

variety of areas. This may be viewed as both a strength and a weakness of the structure of the break-out group format. On the other hand, specific recommendations germane to only a narrow area of concern sometimes did not emerge. However, in their place, broader and more basic needs were revealed that had relevance not only to the crash/accident typology under consideration but also to many aspects of highway safety research. No attempt was made to redirect groups when this kind of movement away from the assigned problem area occurred.

As one would expect, many Research Problem Statements (RPSs), both within and between break-out groups, overlapped to a certain extent in terms of their overall focus, their relevance to other RPSs, or both. While some attempt was made to combine those that seemed too similar to warrant a separate listing, the reader will note that a certain amount of overlap remains.

Finally, while each of the topic areas is presented in the general priority order suggested by the individual workshop sessions, the rankings reflect the biases of those present at the workshop. By the same token, the time needed to complete the research and the costs were the workshop participants' best estimates and should be considered in that light.

KEYNOTE ADDRESS

THE NEED AND POTENTIAL FOR HUMAN FACTORS RESEARCH IN HIGHWAY SAFETY

Dr. Patricia Waller, University of Michigan Transportation Research Institute

Historically we have defined transportation as the safe and efficient movement of people and goods. This traditional definition has served us well, and the system we have built on this foundation has given us the safest highway transportation, based on miles traveled, of any country in the world. Over the past thirty-five years, our Interstate highway system has transformed transportation in ways that those who cannot recall the roads prior to that time can never fully appreciate. I can remember waiting in a long line of vehicles in Georgia while another line of vehicles moved slowly, single file, from the other direction, crossing a long wooden plank bridge that sat barely above the water level over an enormous Georgia swamp. I grew up in South Florida, and it was a major accomplishment to get from there to any other state. We have much to be

proud of and we have many professionals to whom we owe a debt of gratitude.

REGULATORY INCOMPATIBILITIES

Nevertheless, the highway transportation system that we designed failed to take into consideration much of the human dimension. For example, there are built-in incompatibilities. In fact, on at least two occasions the Transportation Research Board (TRB) has created a subcommittee or a task force to try to address some of these incompatibilities.

It is probably not very surprising that incompatibilities exist, when it is recognized that the three major components of the highway transportation system fall under three largely separate authorities. The highway itself has traditionally been dominated by the thinking and the standards established by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and state highway departments. The driver, on the other hand, is under the jurisdiction of state licensing authorities, with some overall guidance (but not to the same extent as in the case of highways) from the American Association of Motor Vehicle Administrators (AAMVA). Finally, the vehicle is pretty much what the industry designs and is able to market. While we hear a great deal about vehicle regulation, there is really relatively little in comparison with the range of decisions left to the individual manufacturer. When, in response to the fuel crisis in the mid-1970s, cars became smaller and trucks became larger, the roadway was ill equipped to accommodate the new vehicle mix. The guardrail that had redirected the 4,000-pound car was likely to overturn the 2,000-pound car. It became necessary to provide a guardrail that would protect not only the smaller car but also the larger, heavier truck.

When it comes to the driver, the problems are even greater. We license persons whom the highway system does not "fit." For example, the standards for signing established by AASHTO and FHWA require 20/20 to 20/30 vision in daylight when the sign is new. Yet virtually all states license drivers who meet a criterion of 20/40 vision, and most states will license drivers with vision as poor as 20/70. And the licensing standards have to be met only at the time of licensure. In some states, after initial licensure the driver may never have to reappear. Signs may remain posted long after their visibility has greatly diminished. Yet drivers are held responsible for being able to see the sign that they may not have been able to see at the time of initial licensure!

In spite of the fact that states persist in describing a driver's license as a privilege, the Supreme Court on

more than one occasion has ruled that it is very close to being in the nature of a right. States may not deny or revoke licensure without due process. Furthermore, from a much more realistic political standpoint, state legislators are very reluctant to enact measures that would result in severe restriction of one's access to the roads, and state administrators and bureaucrats are even more reluctant to use the authority they already possess in ways that might inconvenience the public -- or, worse still, offend their constituency.

Witness the fact that it took decades of effort to achieve special evaluation for licensure to operate a motorcycle on the public roads. Anyone who thinks that a regular driver's license is sufficient to qualify one to operate a motorcycle has never tried to do the latter. And it took even longer to get any special requirements placed on the license to operate a tractor-trailer. When Congress enacted legislation in 1986 that would eventually require that operators of tractor-trailers demonstrate some competence to operate such a vehicle before driving it on the public roads, something like nineteen states still had laws that allowed an applicant to take a road test in a compact car and obtain a license to operate a tractor-trailer in any state in the union. The same applicant could operate doubles in any state except Connecticut. The full implementation of the 1986 legislation is scheduled to be complete as of today, although there has been grandfathering and, in at least one state, a provision allowing the knowledge test to be handled through a take-home arrangement. You need to keep in mind that those take-home applicants will be driving through your state.

THE AGING DRIVER

The aging driver is another area where the highway transportation system has failed to address the needs of the users. Driver licensing programs, to the extent that they have been designed at all, have been designed to qualify young beginning drivers. Vehicles still do not very adequately address the needs of older drivers and passengers. Anyone who has ever tried to read the dashboard at night in a rented car while wearing bifocals knows how much attention has been paid to the older driver. And highways are designed on the basis of standards developed primarily from performance measures obtained from young men. When it comes to the older driver, I am reminded of a response I received from a student to a question on a final exam. He said, "Dr. Waller, you have opened a whole new field of ignorance to me!" That's about where we stand when it

comes to how much we know versus how much we need to know about the older driver.

TRANSPORTATION IN THE LARGER SOCIAL FRAMEWORK

While it is true that our traditional view of transportation as the safe and efficient movement of people and goods has served us well in the past, it has also failed to take into account the larger social framework in which we operate. Transportation is concerned with the safe and efficient movement of people and goods, but it is much more than that. Transportation is an integral part of what we might consider access to full participation as a citizen in our society. Transportation is inextricably related to education, health care, employment, recreation, maintenance of ties with family and friends, and virtually every important dimension of what makes life worthwhile.

Back in the 1950s, when I was a clinical psychologist, the Federal government helped to fund mental health clinics across the nation. Fees were based on a sliding scale related to one's income. The underlying rationale was that mental health care should be available to everyone independent of one's ability to pay. However, it became apparent that transportation was a major barrier to the participation of some portions of the population, just as transportation is a major barrier to access to other kinds of health care, and to education, employment, and all the rest.

Our Interstate highway system was immensely successful in what it set out to achieve. At the same time, the Interstate highway system was a significant factor in the creation of some serious social problems with which we are currently grappling. We built superhighways and we manufactured and sold supervehicles. Those who had the wherewithal purchased the vehicles and used the highways and moved out. In the process we left behind an inner city population with no influence and no affluence. When those with the power and influence moved away, they took with them much of what had sustained the social support systems -- education, health care, cultural activities. These support systems deteriorated, leaving the inner city with limited access to what enables us to become fully participating members of society.

Problems that often originated in the inner city are now creeping into society as a whole. Gradually we are recognizing that they are no longer somebody else's problems. They are everybody's problems, and they are

affecting virtually every aspect of our lives, including our ability to compete economically.

This workshop is not designed to address these larger issues, although they need to be addressed. Efforts are being made elsewhere to initiate a mechanism or mechanisms for considering how we might learn from the past and apply such knowledge to our future programs in transportation. The reason I raise them now is to provide a background for the deliberations of this workshop, a background that reminds us that we need to be mindful of how our activities fit into the larger picture. If we conceive of transportation as simply the safe and efficient movement of people and goods, it is easy to think simply in terms of knobs and dials and displays and how they can best be used by people very much like ourselves.

On the other hand, if we consider transportation as an essential and integral part of our total society, a dimension of our society that enables individuals to function and communities to work, then we need to take into consideration how the systems we are designing may be used by a wide variety of participants -- young, old, educated, not so educated, English-speaking and others, short, tall, fat, and thin, arthritic, distracted, motivated, disinterested, rich, poor, and so forth. We need to consider not just the system itself but its ease of understanding, its ease and cost of acquisition and maintenance, its accuracy and reliability, etc. Incidentally, I have heard nothing so far concerning the human factors issues in maintenance of the electronic equipment that will control the Intelligent Vehicle/Highway Systems, yet maintenance will become more critical than ever, in light of potential product and tort liability.

NEW TECHNOLOGIES AND THE DRIVER

In designing and evaluating new technology and new systems, we need to include the full spectrum of users. For example, using volunteers in the evaluation of our proposals is not adequate. We have to devise ways to include subjects who are more truly representative of those who will eventually be functioning on our modified highways.

The task seems overwhelming. It also means that we need to break out of our traditional ways of thinking about what we do. We need to consider how we might modify the larger system, that is, how we design access to the system. In May I presented a paper at IVHS America on the possibilities for redesigning driver preparation and driver qualification for using IVHS technology. We do not need to limit our deliberations

to the status quo so far as the human element is concerned.

While it is true that the human component of the system is basically unchanged from what we were 50,000 years ago, it is also true that we are capable of learning. Every developing country witnesses a rapid drop in highway fatality rates as the users become more accustomed to the system. It has become popular in some injury control circles to assume that humans cannot be expected to change. While it is unrealistic to think that humans can compensate for every shortcoming in the system at all times, it is also the case that humans can and do learn. A former colleague of mine, on a trip to China, noted that the highway-safety experts paused and looked both ways before crossing the street. He asked whether they had engaged in such behavior as a result of genetic coding or was it possible that the human component had been modified by instruction and experience.

Anyone who has witnessed a son or daughter attempting to master the basic elements of controlling an automobile knows that the experienced driver has been modified considerably through learning. We need to keep this simple truth in mind as we consider how and when it may be appropriate to require short-term training and certification for using certain kinds of new technology.

This approach is not new. Ever so long ago, when I obtained my first driver's license, it was standard procedure for an applicant who took the road test in a vehicle with an automatic shift to have his or her license restricted to operating only vehicles with an automatic shift.

As we consider how new technology will interact with those who operate and maintain it, we need to include the highway engineer, the vehicle maintenance personnel, enforcement personnel, the court system, and all the myriad of participants in what makes our system more or less work. While this conception expands our responsibilities, it may also enhance our opportunities for success. It should give us a wider range of flexibility in how we go about solving our problems.

It will certainly tax our imagination, our ingenuity, and our expertise. One thing for sure -- it will not be boring!

SEEKING NONTRADITIONAL RESEARCH OPPORTUNITIES

As you know, this workshop is focusing on human factors research in highway safety. Traditionally we have thought of research that would be funded by the

U.S. Department of Transportation (DOT), that is, the National Highway Traffic Safety Administration (NHTSA) or the Federal Highway Administration (FHWA). However, we should not limit our thinking to the kinds of research that they might fund. Research needs may be identified that many appear to be more fundamental than those NHTSA or FHWA has previously been willing to consider. Nevertheless, we should not ignore such research issues if we agree that they are truly essential. On the one hand, we may be able to persuade DOT that they should and could fund such research. Failing that approach, if the research is critical to what we need to know, then we need to look elsewhere for funding. We cannot allow the constraints that have existed in the past to limit what we can do in the future. If we are to be truly competitive in a world market, we are going to have to do some things that will be radical departures from past practices. The field is desperately in need of new and innovative thinking and approaches. If we restrict ourselves to simply doing more of the same, we are, in effect, conceding defeat before we even begin. So, do not limit yourselves to whatever you think might be feasible based on past experience. Instead, remove traditional constraints and focus completely on what you see as the real information needs, be they methodological, theoretical, basic information on decision making, cognition, learning, or whatever else. This is not the time to hold back. Rather, it is an opportunity to plow new ground, fire new gray cells, and kindle new possibilities.

There has never been a more exciting time to be in this field, and there has never been a time when there has been greater awareness and appreciation of the critical need for the participation of this group of experts.

BACKGROUND PAPERS

HIGHWAY ISSUES AND HUMAN FACTORS KNOWLEDGE GAPS FROM THE ENGINEERING PERSPECTIVE

Traffic Operations, Highway Safety, and Human Factors

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INTRODUCTION

Traffic engineering is concerned with the safe and efficient movement of people and goods on streets and

highways. Traffic operations is the subset of traffic engineering that establishes the procedures that yield the movement of people and goods. The goal of traffic operations is to make those movements as efficient and safe as possible.

Traffic operations take place on streets and highways; thus there is a direct and important link between highway design and traffic operations. Facilities are designed to operate under specified conditions and within certain constraints. In order to operate, the system must exert some level of control; therefore, traffic control devices (TCDs) become important tools to the operator. The improper use of TCDs can have a serious adverse effect on traffic operations.

Perhaps the most challenging aspect of traffic operations is the human factor. While highway design features and TCDs are fixed or operate within a controlled set of parameters, the range of human (highway user) operating characteristics is enormous, diverse, and constantly changing. In other words, each driver and pedestrian represents a powerful, independently operating "computer" capable of sensing and analyzing information and making decisions. The presence of such power provides a tremendous resource for meeting our mobility demands if it can be directed and coordinated for the collective good of all traffic system users. Such a task is very difficult and complex because these "computers" often have limited communication abilities and skills, a diverse knowledge and understanding of the operating rules, and a unique ability to reason illogically, not to mention the compounding effect of human feelings and emotions.

This paper attempts to explain how the traffic operator currently aspires to the goal of safely and efficiently moving traffic. It also offers some thoughts about areas for further human factors research.

THE TRAFFIC OPERATIONS FRAMEWORK

Traffic operations takes a given highway system, integrates the travel demands placed on that system, and produces a system level of performance reflected by appropriate measures of effectiveness (MOE's). Each component of this simple framework is discussed briefly below.

The Highway System

The driver, vehicle, and roadway have from the earliest days of traffic engineering been the basic components of the highway system. In modern times, we have expanded the definition and description of the traditional trilogy. "Drivers" are now referred to as