience.
- Construction vehicles trying to get into the zone cause crashes. Therefore, perhaps we should consider separating construction traffic and the highway traffic as well as workers and public traffic.
- Problems can stem from complacency due to long periods with no accidents or fatalities. This can lead to failure to ensure proper safety training. Is the bidding process within the State a factor in accidents among short-term project workers? Companies are forced to be competitive in the bidding process and encouraged to cut corners, so in some States they are hiring lower-skilled workers, thus contributing to accidents and deaths.
- Contracts of this nature often involve entry-level, well-paying jobs for young people who do not have prior training or work experience. The demographics of work groups do not favor construction workers over 60 years old. Most are younger.

- The more money going into work zone control, the less there is available for patching, overlay work, etc., on the project. It's hard to change attitudes on funding that have built up over 50 years, but attitudes must be changed on how money is to be allocated.

Liability Issues

- Unfortunately, too often contractors/owners eventually discover the hard way that they should have put more money into the safety (especially after accidents, lawsuits). Good training, adequate signs, etc., will go far to head off liability costs.

Human Factors

- Human factors play a role. The basic problem is not with desensitization of drivers, but a familiarization on the part of the repeat drivers. Strangers do use the information. It's the regulars who don't see flaggers, devices, barrels—the drivers have become so routine in driving, thinking of other things, that they lose sight of driving tasks and don't pay attention, especially truck drivers, who are so tired they are driving in a daze. Even drivers who are otherwise alert will stop paying attention.
- Pennsylvania is concentrating on not on slowing people down—which is considered a lost cause. Accidents usually occur where there is a disruption in the traffic flow. We should look at the construction methods we are using and target those disruptions to the traffic flow.

- To achieve speed control, it has been found that the tunnel effect will slow people down because it makes them *perceive* the lane is narrower.

- Another successful method is to leave both lanes open to the taper and put up a sign: "Merge: Take Your Turn." The value of this sort of system may not be in actual throughput, but in the fact that there is a *justice* value. This can reduce frustration that could create later problems.

- Much of the existing problem has to do with the duration of the work. People get used to it and stop thinking of it as a work zone.

- The bottom line is that people want traffic maintained without interfering with their own convenience.

- Public attitudes about spending habits can be changed through education programs, public service announcements, etc., but the problem is how to get attention for *this* cause as opposed to other worthy causes. People must be made to understand that providing the investment for safety makes the project cheaper in the long run.

WORK ZONE SAFETY IMPLEMENTATION

WORKSHOP REPORT

Jon V. Jackels

Work Zone Safety Coordinator
Minnesota Department of Transportation

WORKSHOP FORMAT

The workshop consisted of introductory remarks by the facilitator to "set the stage" for the topics included in the workshop. The mission statement was reviewed and agreed on by a majority of the participants so discussion could be effectively limited to those areas intended.

The remainder of the workshop consisted of open discussion identifying topics and practices to ensure proper work zone traffic control and safety implementation. These practices were refined and agreed on by most participants.

The workshop concluded with the development of an outline presented at the closeout session. This outline may be used, by any agency, to develop practices (policies, procedures, etc.) to ensure quality traffic controls are used.

WORKSHOP MISSION

The mission of this workshop was to identify good practices, for public and private agencies, that ensure quality work zone traffic controls are applied in all construction, maintenance, utility, and incident management work zones. This includes, but was not limited to:

- aspects of the agency's management system
- goals of the agency at all levels, from the CEO to the field personnel
- identification of important elements of work zone traffic controls
- training of all personnel involved with work zone traffic controls
- selection of proper work zone traffic control devices
- methods to ensure all devices are of adequate quality.

The need for a comprehensive work zone traffic control and safety plan was stressed during the discussion of the mission statement.

MINNESOTA'S WORK ZONE SAFETY ORGANIZATION

The three main components of Minnesota's work zone safety organization are:

- Work Zone Safety Coordinators;
- Work Zone Safety Committee; and
- Work Zone Safety Advisory Committee.

Work Zone Safety Coordinators

It is essential that the responsibility for work zone traffic controls be assigned to specific individuals. The axiom "Safety is Everyone's Job" is true; however, specific duties must be assigned to individuals or the job never gets done. It is key that the authority to make decisions be delegated to the lowest level possible to ensure that changes are made in a timely and efficient manner.

To accomplish this, Minnesota established a full-time Statewide Work Zone Safety Coordinator position in 1989. This position exists to coordinate all work zone traffic control and safety efforts in Minnesota.

In addition, each of MN/DOT's eight construction districts has a District Work Zone Safety Coordinator. The duties of the district coordinator are to provide technical expertise for the district and ensure that proper traffic controls are used in all work zones.

To provide project-level work zone traffic control and safety each project has a Project Work Zone Safety Inspector. This inspector has the responsibility and authority to ensure all traffic controls meet project requirements.

Work Zone Safety Committee

The role of the committee is to act as the focal point for work zone traffic control and safety efforts in Minnesota. Committee members include FHWA; Associated General Contractors; the Northland Chapter of the American Traffic Safety Services Association; counties; cities; law enforcement; and functional groups of MN/DOT (traffic engineering, construction, maintenance, state aid, and safety).

The major activities of the committee include:

- presentation of annual work zone safety awards for construction, and county efforts;
- review and application of new technologies in work zone traffic control;
- development and delivery of public education and awareness programs;
- research and development of new techniques and improved work zone traffic controls;
- providing designated law enforcement in work zones; and
- implementing work zone traffic control and safety policies in Minnesota.

Work Zone Safety Advisory Committee

This committee consists of representatives of construction contractors and labor unions that meet monthly with the commissioner of transportation to discuss work zone traffic control and safety issues. The committee's primary role is to keep communications open among labor, industry and government. This group is also active in promoting the efforts of the Work Zone Safety Committee on a statewide basis.

Members of this committee are active in promoting legislative initiatives concerning work zone traffic controls and safety as well as public education and awareness programs.

ELEMENTS OF A TRAFFIC CONTROL AND SAFETY PROGRAM

It is essential that all work zone traffic control and safety programs include:

- work zone traffic control standards and guidelines;
- technical training;
- investigation of state-of-the-art work zone traffic controls; and
- quality control.

Work Zone Traffic Control Standards and Guidelines

It is essential that all agencies adopt and use work zone traffic control standards and guidelines, which must be drawn in accordance with Federal, State, and local regulations.

Technical Training

To ensure that proper traffic controls are installed in work zones, it is important that all workers receive training that is consistent with their job responsibilities and authority. This training varies from traffic engineering courses to work site traffic control supervision to flagging and basic traffic awareness training.

Investigation of State-of-the-Art Work Zone Traffic Controls

It is MN/DOT's philosophy that the best technologies and techniques need to be applied in work zones to provide safety for the worker and traveler. To accomplish this, there is a Work Zone New Products Subcommittee that reviews new technology in work zones. This review includes a research summary and covers traffic control device performance, and traffic control techniques.

Quality Control

Work zone traffic controls must earn the respect of the driver. To accomplish this it is necessary to use properly installed, high-quality traffic control devices. It is believed that if the workers cannot show enough respect for the devices and the drivers to provide high-quality traffic controls, the drivers will not respect those devices.

ELEMENTS OF WORK ZONE TRAFFIC CONTROL IMPLEMENTATION

It is essential that all agencies develop a traffic management plan for handling traffic near work zones. This traffic management plan has many key elements. The two major elements concerning the implementation of work zone traffic controls are:

- work zone traffic control operations; and
- work zone traffic control monitoring.

Work Zone Traffic Control Operations

Work zone traffic control operations are those items provided in the planning and design process to aid in providing traffic safety in work zones. The key components are traffic control plans, pay items and to project specific public awareness.

Work Zone Traffic Control Monitoring

The most critical element of the traffic management plan is the monitoring of work zone traffic controls during field operations. To ensure that proper monitoring is accomplished, it is necessary to assign the responsibility and authority to a specific individual on the project. This individual ensures that proper monitoring of devices is conducted and any corrective actions are taken promptly. The primary duty of this person is to enforce the work zone traffic control standards and guidelines that apply to this specific project.

Other critical components of monitoring include enforcement of traffic laws and collecting and analyzing work zone accident data. It is important to provide the proper level of law enforcement on projects to ensure the safety of the worker and the motorist. It is also important to review accident data on a project, state, and national level to identify areas that need improvement.

ENSURING USE OF QUALITY WORK ZONE TRAFFIC CONTROL DEVICES

The mission of this workshop is to identify good practices that ensure quality work zone traffic controls are used. To accomplish this, it is essential that all agencies have:

- management commitment;
- qualified field personnel; and
- project manager tools.

Management Commitment

All agencies, public and private, who affect the normal flow of traffic must be committed to work zone traffic safety, from top management to field personnel. This is essential for proper allocation of time, money, and personnel resources to work zone traffic control and safety.

It is important that all workers and travelers be aware of this commitment to traffic control and safety in work zones. This is communicated to the worker through training programs and delegation of authority to field personnel. This commitment is communicated to the driver by the attention given to work zone traffic controls and law enforcement on all projects.

Qualified Field Personnel

Field personnel are the key to quality work zone traffic controls and the success of any work zone traffic safety program. Therefore, it is necessary to provide training for these workers so they are qualified to ensure proper traffic controls are installed and maintained for the life of a project. This training must be consistent with job responsibilities that may range from traffic awareness for all workers to formal certification programs for work site traffic control supervisors.

Project Manager Tools

The goal of any work zone traffic safety plan should be to provide project managers with the proper tools to provide work zone traffic controls. These tools include:

- ATSSA quality standards;
- regular surveillance of traffic controls;

- penalties for non-compliance to Traffic Control Plan and standards;
- regular work zone safety meetings; and
- input to work zone traffic control standards and guidelines.

Like any other tools, these must be available for use by field personnel and must be kept up to date to ensure their application provides quality work zone traffic controls and safety.

It must be remembered that any successful work zone safety implementation plan must focus on the needs of field personnel and the traveling public. All other elements of the plan are important. However, if the worker is not given the necessary tools, this plan will not aid in providing quality work zone traffic controls.

MISSION OF WORKSHOP

This Conference was an excellent opportunity to discuss and share experiences in providing work zone traffic controls for all activities on streets and highways. The workshop format facilitated formal participation by all Conference delegates. This participation provided a way to capture the experiences of work zone traffic control and safety experts from across the country.

The workshop, Work Zone Safety Implementation, could include all aspects of work zone traffic controls. However, the following mission statement was adopted to direct group discussions:

Identify good practices, for public and private agencies, that ensure quality work zone traffic controls are applied in all work zones.

Throughout the workshop discussions, it was stressed that everyone must be committed to work zone traffic control and safety. Also, field personnel are the key to ensuring proper application of quality work zone controls. Therefore, they must be given the tools that allow and facilitate these applications.

The planning committee for this conference asked that we address the quality of work zone traffic control devices and improved quality assurance during our discussions. During these workshops we identified many tools that can be used to improve the quality of the devices and traffic safety.

It is important to note that it was difficult for the groups to get out of the contract administration mode and concentrate on all work zone activities. Some discussion focused on how to use administrative techniques for permit type and maintenance operations—for example, the use of penalties and incentives along with regular surveillance on these types of operations.

It was stressed by both groups that these good practices should be used by all agencies to improve the proper application of quality work zone traffic controls.

The categories of good practices developed during these workshops were:

- surveillance of work zone traffic controls;
- quality of work zone traffic controls;
- law enforcement;
- positive and negative incentives;
- development of a safety culture;
- improved work zone traffic control assurance;
- traffic management scheme; and
- issues that need additional attention.

The good practices are listed under each of these categories. Many of them could be developed into an entire section for this report. However, time did not allow this during the workshops, and it is hoped these practices will be developed and included in the National Work Zone Safety Program.

Surveillance of Work Zone Traffic Controls

- There should be regular surveillance by the owners (DOT, local road authority, etc.) project personnel.
- Regular surveillance by the contractor should be formalized by the use of a daily traffic control checklist that must be provided to project inspectors.
- Establish a 1-800 telephone number so problems can be reported by the traveling public.

Quality of Work Zone Traffic Controls

- Use the ATSSA *Quality Standards for Work Zone Traffic Control Devices* in all work zones.
- Develop procedures that ensure the crashworthiness of all work zone traffic control devices.
- Develop procedures to ensure the quality of the traffic control scheme and layout of traffic controls. This includes communication between field and design personnel.
- Improve the visibility and recognizability of all workers.

Law Enforcement

- Make law enforcement officers an integral part of the project team by including them in planning and design efforts, field safety meetings, surveillance of traffic controls, and enforcement of traffic laws.
- Provide work zone traffic control and safety awareness training for all law enforcement personnel.
- Use dedicated officers for traffic law enforcement.

Positive and Negative Incentives

Worker and agency

- Use penalties for non-compliance to work zone traffic control standards, guidelines, and plans. This varies from hourly penalties to shutting down the project.
- Develop and implement a work zone safety awards program to recognize extraordinary efforts in providing work zone traffic controls and safety.
- Implement a bonus program that provides incentive to perform beyond minimum requirements.

Facility owner (road authority)

- Realize that application of proper work zone traffic controls makes it possible to deliver a project on time, within budget, safely, and with reduced exposure to liability.

Public

- Enforce traffic laws in work zones to demonstrate the importance of driving safely in them.
- Use double fines in work zones to show the extra importance of driving safely in work zones.

Development of a Safety Culture

Workers

- Communicate management commitment and support to all workers.
- Make work zone traffic control and safety an integral part of all work activities. Too often traffic control and safety are considered add-on items that are neglected when time is short.

Public

- Develop and deliver work zone traffic safety public education and awareness campaigns on national, regional, statewide, local, and project levels.

Improved Work Zone Traffic Control Quality Assurance

- Provide improved technical training for all workers that is consistent with their job duties and responsibilities.
- Develop certification programs to ensure those responsible persons are qualified to apply work zone traffic controls.
- Develop a work zone traffic control field manual for work zone traffic control that facilitates application of standards and guidelines.
- Formalize agency policies concerning work zone traffic control and safety so all workers are aware of their duties.
- Provide flagger certification to ensure that all flaggers are capable of controlling traffic through a work zone.
- Assign responsibility and authority for work zone traffic controls to field personnel.
- Listen to field personnel to improve work zone traffic control and safety standards, guidelines and policies.

Traffic Management Scheme

- TCPs should be developed for all long-term projects. TCPs should include guidance on solving common problems encountered in the field. Examples include providing extra traffic control devices, how to handle changes to the plan, how to provide traffic controls for unexpected drop-offs, etc.
- Provide for regular work zone traffic control and safety meetings at all levels. These levels include project, local, statewide, regional and national.
- Provide timely responses to all deficiencies in work zone traffic controls.

Other Issues Requiring Attention

Following is a list of items that the groups decided need additional development:

- work zone traffic accident analysis system to identify traffic safety problems;
- a national work zone traffic safety public education and awareness program;

- work zone traffic control training and awareness for upper management;
- use of lane rental and A+B bidding concepts to improve traffic safety by reducing exposure;
- implementation of new technologies and techniques to reduce hazards and improve safety; and
- inclusion of specific guidance for pedestrian traffic controls in the *Federal Manual on Uniform Traffic Control Devices* including fences, detours, and walkways.

CONCLUSION

This Conference and workshop have shown that most work zone traffic control and safety issues and concerns were shared by all delegates. It is obvious that these types of forums facilitate development of common solutions to these concerns. Therefore, the groups both recommend that this national work zone traffic control and safety conference become an annual meeting. This would allow attendance at the meeting by public officials, as well as provide solutions to common problems in work zone traffic control and safety.

Additional points raised in workshop discussions:

To counter the problem of motorists attacking workers on site, it was suggested that input from troopers during the planning stages could be valuable. At the site, however, flagger training is often more important than relying on the use of troopers to prevent violations. Workshop participants also believed that some voluntary flagger training for troopers could be useful.

In some States, troopers at work zones serve more to enhance safety rather than to enforce the law. In California, some troopers serve a joint role; some officers on bikes are assigned solely to enforce safety in work zones. Also in that State, safety measures are enforced via fines and penalties imposed against work zone contractors.

Quality Control Issues

- Participants recommended that Traffic Control Devices (TCDs) be subjected to regular and sponta-

neous inspections, and that they comply with existing standards and specifications of design and performance.

- Information for motorists should be user-friendly; encourage alternative transportation where possible; advise them of the duration of the project; and notify them of applicable fines and penalties. Symbols and signs should be easily understood whatever the driver's native language. In addition, work zone safety should also be addressed in State driver's handbooks and incorporated into the driver's tests.
- Public awareness programs should be implemented through national campaigns, driver's education programs, the public schools (including elementary schools), and partnerships with motor carriers through penalties/incentive efforts, insurance companies, and commercial driver's license activities.

Victor H. Liebe

Director of Education and Training
American Traffic Safety Services Association

Everyone who participated in my two workshops worked very hard to produce some really meaningful recommendations.

The first key to effecting work zone safety is to understand why problems exist, and why there are no uniform practices in designing work zones.

Although those in a State agency conduct projects of a similar nature as those in a municipality, and perhaps a utility contractor has a similar project, all three are treated differently from the standpoint of traffic control. Thus there is a problem in maintaining uniformity. It differs from job to job, and from area to area.

We sought to identify the basic problems, and found that one of the major items was lack of enforcement. Perhaps even more important are monitoring and inspection: Who's in charge? Who is checking to see that the system is the way it's supposed to be, whether it is of a quality design, whether it is maintained at a high quality? In other words, does the system work?

Enforcement is a logical follow-up: What compels a contractor or even an agency work force to change the system to make it work? Perhaps it has something to do with pay practices on the part of the contractor. There was much discussion of contractor payment for traffic control work—lump sum vs. item-per-day basis. There were no States represented that paid on an item-per-day basis, so we couldn't really define that part of it. The States that were represented all paid on the basis of a lump sum; however, it was a modified system that allowed for maintenance, improvements, changes, modifications and so on. So in effect you have a value per day basis. This was not a real issue, but it does boil down to contractors getting paid for the work they do, and if payment is not made justly, then the quality of work suffers.

RECOMMENDATIONS

We came up with some solutions to maintaining a good plan:

- It was recommended that there be more joint participation. What we're really talking about is this partnering concept, albeit from a somewhat different approach. It was the consensus of both groups that there should be more joint participation by State agencies, counties, municipalities and other jurisdictions, contractors, and associations. We talked about the chartering organization that ATSSA has as a mechanism to get people to cooperate.
- It was also suggested that we need some type of central clearinghouse where people can inquire about common practices, a source of information that is easily accessible. We talked about a number of possibilities there, and I think this has good potential for development on a national basis.
- Pre-qualification of contractors: I'm sure this is not a practice of all State agencies, but the recommendation was to encourage that.
- More frequent inspections: Better follow-up must be encouraged by some means or mechanism, but we're not sure what that mechanism should be. Constant, continuous inspection, knowing the current situation, is very lacking right now, and there needs to be significant improvement in this area.
- The issue of the Manual was discussed, about what it really is and what the group thought it should be. Some thought there is not specific enough information in the Manual. There was some desire to see the Manual separated into more specific areas, perhaps into three parts covering the general categories of a high-speed, high-volume expressway type of operation. Many of you who have participated in

activities related to the Manual know it assumes high-speed, high-volume situations. All other designs, all other roadways, are patterned after that because the concept of handling traffic control is the same; it's just done in a slightly different way. This is not presented clearly, but if the Manual were segmented into parts showing peculiarities, a variety of lane closures, handling perhaps intermediate speed, intermediate-volume type situations, and the low-speed, low-volume type of activities, this could be useful. We didn't spend a lot of time thinking about exactly just how each type of category should be derived, but merely recommend this as food for thought. We're not suggesting complete reorganization of the Manual; it's a good document, but how can we make it better, more usable, more understandable?

- One problem we noted, which is evidenced here, is a lack of representation by some major municipalities. We have some city, some county, some State representation but virtually no major municipality. We don't have significant representation by municipalities, and I think their input is as valuable as anyone else's. The emphasis seems to be on agencies and State departments of transportation, and I think we need to get the cities more involved. That was a recommendation of our group.
- It was also recommended that some design manuals be developed, and that there be more in the MUCTD on how to develop a good Traffic Control Plan. It was the group's consensus that there be guidelines, but that there be enough flexibility to

leave leeway for judgment and discretion. However, there is still a lack of a single document, a single source that describes how to put all of the elements together that are needed to design a good Traffic Control Plan. It's more than just a "cookbook" situation, putting in amendments. You have to look at volumes, speeds, quality traffic, congestion, capacity. My personal view is that we must include the people who are involved: traffic engineers, engineering technicians, people with that education. This may sound like a simple answer. We have those people in the world today, but maybe we don't have enough of them in certain areas. Again, it was recommended that some kind of source be developed, similar to the clearinghouse mentioned earlier, possibly a design manual, perhaps done by AASHTO as the appropriate source, just like the AASHTO Design Guide. It is recommended that this at least be considered. We do have a handbook that is a good document, but only engineers can understand it.

- The last item that we focused on was the education of the driver: getting the public involved, making them want to buy into a program, making them understand that they are a part of the problem as well as a part of the solution. Everything we do is for the sake of the driver, as well as for the workers. Some time ago, FHWA made a couple of pilot public service announcements, and we were wondering what happened to those. Perhaps PSAs could make only a small dent in a major problem, but something needs to be done to raise the public's awareness. In other words, we need a greater emphasis on public education.

Additional points raised in workshop discussions:

Contract Issues

- Participants agreed that there is often a gap between contract specifications and job site realities. Enforcement of standards imposed must be a goal. Compliance often becomes problematic when it comes to subcontractors: How can their compliance be assured? One answer is to define the applicable criteria related to their bid from the beginning of the contract process. However, sometimes the problem lies in the fact that one entity will bid while others actually do the work, and there is no communication between the two separate disciplines.
- Meeting standards set for traffic control devices can be achieved through assessment of penalties applied for every day the contractor is not in compliance.
- Sometimes problems arise not with actually providing the materials but with ensuring proper maintenance. In some States with heavy traffic in well-populated urban areas, people are assigned whose job is solely to maintain equipment.

New York has a centralized statewide team to evaluate work zone issues and prepare a report on these annually. Pennsylvania has prepared a detailed work zone manual addressing each potential situation which may be of concern. Inspectors have no leeway to tolerate lapses. Participants suggested that such a manual is a good idea, but it should responsive to the public and to practical needs. Consistency of standards and enforcement provisions is essential.

Liability Issues

Although liability may arise even if one lives by all the rules, tort liability is a lightning rod.

- One participant cited the need for more detailed specifications or standards, but if these are too specific, they become a resource for lawyers to use in litigation. General guidelines, he said, are preferable to specifications. Another participant disagreed, citing a need for explicit guidance and incentive to use the latest technology.
- Contractors often will ignore guidance; thus, documentation as to why a specific practice was instituted is needed.

Retroreflectance Standards

- ATSSA will demonstrate a mobile reflectometer which will collect data for safety management systems on reflectance performance. It will work by having a vehicle go down the roadway and use a strobe light to measure feedback from devices. Data will be collected using an onboard computer. These vehicles will cost about \$125,000 each, but FHWA is trying to bring down the price.

Problem Solving

- Most work zone problems can be resolved through good execution. The real needs are training and motivation, throughout all levels of an organization, as well as quality testing of implemented plans.
- The moderator advocated improved quality assurance along the entire chain of command of a traffic program (TCP), using experienced and trained personnel. A poorly designed TCP costs time and money to defend in court, with the weak link often being the TCP implementation.

Training Issues

Regarding flagger certification and traffic control planning training, in states such as Nevada financing training can be an issue. The State wants to be able to use apprentices and then develop qualifications. However, less training often means higher accident probability. Retention levels among trainees are a concern. Minnesota's experience is that shorter sessions over time increase retention.

Enforcement and Inspection

- Enforcement can be viewed as a follow-up to inspection, which ideally should occur early in the process to discourage implementation of undesirable traffic control plans. In New York, following clearly defined inspection procedures is the responsibility of professionals hired by the State DOT. Contractors are expected to implement quality plans, although inspection is important and New York does conduct spot checks.

- Some believed a job should not start without the approval of a certified inspector/engineer. In Illinois, a specific date is established for a project to implement the TCP and a contractor gets 25 percent of a lump sum after the implementation is approved by a traffic control supervisor. A contractor must set up a lane closure correctly to get paid.
- A State's liability is raised if enforcement of contractors is inadequate. One participant's observation: "You can't expect what you don't inspect."

The Federal Role

The moderator suggested that Federal approval of devices at some point in the future is unlikely. FHWA basically does not approve devices, but it does set standards. However, even if a product meets a standard, that does not imply approval.

CONTRACTORS CONSTRUCTION MANAGEMENT

Robert Attaway

Highway Program Director

Institute for Transportation Research and Education

North Carolina State University

Joseph R. Julian

President

James Julian, Inc.

It is appropriate that one of the topics discussed in our workshops was partnering, since we actually “partnered” to conduct it. We will try to summarize some of the highlights of our discussions on construction management and how it is working in the States.

Actually, we thought this was going to be a pretty mundane topic, but when we started our sessions it turned out to be very interesting, so we’re going to cover it in some detail.

PARTNERING

In the first area, partnering, we discovered that there is a lot of it going on and, for the most part, people felt pretty good about it, and that it was successful and working well. We had extremes from some States with no partnering to other States where it’s used on every project.

A couple of things I’d like to point out: Most of the problems we talked about resulted from one or more parties not being honest. Not getting everyone to buy in up front is a problem that needs to be addressed for effective partnering. Making a commitment to get the decision making down to the lowest level—that was something we also felt is important if the partnering process is going to work. If that’s done, a lot of the problems that arise will be resolved quickly and painlessly.

We discussed some agencies that allow changes to be made up to \$50,000. These could be made by the project engineer. That’s the type of thing this partnering process allows. In addition, partnering

permits us to change the way we may have done business in the past. Some of the participants were joking that if they discussed five years ago the same issues they are discussing today, they’d all be in jail.

Another issue raised was sharing the risk, not only from the State side but from the contractor’s perspective.

Partnering is an evolutionary process. There have been States where it has been a resounding success and other States where it has had mixed success. But in terms of traffic sequencing and putting the issues out on the table in a candid manner where everybody knows all the facts, we think partnering has great potential for improving the entire construction process as well as safety on the project.

TRAINING

This was one of the emphasis areas in our discussion. One of the things we addressed was the need for uniformity in training, the need to make it available, and the need for incentives. Our unanimous consensus was that training is needed and that everyone who’s out there working should be trained. There’s no question about that.

The second recommendation is that training be uniform, particularly for flagging; one procedure needs to be established so that from project to project and State to State, flagging will be uniform. Training should also be uniform for traffic control. There was some discussion about what direction traffic control training should take and what existing training courses offer and how they may be improved.

The certification issue was something we discussed a lot in both sessions. There was not a strong consensus about whether or not certification is the way to go. There was a consensus, however, that training should be accomplished, with perhaps certification as to training having been completed but not as to a certain level of competence.

LUMP SUM VS. UNIT PRICING

The next subject that we talked about—particularly in the second session, in a rather spirited manner—was lump sum vs. unit cost as a means for paying for traffic control items and traffic control people. Problem number one was that lump sum may not be the best way to pay for traffic control items such as flaggers, variable message boards, arrow panels, and other safety items. Among the participants at both our sessions, there was a wide range of experience related to different States and how they handle this issue. I think one of the solutions we discussed was that pre-set items, like flaggers—which are very hard to plan and could run way above planned quantity—might be the way to go. We do that in Delaware and it works well. There's very little controversy about it and it's periodically adjusted for inflation.

Presumably if a new traffic control device comes on the market, particularly with a unit price structure, there's a possibility for a quick response and it's something we can use in our applications. The other side of that issue is that unit prices can be an administrative nightmare. Counting the number of barrels on a 10-mile area on I-95 and counting them every day, is without question an administrative nightmare. So we concluded that it might be better to use lump sums for some items, while using unit prices on others.

There was some opinion that if you're doing it on a unit price basis perhaps the contractor's interest is not as great as it would be if it were a lump sum or if he had an incentive to make sure it's right and economical. It was also argued that lump sum jobs may provide better traffic control. I'm trying to be as objective about this as I can, because I'm a contractor and I agree with that. The bottom line is that there's got to be a balance. Lump sum payments may be the way to go in some instances, where unit prices for variables such as flagging might be appropriate if there is control set up to start with.

We need to be as innovative as possible with changes in lump sum prices that may have an impact on traffic control. One of the problems with lump sums is that if there is a resequencing of the traffic lanes, for whatever reason, then all of a sudden there have to be major negotiations as to how the lump sum is adjusted to reflect this resequencing. This could chill the whole process, and the time spent in renegotiating the entire operation might impede the opportunity. That's why we concluded there should be a balance.

INCENTIVES AND DISINCENTIVES

First, there are not enough incentives. The solution that some States are using involves lane rentals and interchange rentals. In Oklahoma, interchanges rentals are actually coming up, wherein the contractor has a specific amount chargeable for shutting down an interchange or lanes, and if he exceeds the allotted time, then he's charged for that specific amount. One contractor we discussed even splits his incentives with his subcontractors and suppliers.

Second, can work zone traffic control be included in incentives and disincentives? I think we're all familiar with A+B contracts, but somebody talked about A+B+C, with C being quality performance issues. It would be a wonderful thing if we could devise a method of assigning value to superior performance on traffic zone safety. I don't know how to do that, but it might mean giving the contractor an incentive for achieving not only the specified performance but a superior performance.

Our philosophy has always been that if you can get the job done sooner, obviously the exposure is decreased, not only to the traveling public but to the workers. So there's been a strong emphasis on being as innovative as possible in changing and improving sequences of lane closures, etc. We talked about how long it takes to get change orders processed. This is an issue we'll probably have as long as we have construction. But it relates to a traffic issue that needs to be dealt with as soon as possible.

It was pretty much agreed that incentives may not be workable in all jobs. But if a matrix could be developed regarding incentives for superior performance, everybody would win in that situation.

Additional points raised in workshop discussions:

Use of Intermediaries

- One effective tool can be the designation of a facilitator to act as a third party who sets procedures for settling disputes up front.
- Florida has been using a system which involve scheduling a three-day session to put all issues on the table with everyone involved to ensure all parties understand what is expected of them. This process is now incorporated as a part of Florida contracts involving work zones. It offers professionals a way to solve problems without the situation becoming adversarial.

The process starts at the time the contractor is selected; meetings are held before construction planning sessions take place.

At the first meeting the parties discuss:

- expectations—on-time, in-budget, no claims, etc.
- dispute resolution—how issues are decided and by whom.

A document is signed to confirm what has been agreed and this serves as a resource in the event disputes later arise. It specifies deadlines for action (i.e., a time line for resolutions, etc). This helps speed the process because all understand their roles in advance.

BENEFITS OF PARTNERING

- Exchange of ideas: Florida and Minnesota use retired contractors to review plans and give their valuable perspective.
- The biggest advantage is in the decision making process—things move more efficiently.
- Issues can be negotiated onsite.

Speed Enforcement in Work Zones

- Contractors' biggest concern in work zones is speed and the closeness of trucks. For example, in Maryland there were once advisory speeds of 10-15 miles below posted speed, but these were not normally enforced until something tragic happened.
- There is a real need to educate the public about why speed controls are necessary. In addition, speed limits must be credible. It was suggested that speed limits be set based on the degree of exposure. In addition, the level of traffic control and enforcement would depend on the real need for the lower speed.

Public Awareness

- Dedicated funds are needed to improve public awareness of work zone safety issues; money for this purpose is available for NHTSA.
- In South Carolina, the public was surveyed on their response to work zones. To motorists, this seems to be a non-issue, because work zones don't affect them except to cause delays.
- Public programs that take a personal approach, such as those depicting families left behind when people are killed, can be effective.
- North Carolina developed a sign and two mascots (Buddy Barrel and Connie Cone). Materials were developed for distribution in meetings, at the state fair, etc. Truckers can also be allies in this effort.
- Though many States have developed public awareness programs, the USDOT has not produced anything outside NHTSA. DOT could be a catalyst for a national campaign.
- In South Carolina, public service campaigns aired through commercials and news broadcasts have made a difference with motorists.

Recommendations

- Coordination among agencies about detour and alternative routes.
- Establish driver call number to report violations (as in HOV lanes).
- Driver education on safety.
- Upgrade driver's license requirements to include safety awareness.
- Produce videos on work zone safety, PSAs, etc.
- Consider closing roads when necessary.
- Do more night work.
- Find alternative routes or detours (using traffic impact analyses to demonstrate needs).

Incentives

- In high-volume areas such as Virginia, traffic volume has outpaced our ability to work in a window (e.g., between 9 a.m. and 3 p.m.); so night work is about the only option left, but it requires a lot of preparation. Daytime windows don't work because construction trucks can't get to the site and still back up traffic. In addition, during holiday travel weekends, hunting season, Memorial Day, etc., there are problems because of heavier traffic volumes.
- Jobs with high liquidated damages force contractors to plan well. A downside of incentives is that a contractor may push to get the work done quickly but the work may be less than the best quality.
- Worker safety is an issue of concern: every hour and day the job is done sooner means less exposure by workers to risks.

Training

- Training is addressed in ISTEA's section on the national program. DOT oversees training and certifications procedures.
- ATSSA offers a course and certificate in a three-day program.
- Rhode Island has union problems with certification because different groups are in different unions; some subcontractors attend the courses; the problem is getting flagger certification. FHWA helps with the classroom programs, which are growing but not yet well organized.
- Maryland requires certification of traffic managers. Delaware uses a national certification program; it is not required for flaggers. Some States use retired personnel on call and say this works well.
- Twenty States require certification of flaggers; however, there is a lack of consistency with setup, and flagging procedures sometimes cause problems for motorists.
- Virginia has developed its own certification program, and as a result professionalism has improved.

Cost Factors

- In North Carolina, if changes are safety related, authorization on the job is unlimited. There are advantages to reducing or eliminating bureaucracy.
- Accident reports should be required under contracts. A safety person should be on staff; if the contractor's personnel perform this function, no one from the State should be needed in that role.

INTERACTION WITH PUBLIC AND HIGHWAY USERS

Maj. Thomas H. Milldebrandt

Criminal Justice/Traffic Law Enforcement Consultant

Two identical panels were held, with a total of 27 participants contributing during the discussions. The participants represented such diverse disciplines as law enforcement, State and local highway administration, organized labor, public utilities, public relations, Federal highways, equipment manufacturers, and transportation associations.

The panel discussions and recommendations are grouped in six principal areas:

- Problem Identification
- Funding
- Education
- Driver Licensing
- Credibility
- Open Communication

PROBLEM IDENTIFICATION

It was unanimously agreed that to make any public information drive successful we must identify the areas that pose the most problems to drivers in work zones. This process begins with compiling far more extensive and accurate crash statistics, including total, property damage, injury, and fatalities data. Although a single fatal crash is extremely significant to those directly involved, using the published national figure of 700 fatalities in work zones fails to signify a significant national concern.

Meaningful data could be collected using statistically recognized sampling techniques. When collected, this information should be disseminated nationwide to all concerned agencies, including national and local media outlets.

Although this problem identification effort is desperately needed, while the statistics are being gathered and disseminated, the highway and law enforcement agencies should make maximum use of the shock value of local tragic work zone crashes.

More research into human factors needs to be conducted in order to firmly identify the driver's needs in work zones.

FUNDING

It was the consensus of the panel that if we really are as serious about work zone safety as ISTEA suggests, legislatures must then provide the funding necessary to fully educate the public, provide more police presence on the highways, and train the parties involved. Every possible approach to increasing safety in work zones starts with Congress and State legislatures appropriating the funds necessary to implement new ideas.

These activities include producing and disseminating public information through safety videos, television and radio commercials, mailers and driver education material. Funding is also critical to provide for essential police enforcement and direction within work zones.

EDUCATION

We must better educate all parties involved in work zone safety, including contractors, workers, law enforcement personnel and the motoring public. The panel viewed a traffic safety video entitled, "Getting Past the Orange Barrels," produced by the AAA Foundation for Traffic Safety. This is an excellent example of an educational tool that is already available. More use should be made of this video, and additional materials are urgently needed.

Work zone safety needs to be emphasized at all educational levels, beginning in elementary schools and continuing through driver training and driver's license testing.

DRIVER LICENSING

The panel recognized an alarming deterioration nationwide in the level and quality of training and testing of new and experienced drivers.

Driver licensing procedures seem to have become focused on revenue generation rather than education and testing to put qualified operators behind the wheel. This is having a deleterious effect on motor vehicle operation in general and work zone safety in particular. Of great concern to the panel was the lack of regular reexamination of all drivers and inadequate vision testing of elderly drivers.

CREDIBILITY

Transportation agencies in their traffic control plans, contractors in their implementation of these plans, and enforcement agencies in requiring compliance must be consistent in their efforts. Otherwise, the motoring public becomes desensitized and disgusted with work zone areas.

Currently speed zoning in work zones is often decided arbitrarily, in some cases by statute. In order to gain credibility with the motoring public such limits should be set based only on practical and proven engineering standards. Mississippi's attempt to set such limits, "A Methodology for Establishing Speed Limits in Work Zones," was discussed and seemed to hold promise.

OPEN COMMUNICATIONS

There must be open communications among officials, contractors, laborers, transportation agencies, Federal officials, State legislatures and Congress. All parties involved in work zone safety must work together to exchange ideas so that everyone shares the same information and understands each other's problems. Conferences like this one are a good start, but we need to expand them to include Federal and State legislators.

We need a national program, a unified front, so that individual jurisdictions do not have to create and recreate workable solutions to the same problems.

INNOVATIVE IDEAS

While much of the panel's attention was focused on problems and needs, several innovative ideas were presented that seemed to be headed in the right direction:

1. The New Jersey State Police has received funding for a Work Zone Safety Unit comprising 24 officers who are dedicated to full-time duty enforcing construction safety regulations. Six of these officers assigned to each geographic region enforce all regulations in work zones, with emphasis on speed enforcement and ensuring proper signing as required by the State's Traffic Control Plan (TCP).
2. In Oregon, the State Legislature provided for eight new officers. The State Police apportioned monies to existing officers statewide to provide dedicated "on duty" officers in work zones.
3. In Maryland, the State DOT regularly conducts "peer reviews" of work zones. They ask selected citizens, usually from civic organizations, to drive through a work zone. No pre-briefing is given and only two questions are asked after the drive-through: "Did you feel safe?" and "Did you know where you were going?" Answers to these questions give MDOT valuable information on which to base changes to the reviewed work zone and future TCPs.
4. The Rhode Island State Police assign four or five officers to work selected work zones at night. One unit is placed at the beginning of the work zone and the second at the beginning of the taper. The officers in the second unit are out of the vehicle, making their presence obvious. Funding for this type of assignment is written into construction contracts.
5. Minnesota DOT has funded a public education program in which second graders are introduced to work zone safety through activity books. This program is fully funded at about 30 cents per pupil.
6. In Arizona and Vermont, city newspapers carry regular daily announcements about where construction is going on so motorists can avoid it if possible.
7. In Nevada, organized labor is lobbying at all levels of Government for increased awareness of, publicity about, and enforcement in work zones.

In response to a questionnaire, panel members in general thought that "the jury was still out" as to whether or not current programs to double fines in construction zones were productive.

Additional points raised in workshop discussions:

Enforcement Agencies' Role

- The police should be involved in developing Traffic Control Plans. Too often, if involved at all, they are called in at the last minute simply to be instructed in their anticipated participation.
- Enforcement agencies are notoriously undermanned and are consequently reluctant to dedicate manpower to areas other than those of the highest priority. In order to garner support for work zone enforcement, police administrators must be sold on its importance to their total police mission.
- One of the most effective ways of assuring an active police presence in work zones is to make provisions in the construction contract for the employment of off-duty officers. This guarantees uniformed officers in marked patrol cars during construction activities. Often, however, this manpower is underutilized by the lack of clear-cut assignments, training and supervision of these officers.
- Besides providing for off-duty officers, increased police participation in work zone safety can be accomplished by training area supervisors and patrol officers in the provisions of Chapter VI of the MUTCD in general and the current Traffic Control Plan in particular.
- The police should have authority to cite those responsible for implementing and maintaining the Plan when they do not comply, as is the case in Arizona.

Educational Programs

- Public education programs are needed to better inform the public concerning the hazards of work zones. Efforts are needed to reach various segments of the public, including all motorists, older drivers, children, contractors, construction workers, police, and highway officials.
- Tools that are effective in reaching the public include radio, television, newspapers, outdoor signs, and direct mail.

Ideas That Seem to Work

- Vermont created a public relations campaign involving "Reggie Radio," a cartoon character who promoted work zone safety. This seemed to spark the public's interest and get them more involved.
- Persuade local news media to enter a work zone with a camera and reporter. This makes a great public interest story, alerts the public to work going on in the area, and reminds them that work zones are dangerous.
- Continuously run instructive videos in state driver licensing offices. That way they are viewed while the motorists stand in line for licenses.
- Make fines in work zones include demerit points as well as doubled fines. One could model the idea around the existing legislation regulating school zones.
- In New Jersey, when projects are bid, the hours of "traffic director" time are contracted and added to the contractor's bill. The officers are then assigned to a job. When the six officers are all busy, the State then uses off-duty officers to cover the remaining jobs. Thus, officers are trained as well. The program is partially funded through a combination of DOT and FHWA funds and receives a lot of support.
- New Jersey also has created Snow Emergency Rooms, where police with weather condition information can call back and alert the Room to where snow crews need to be dispatched.

Jerry L. Graham, P.E.

President, Co-Owner and Founder
Graham-Migletz Enterprises, Inc.

In my consulting practice I spend a great deal of time developing and presenting work zone training courses for engineers, technicians, and flaggers. These courses detail the standards and guidelines used in planning and setting up work zone traffic controls.

A question often asked by my students is, "Who is educating the driver about the meaning of work zone traffic controls?" How many of you feel that even 10 percent of drivers know the meaning of the stripes on barricades? A device as powerful as the arrow panel may have an intuitive meaning to many drivers, but who is telling the driver what is meant by the caution mode on an arrow panel?

There are some efforts underway to educate the public, but much more needs to be done. The State of Iowa has recently added a work zone question to their driver's test, and Minnesota has an educational program for elementary schools called, "What's Your Orange I.Q.?" For our discussions here, I reviewed a number of drivers' manuals to determine how much information they include about work zones.

One organization, the AAA Foundation for Traffic Safety, sponsored a video that was produced by Graham-Migletz Enterprises, Inc. This video is meant to educate drivers about the meaning of many of our common work zone safety devices. I believe that educational materials like this video should be required viewing when obtaining a driver's license.

The unfortunate truth is that you can obtain a driver's license in most States with very little knowledge of work zone traffic controls. Is this situation fair to the people who must work on our streets and highways?

Another obvious way that we affect drivers is the way that we set work zone speed limits. Graham-Migletz Enterprises, Inc. has been studying the methods States use to set speed limits in work zones. Some States have a blanket speed limit that must be installed in every work zone. These limits are often mandated by well-meaning legislatures. However, the effects of the reduced limits on accident rates in work zones would probably surprise most of the politicians responsible for imposing these mandatory limits. Simply lowering the work zone speed limit can actually *increase* accident rates!

Our panels covered two primary topics: public information and use of enforcement techniques. The participants recommended that FHWA and NHTSA increase efforts to get information to drivers about work zones. Two videos were viewed that could be useful in accomplishing this. These should be available at offices where licenses are renewed.

Enforcement is not a panacea for poor traffic control practices, and should be planned and coordinated with enforcement agencies. Traffic control plans should be designed to accommodate enforcement efforts.

Additional points raised in workshop discussions:

The participants made the following observations about issues related to interaction with the public:

- Creative funding mechanisms for educational programs are needed. Suggested resources include grants, FHWA, and contractors. South Carolina has produced an effective video on speeding through work zones.
- Work zone safety education should begin in childhood. Pennsylvania has developed a successful program to educate children.
- Industry and agencies should work with the National Safety Council to integrate work zone safety into their programs.
- Citizen peer review also can be effective. In North Carolina, there is a work zone safety team comprising contractors, DOT and law enforcement representatives, and EMS personnel who meet to discuss current work zones in the State.
- Enforcement capabilities can be enhanced through better communication between the project manager and troopers, the placement of police cars in work zones, and proper accident reporting.
- The FHWA should develop a users guide to highway construction and work zones that States could distribute and use for their own educational programs.
- Work zone safety information should be disseminated through driver education programs and coordination with organizations, including the AARP.
- Every license renewal should include eye exams to test ability to comprehend shapes and colors.
- There should be greater focus on proper signage in work zones; it was recommended that penalties be imposed for improper signage.
- Highway advisory updates on the radio are desirable, but reports should be updated regularly to maintain credibility and drivers' confidence in the system.
- States should consider awards programs to recognize contractors with low accident rates in work zones.

ADVANCED TECHNOLOGIES

Dr. Ray Benekohal

Associate Professor of Civil Engineering
University of Illinois at Urbana-Champaign

A total of 35 people participated in two three-hour Advanced Technology sessions. They represented private companies, Federal, State, and county governments. The following five topics were discussed:

- I. Future of the industry
- II. New safety devices, technology and reflectance standards
- III. Information gathering techniques and devices
- IV. Institutional issues (barriers)
- V. New traffic control devices (TDCs), novelty effects and uniformity issues

The issues identified and the recommendations are summarized here.

I. FUTURE OF THE INDUSTRY

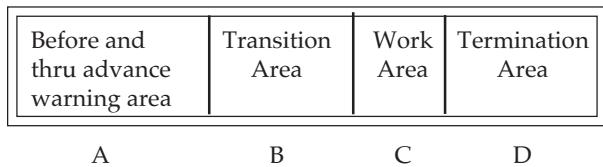
The traveling public will be seeing more work zones in the future as the highway systems undergo rehabilitation and maintenance. Advanced technologies can be helpful in making work zones safer and more efficient. The following points were made in the sessions:

1. We must consider safety of workers and drivers as well as travel needs of drivers.
2. We will see more work zones in the future, and more nighttime work zones.
3. More active TCDs should be used as opposed to the current passive TCDs.
4. We need to do more public relations and educate everyone involved about work zone safety.
5. We need better definition and understanding of work zone problems to find more effective solutions.

6. Industry should use advanced technologies to promote and improve work zone safety. Advanced technologies are not just electronics, but includes new materials, procedures, and processes.
7. Using real-time work zone traffic control is a viable option and should be encouraged. However, there are issues related to cost, its utility on all roads, and getting approval of their use.
8. Increase cooperation among and involvement of all parties involved (e.g., trucking industry, law enforcement, and local government).
9. We have to deal with diverse groups of motorist in work zones and need to be aware of their capabilities and limitations (e.g., impaired-normal, older-younger, and truck-car drivers).
10. Enforcement of the existing laws is a challenge now. How will the future laws due to advanced technologies will be enforced.
11. It should be realized that the industry mainly responds to the needs and often times does not lead.
12. Different levels of protection may be needed depending on the type of road and volume of traffic. One work zone traffic control solution may not fit every condition.
13. Promote safer design of work zones for prevailing speed (realizing that speed reduction will not always work).
14. Provide re-routing traveler information on a real-time basis.
15. Do not overload drivers with messages, there are already a lot of signs in work zones.
16. Credibility of on-line messages must be high; otherwise, they will not be effective.
17. Cost of new traffic control devices is a concern.

II. NEW SAFETY DEVICES, TECHNOLOGY AND REFLECTANCE STANDARDS

New traffic safety devices and technology can help to improve work zone safety and provide real-time information to drivers. The definition of "work zone" was broken down into four areas and recommendations were made for each.



The recommendations for area A are:

1. Notify drivers (audio, visual) on condition and status of work zone on real-time.
2. Provide re-routing options.
3. Promote advance trip planning and work zone notification.
4. Develop seamless traffic management system for better congestion control on work zone, detours and alternate routes.

The recommendations for area B are:

1. Develop positive (visual not necessarily physical) guidance systems that are interactive.
2. Use advanced technologies to increase compliance on placement of TCD.
3. Intrusion alarm for drivers and workers but don't over do it.
4. Explore the feasibility of using new devices and paving materials to warn the out of control vehicles (there was some support for this).
5. Explore the feasibility of using interactive lighting, marking and visual aids (e.g., sequential lighting).

The recommendations for area C are:

1. Use warning devices that rely on more than audio aids.
2. Study how new materials and techniques can reduce duration of work zones.
3. Improve delineation of work space and reduce distraction to drivers.
4. Explore the use of more robotics devices for work or flagging.

5. Explore improving enforcement by electronically monitoring speed of individual vehicles (e.g. using ID tags).

6. Consider lighting roadways under construction.

The recommendations for area D are:

1. Study further delineation of termination area so vehicles would not race to get to the open lane.
2. Explore feasibility of sequencing vehicles out of work zone speed.

Additional recommendations were made to improve overall work zone safety:

1. Explore providing horizontal guidance (e.g. wet reflective pavement marker).
2. Promote evaluation and use of new devices and determine their benefits.
3. Provide additional dedicated flexible funds for developing and evaluation of new devices.
4. Maintaining uniformity was a concern.
5. Promote "partnering" and bring in a broad range of people.
6. On reflectance standards the following recommendations were made:
 - Support setting retroreflectivity standards/guidelines.
 - Continue studying ways of improving visibility of work zones (e.g., night vision or use of wider letters).
 - Pursue development of low-cost-more-efficient retroreflectivity inspection or measuring devices.
 - Encourage development and evaluation of new retroreflective materials.

III. INFORMATION GATHERING TECHNIQUES AND DEVICES

1. Develop more uniform and consistent criteria/procedure for accident reporting.
2. Use advanced technologies to gather more comprehensive and more useful accident data.
3. Develop computerized work zone data collection devices, including hardware and software.

4. Measure accident exposure rates for work zones.
5. Provide education and training to staff/operators on how to use the advanced technologies or new devices.

IV. INSTITUTIONAL ISSUES

1. Consider life-cycle cost concept (including accident cost) in assessing the benefits or costs of using advanced technologies or new devices.
2. Need to clarify what category of funding can be used for new traffic control devices (TCDs).
3. Need more flexibility on trying new work zone TCDs.
4. Study liability issues and effect tort reform.
5. Provide information clearinghouse on the use of new TCDs.
6. Establish new category of funding for testing or development of new TCDs.

V. APPROVAL OF NEW TCD, NOVELTY EFFECTS AND UNIFORMITY ISSUES

1. Utilize available channels for testing of new devices such as NTPEP and ASCE's Hi TEC.
2. Novelty effects of new devices is a concern.
3. Uniformity of devices/procedures is a concern because travelers expect that.
4. Enforce the existing laws/regulations to increase the effectiveness of TCD.
5. Enforce existing specifications in MUTCD on setting up traffic control plans.
6. Provide adequate funding to address work zone safety.

Dr. H. Gene Hawkins, Jr.

Associate Research Engineer and Program Manager
Texas Transportation Institute / Texas A&M University System

Many of the findings from our workshops have already been described by the previous speakers.

I presided over two very interesting, but different, workshops. The discussion in the first workshop tended to be more general and covered a wide range of topics. Not only did we talk about advanced technologies, but we also discussed some low-tech applications for safety devices and retroreflectivity. The second day's workshop, on the other hand, discussed far fewer topics, but went into much more detail on those subjects. The participants in both workshops often went off on tangents which were related to our subject matter, but were outside the scope of the workshops. However, when I reviewed my notes in preparing these summary comments, I found that the recommendations from both workshops were amazingly similar.

These are the major recommendations that resulted from one or both of the workshops on Advanced Technologies:

- At the beginning of each workshop, I asked the participants to describe what they thought work zones would be like 50 years from now, in the year 2044. Their thoughts were that most of the work zones would be physically separated from the traveled way, the MUTCD would be in an electronic format contained within the vehicle, traffic in work zones would be controlled with portable traffic management systems, lighting would be better, and many aspects of the vehicle/roadway system would be automated.
- Early in the discussion, we agreed that future emphasis should be on "work zone traffic management" instead of the more traditional "work zone traffic control." We will have to learn to do a better job of managing our traffic in work zones instead of just trying to control it while it is in the work zone.

- For drivers to respond properly to work zones, they have to have confidence in the information given to them. A recurring theme of the discussions in both groups is that advanced technologies should be used to improve the timeliness and accuracy of the work zone information being presented to drivers.

- Speed control was a popular topic in both workshops. One group felt that technology should be used to reduce speed differentials in work zones by slowing down vehicles traveling at excessive speeds.

- Obviously, any discussion about advanced technology applications in transportation must be considered within the framework of Intelligent Transportation Systems. However, ITS has not really considered work zone applications as a specific element of the overall system. Both of the workshops recommended that Work Zone Traffic Management become a component of ITS. We even developed some User Services for work zones. These include:

- Intrusion alarms
- Crash alarms
- Automated vehicle positioning
- In-vehicle work zone information
- Pre-trip work zone information
- Vision enhancement.

- The ISTEA program should be revised to require a work zone safety management system.

- A few of the specific applications for advanced technologies include:
 - Continuous lighting
 - Complete separation of vehicles and work areas
 - Wider use of automated traffic control
 - Use of advanced technologies to ensure that traffic control devices are in place and functioning
 - Vehicle speed control technologies to reduce the speed of vehicles traveling faster than the rest of the traffic stream
 - Use of camouflage to hide work zone activities from drivers
 - Electronic drivers' licenses could be used to identify the specific individuals who are violating traffic regulations.
- Implementation of new technologies into actual practice is a difficult undertaking in the best of circumstances. Both groups indicated a need to streamline the procedures by which new technologies and / or devices are brought into practice. One of the groups indicated the need for a national system or clearinghouse to ensure uniformity of systems. Also, economic incentives are needed to encourage contractors to implement new technologies and to be accepted by agencies. The use of national demonstration projects may be useful for gaining acceptance of advanced technology applications for work zones.
- One of the groups emphasized the need to improve nighttime and wet weather visibility in work zones. Some of the suggestions included:
 - Wider edge lines
 - More lighting, including temporary high mast lighting
 - Wider use of strobes
 - Greater use of RPMs.

• The two groups had completely opposing opinions on one subject: The first day's group felt that congestion pricing may have a role in work zone management. The second day's group completely opposed the idea.

• With respect to the proposed retroreflectivity standards, the first group had a few comments. For the standards to have any real meaning, they must be something that can be implemented and measured by field personnel. Some suggested that different standards may be needed for work zone applications.

• Both of the workshops also recognized that the effectiveness of advanced technologies will be limited by the capabilities of the field personnel who will have to implement them. Therefore, proper training of field personnel is a vital element of any effort to bring advanced technologies to work zones.

As a final note, I would like to thank ARTBA and FHWA for putting on this conference. I would also like to extend my appreciation to ATSSA, AASHTO, and the other contributing organizations for their support of this conference.

I really don't believe that the comments we have heard today are anything of an earth-shattering nature. We have heard most of them before, and I think that a group of three or four individuals could have developed the same recommendations if they had been locked in a room for two and a half days. However, the value of this morning comments is that they were developed through the efforts of some 200 highly knowledgeable individuals who represent the future of this industry. The collective contributions of these individuals give the results of this conference a legitimacy or authenticity that would not be present if the recommendations were developed by a single consultant or agency.

Additional points raised in workshop discussions:

Retroreflectivity Considerations

- Definitions of both too little and too much brightness.
- Use of larger signs and / or brighter signs to improve the conspicuity of signing.
- The application of different procedures in work zones for measuring and implementing retroreflectivity standards.

Miscellaneous Ideas

- In-vehicle technologies should be developed for automated vehicle guidance, to provide advance information to stimulate driver attention, and to warn drivers of impending crashes (e.g., alarms).
- Use advanced technologies to improve the acquisition of data used for work zone traffic management.

- Develop technologies that can vary the light output of devices according to the amount of light that is appropriate for a given situation (dark night, dawn, dusk, rain, fog, snow, etc.).
- To take full advantage of emerging technologies, it will be necessary to improve processes for implementing new developments. This may be accomplished through:
 - Economic incentives to encourage contractors to adopt technologies which can improve safety.
 - Economic incentives to encourage contractors to comply with existing standards.
 - Wider use of demonstration projects to gain governmental agency acceptance of advanced technologies and assist in the implementation in areas of identified need.

OUR ROLE IN THE PROCESS/ FUTURE OF WORK ZONE SAFETY

CONCLUDING REMARKS

Dr. Nicholas J. Garber

Professor of Civil Engineering
University of Virginia

ARTBA has asked me to offer a few closing remarks in summary of this Conference. This will prove difficult, but I believe there are at least a few points that I can make here.

One of the major themes we have discussed relates to the characteristics of the people who are using the road. We need some research in this area, and some data, so we can identify the characteristics of those users, including drivers and pedestrians. Both the workers and the drivers must be educated as to the problems of work zones and how they can cooperate in realizing some of the goals we need to achieve.

Another important topic that was established here is the need for positive and negative contractor incentives that are related to performance.

Most of the groups also recommended reducing exposure of motorists to work zones.

With respect to the implementation of work zone safety, several factors were identified: enforcement of standards, developing incentives to agencies and workers, law enforcement, development of a "safety culture," and improved quality assurance.

With respect to speed, a new term, "speed management" was suggested. While we do not want to increase the number of situations in which speed must be varied, at the same time we have to be able to identify the correct speeds for work zones and the means to bring drivers to comply with the reduced speeds in those zones.

Partnering is also considered a very effective method to achieve a greater measure of work zone safety. It has been suggested that with respect to exposure and construction, the best way of paying for work zone traffic control could be a combination of both unit cost and lump sum. We should also consider specific means by which we could reduce the duration of the contractor activities and thus decrease exposure.

Another important issue relates to means of segmenting traffic in terms of speed and volume (high speed/high volume, medium speed/medium volume, low speed/low volume). This is something that can't be done right now, but it is something we should keep in mind.

With respect to advanced technologies, one important factor which has been noted is the need for real time traffic control devices. The motorist entering a work zone wants to know what's happening now, not what was happening two hours ago. So developing means to get that information to the driver is essential. In addition, there should be an effort to make data collection in work zones easier and more detailed. How those data might be collected—whether by police officers or work zone employees—and identifying what type of data are needed also are important issues.

Also it has been suggested that additional funding for congestion management and work zone safety should be strongly considered.

Finally, it was recommended that cooperative efforts among ARTBA, ATA, FHWA, AASHTO, State Departments of Transportation, NHTSA, and other associations are needed. Unilateral efforts may not be as effective as a cooperative effort. The establishment of a national clearinghouse may be one step by which we can better disseminate the information that is generated through these efforts.

Where do we go from here? It is the individual responsibility of each of us as we leave here today not to forget what we have been discussing over the last three days, but in every little way, in every action that we take, whether in designing or in supervising construction or in supervising contracts or in manufacturing, we should make the effort to achieve and implement the constructive ideas we have heard here.

Having said that, I would suggest to ARTBA and FHWA that once these proceedings are published, it would be very useful to have more regional conferences where these issues can be discussed in detail, where additional issues may be raised, where additional ideas can be addressed.

Let me take this opportunity on behalf of ARTBA, FHWA, AASHTO and ASSTA to thank you for participating in this Conference. It is fantastic, the amount of work which has been accomplished here in the past three days. I also want to thank the cooperating organizations who sponsored and put together this program. It will go a long way toward bringing us all to a better understanding of work zone safety and how it can be enhanced.