NHTSA'S IVHS Collision Avoidance Research Program: Strategic Plan And Status Update

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ABSTRACT

Although crashes are relatively rare events, nearly 40,000 individuals are killed in motor vehicle crashes annually in the United States. Another 5 million are injured and the societal costs exceed $137 billion annually. These are unacceptable statistics that can be significantly reduced by improving the collision avoidance capabilities of motor vehicles. The maturity of advanced technologies provides the opportunity for major breakthroughs in assisting drivers to avoid crashes. This paper provides e status update on the National Highway Traffic Safety Administration's (NHTSA) program to facilitate development and early deployment of cost-effective, user-friendly collision avoidance systems. The program includes an expanding crash avoidance knowledge base; development of a vital set of research tools, including the National Advanced Driving Simulator; identification of crash avoidance opportunities; examination of key human factors and system design issues; and development of performance specifications for crash avoidance products and systems. These specifications will define performance characteristics in engineering and human factors terms and will help guide product development toward achievement of maximum safety potential.

BACKGROUND

Since the last ESV Conference in Paris in November 199 1, NHTSA has prepared a strategic plan to describe and guide its Intelligent Vehicle Highway Systems (IVHS) program (NHTSA, 1992), has received significantly increased funding support for the program (Fiscal Year 1994 budget of $14.5 million), and is currently implementing this program.

The mission of NHTSA is to reduce traffic crashes end resulting injuries and death. Traffic-related deaths in the United States in 1992 declined to the lowest point in 30 years and the fatality rate fell to 1.8 deaths per 100 million miles travelled, down from 2.6 in 1983, and now et its lowest in history. Many people now walk away from collisions that would have killed or seriously injured them a decade ego. The improvements in the fatality rate reflect increased use of safety belts, greater availability of air bags, improvements in vehicle crashworthiness, a growing awareness that traffic casualties are a major public health problem, progress against alcohol-impaired driving, and improved road design.

Until recently, technology did not exist to make significant improvements in the crash avoidance capability of motor vehicles above that offered by existing countermeasures, such as antilock brakes and center high-mounted stop lamps. Recent advances in electronics, control systems, processors, and communications now allow for the design of collision avoidance systems with increased sophistication, reduced cost, and high reliability. In the United States, such technologies have been termed IVHS. With regard to IVHS. NHTSA is seeking to fulfill its mission by facilitating the development of safety products and systems and by evaluating the safety impact of introducing such systems into motor vehicles. This requires research into the science of crash avoidance.

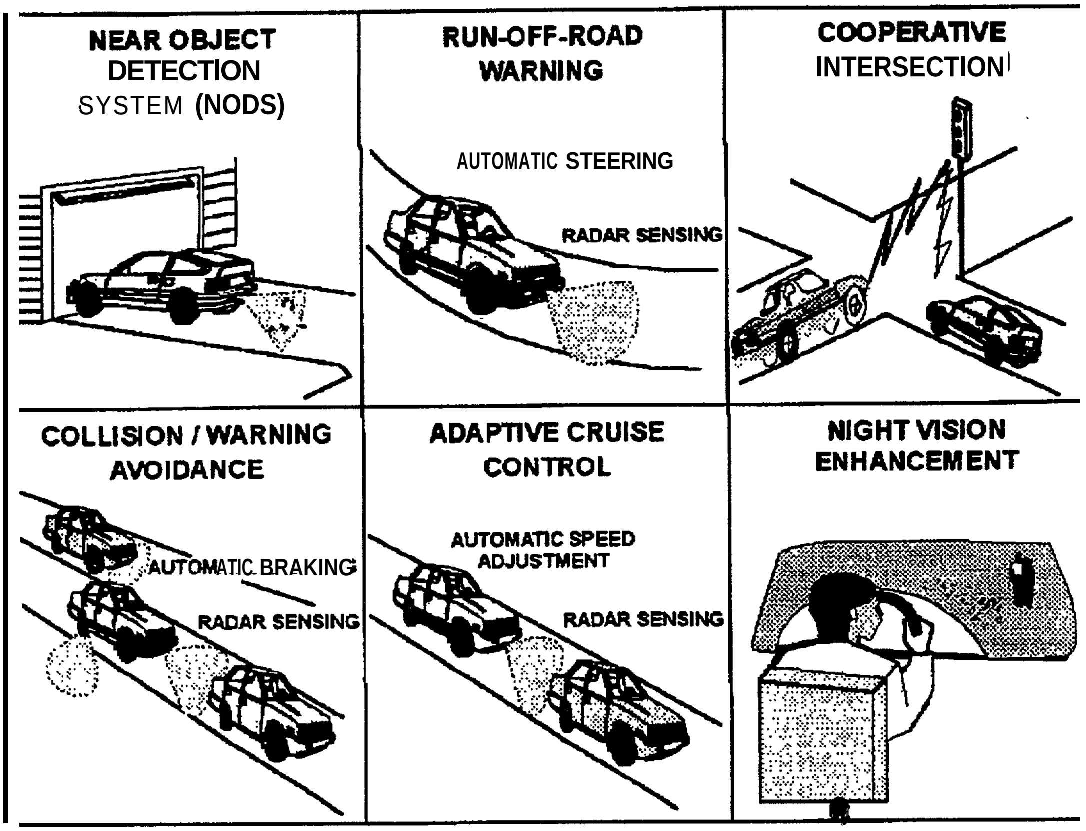

Figure 1. Examples of Potential IVHS Crash Avoidance Systems

In NHTSA's vision of tbe future driver-vehicle-highway environment, a wide variety of innovations will appear within and outside of the motor vehicle to supplement the driver's efforts at vigilance and control. Some example systems are illustrated in Figure 1. Such systems will ensure the driver's own state of fitness, enhance driver perception on a continuous basis, give warning of impending danger, and/or intervene with emergency control if a crash is imminent

NHTSA is currently implementing a greatly expanded crash avoidance research and development effort following the five-thrust IVHS program illustrated in Figure 2. The agency is establishing safety targets for crash avoidance technology, developing performance guidelines for such systems, working with industry to demonstrate the most promising ones, and facilitating their deployment in the marketplace NHTSA is also playing a major role in ensuring the system safety of IVHS initiatives other than collision avoidance, e.g., mobility and productivity enhancement systems Through this process, NHTSA will facilitate and hopefully stimulate industry efforts which result in commercialization of safety-effective IVHS products. The NHTSA program will provide the engineering and human factors basis for achieving the potential safety benefits promised by IVHS.

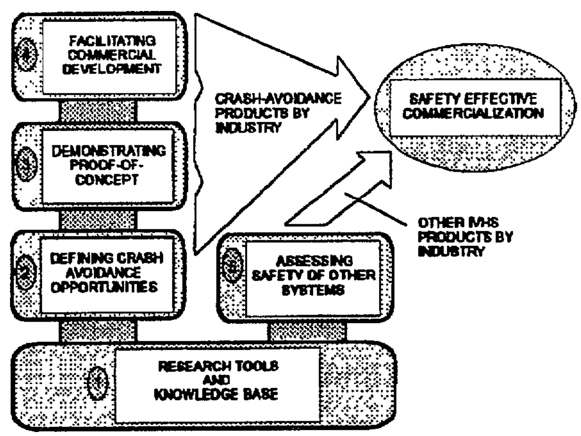

Figure 2. NHTSA's Five Thrust Program In IVHS

THRUST NUMBER 1: BUILD RESEARCH TOOLS AND COMPILE KNOWLEDGE BASES

Given the diversity and complexity of motor vehicle crashes, development of effective countermeasures can be realized only through a comprehensive understanding of crash antecedent events and relevant behavioral, vehicular, and roadway factors. The development of these countermeasures requires innovative research tools and analytical techniques. These research tools are vital to understanding and documenting the safety benefits and potential liabilities associated with new countermeasures and to define requirements associated with their design and implementation. Accordingly, the agency has defined goals for obtaining the research and analysis tools necessary to evaluate crash avoidance concepts and products and a more sophisticated and systematic knowledge base of driver-vehicle performance and behavior needed to support safety system development.

National Advanced Driving Simulator (NADS)

A critical research need relevant to crash avoidance is improvement in our state of knowledge about how drivers interact with the their vehicles and the roadway environment. This information is necessary for the development of advanced countermeasures and other vehicle components that are compatible with the performance capabilities and limitations of drivers. Simulators will be essential to this improved understanding of driver behavior since they provide a means for carrying out highly controlled experiments in crash imminent situations without putting subjects at risk. While many levels of simulation sophistication are possible, NHTSA IS focusing on the development of a high-fidelity, moving base simulator. The state-of-the-art in highway vehicle simulation technology has progressed to the point where it is now possible to replicate, with impressive fidelity, the highway driving scenario. Emerging technologies in mechanical system dynamics and parallel computing, combined with high-speed computer graphics and motion base control technologies, have sufficiently evolved to support a national research facility for man-in-the-loop, real-time vehicle driving simulation, thus allowing researchers to present the antecedent events of a likely crash situation and then study the responses of both driver and vehicle. Most importantly, these simulated conditions can be presented in a precise and repeatable manner with complete safety for the human subject.

Two teams have recently begun a 13-month NADS design competition. At the completion of the design competition, the team with the winning design will carry out the actual construction of the NADS facility.

Portable Driver Performance Data Acquisition System for Crash Avoidance Research (DASCAR)

In addition to simulation, real-world, in-vehicle data are also important. To address the need for such data, this project is applying state-of-the-art technology and methods to develop an easily-installed, portable instrumentation package and a set ofanalytical methods/tools to allow driver-vehicle performance data to be collected using a variety of vehicle types (Figure 3). The instrumentation suite will be unobtrusive to subjects and inconspicuous to other drivers; thus, it will support "naturalistic" studies of driver performance/behavior on the road.

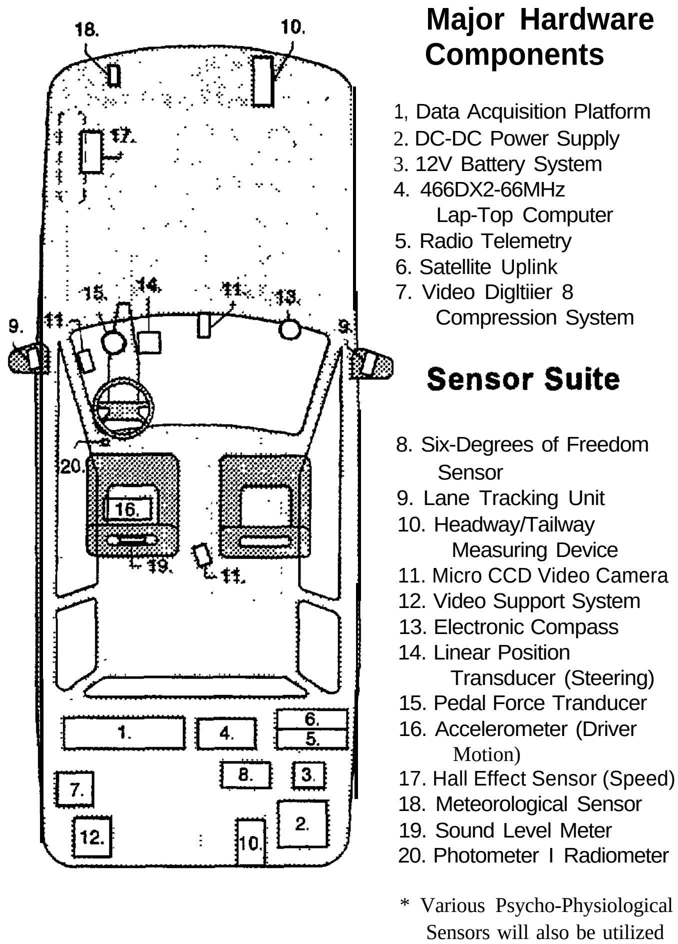

Figure 3. Portable Driver Performance Data Acquisition System for Crash Avoidance Research (DASCAR)

A prototype system is currently being fabricated and will be available for pilot testing in late 1994 Following validation of the prototype design, multiple units will be constructed and utilized to compile needed in-situ experimental or baseline human factors data.

Quantitative Characterization of Vehicle Motion Environment (VME)

This project is developing and validating a measurement system that can quantify the specific motions that vehicles exhibit as they move in traffic (Figure 4). The VME system will establish the locations and motions of all vehicles within the field of view relative to roadway boundaries, other features, and each other. The pertinent variables address vehicles in near proximity to one another, including spatial clearances, relative velocities, and angles of nominal attack vis-a-vis other vehicles and fixed objects. In operation, the VME will gather information on successful collision avoidance maneuvers. Information such as reaction to other drivers cutting in front, normal following distance, typical lane change trajectories, and response to inclement weather will be collected Thrs information will provide a geometric and kinematic data base which can be used to design IVHS countermeasures that intervene and/or provide collision avoidance warnings to the driver That is, countermeasure parameters can be superimposed analytically on the vehicle motion record to assess their likely performance

The initial VME measurement systems will be available for testing and validation in the fall of 1994 Once validation is complete, the units will be utilized to acquire baseline information on all aspects of driving

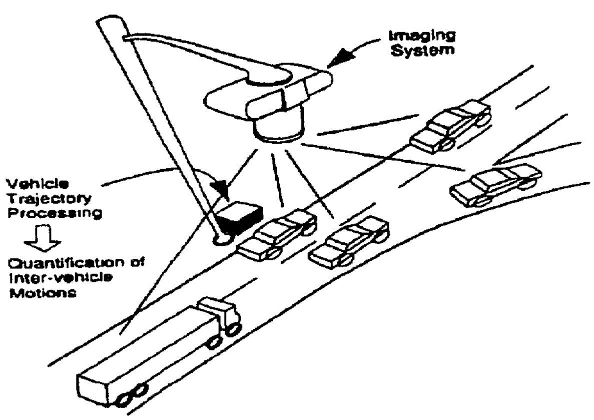

Figure 4. Vehicle Motion Environment (VME) Operation Concept

Variable-Dynamics Test Vehicle (VDTV)

Currently underway is a "needs" study and development of preliminary performance specifications for vehicle(s) with the capability to systematically vary vehicle control and handlmg characteristics This phase will be completed in mid-1994 If the need is demonstrated, the VDTV will be constructed, tested, and validated in the second phase.

It would be used to establish the performance boundaries for IVHS systems that directly control vehicle motion, i.e., determine the vehicle-related limitations that should be placed on control algorithms It will also allow determination of how drivers react to various proposed IVHS crash avoidance concepts. including the effect of vehicle characteristics on device effectiveness The VDTV could also be used to validate NADS control algorithms and as a crash avoidance research vehicle to support the safety evaluation of automated highway system (AI-IS) concepts.

Driver Workload Assessment

In order to evaluate the effect on driver workload imposed by adding IVHS devices/systems to motor vehicles, a measure of today's workload is needed as a reference baseline. Since neither workload data nor a standardized approach for establishing such data exist, this initiative is (1) developing a capability to evaluate the effects of high-technology systems (e.g., crash avoidance systems, route guidance, and navigation systems) on driver safety performance, (2) developing standardized driver workload measurement protocols (including instrumentation), obtaining baseline workload data, and evaluating high technology systems that are currently being implemented, (3) identifying aspects of system design and operation that can compromise safety, and (4) obtaining data relevant to human factors guidelines for the driver-vehicle interfaces of these systems.

Table 1 shows sample results from the workload study. Video recordings of driver glance duration and frequency (taken during normal driving) indicate that, among conventional instrument panel controls and displays, the task of manually tuning a radio requires the greatest allocation of visual resources and, thus, creates the greatest workload for the driver. This is seen most vividly in the high number of driver glances required to carry out this task New in-cab devices should be designed to create minimal visual or other workload demands on the driver. A new in-cab device causing a high visual demand--equivalent to manually tuning a radio--might cause excessive distraction to drivers and, thus, constitute a safety hazard

Crash Avoidance and the Older Driver

Numerous physiological changes and related performance decrements relevant to driving are associated with aging They include diminished ability for visual accommodation, decreased ability to see in darkness or diminished light, decreased accuracy of distance and closing speed estimation. longer glance times required to read instrument panel displays, decreased ability for selective attention, slower speed information processing and decision-making, and slower motor reaction times. Some deficits occur almost universally in older persons: others are not universal, but occur at a higher rate. This study is analyzing the traffic crash experience of older drivers, assessing their capabilities and limitations as drivers, and identifying and evaluating vehicle design features that will ensure the safety of their driving while accommodating their mobility needs

This study is being coordinated with the broader NHTSA programs dealing with the safety and mobility of older drivers that are discussed in a paper in the IVHS Human Factors Session of this conference

Table 1
Illustrative Visual Glance Data: All Subjects Combined

	Average Glance Duration (sec)	Mean Number of Glances	Average Time Off Road (sec)
Left Mirror-Detect	1.44	1.29	1.85
Left Mirror-Descrimination	1.77	1.58	**2.79**
Rear Exact Speed	1.50	1.45	2.18
Manually Tune Radio	1.33	11.31	15.10
Change CB Channel	1.18	**3.93**	**4.63**
Wipers On/Off	1.00	1.13	1.13

In-Vehicle Crash Avoidance Warning Systems - Human Factors Considerations

This project is attempting to identify driver requirements for effective warning system design and for evaluating the potential of warning systems to help drivers avoid crashes The research is addressing the following human factors questions:

- What type of information should be presented to the driver - status or guidance? How should the information be presented (e.g., visual display, aural signal)? When should it be presented to provide the driver with enough time to take action?

- What system characteristics (e.g , location, display identification, information content) should be standardized to prevent problems for unfamiliar drivers?

- Will a vehicle equipped with multiple warning systems confuse or overload the driver? If multiple warnings are present, how should they be designed to minimize confusion? Should priorities be established in the event of simultaneous warnings?

The first product of this research was the development of a set of preliminary human factors guidelines for crash warning devices (Lyons, et al., 1994). These guidelines are intended to be sufficiently general so as to permit the use of various display technologies, from traditional automotive displays to CRTs, voice, or other formats

Evaluation of Potential Health Hazards from Wide-Spread Usage of Collision Avoidance Systems

Widespread introduction of collision avoidance systems which utilize active sensor systems could result in a noticeable increase in the emittance of electromagnetic radiation, Example sensor technologies include radar, laser, and radio frequency transmissions. If any potential health or safety hazards could arise from the use of active sensors, NHTSA seeks to identify and quantify the nature of such potential problems as early as possible The goal of this study is to provide design criteria that minimizes any potential health hazards to the population

Vehicle-Induced Feedback Cues and Their Relationship to Driver Performance and Safety

Driving involves a continuous interaction of the driver with his or her vehicle and the roadway environment. Visual cues from the roadway are obviously of paramount importance to driver performance. Less obvious is the importance of cues and feedback from within the vehicle, such as kinesthetic, vestibular, and cues associated with certain vehicle response characteristics, e.g., body roll, tire screech, apparent oversteer/understeer. The role of these vehicle cues relative to driving performance needs to be better understood IVHS technologies present the possibility that such cues may be radically changed in future generations of vehicles. The effects of such changes are largely unknown and could greatly influence how well drivers control their vehicles.

This project will develop guidelines for system designers to highlight the importance of vehicle cues to driver performance and system safety and to ensure that contradictory or counterintuitive feedback systems are not developed by different manufacturers Lack of standardization could cause vehicle controllability problems for a driver operating an unfamiliar vehicle

This project will also gather experimental data on the phenomenon of driver risk compensation, the possible tendency of drivers to drive faster or otherwise increase their risktaking in response to improvements in highway or vehicle safety, thereby partially or even fully negating the positive effects of crash avoidance countermeasures. Risk compensation has been hypothesized to be an attenuating factor in countermeasure effectiveness, but to date there is little empirical evidence to document its existence or significance to motor vehicle safety.

THRUST NUMBER 2: IDENTIFY PROMISING CRASH AVOIDANCE OPPORTUNITIES

The technological potential of IVHS presents an array of opportunities and challenges to the motor vehicle industry and to NHTSA in performing its mission to reduce traffic crashes and resulting injuries and death One of the challenges is to effectively use the collision record with a new focus on crash avoidance. Looking carefully at the precrash circumstances associated with various crash types, the accident information must be analyzed to determine critical driving hazards. Countermeasures to address these hazards can then be specified in performance terms that match real needs. There is, however, a weak link in the logic chain between available technology and the prevention of target crashes The mechanisms of intervention of IVHS devices in crash scenarios (and, in particular, driver actions) are not well understood. There is a pressing need for analyses of candidate technological solutions in relation to the parameters of target crash scenarios and the capabilities and limitations of drivers. This approach will identify the most promising countermeasure functions which, in turn, can lead to assessments of the most promising applications of technology and associated R&D needs

The problem definition/analysis methodology being pursued by NHTSA incorporates the following key elements,

- Quantification of the baseline crash problem size (in terms of numbers of crashes, injuries, and fatalities) and description of crash characteristics
- Description, analysis, and modelmg of target crash scenarios in sufficient detail (i. e , clinical assessment) to permit understanding of the principal causes, time and motion sequences, and potential mterventrons
- Assessment of countermeasure mechanisms of action (countermeasure concepts) and technology status (sensors, processors, control and communication systems) to identify candidate solutions
- Assessment of relevant human factors and other "real world" factors affecting potential countermeasure effectiveness, e.g., vehicle response capabilities, driver reaction times, false alarm rates, driving behavior.
- Modeling of countermeasure action to identify critical countermeasure functional requirements and where possible, predict effectiveness
- Identification of priority technological, human factors, and other R&D issues that need to be resolved to ensure that the countermeasure's safety enhancement potential is reached.

This approach recognizes that the mechanisms of intervention of IVHS devices in crash scenarios (and, in particular, driver actions) must be understood in order to predict potential device effectiveness and benefits, identify critical system performance goals, and guide agency and industry efforts along paths of greatest potential safety benefit. The analysis of collision records systematically guides NHTSA toward the key questions to be answered during countermeasure R&D efforts.

Figure 5 shows the distribution of crash types that provide the maximum opportunity for significant safety improvement through the introduction of safety-effective collision avoidance products/systems. Single vehicle road departure, rear end, and crossing path (intersection) crashes comprise nearly three-fourths of all crashes in approximately equal proportions. The remaining fourth is comprised of blind-spot. head-on and other crash types. Additional contributing factors such as reduced visibility, e.g., at night or in degraded weather conditions, and driver drowsiness, occur across the spectrum of crash types shown in Figure 5.

More detailed data specific to individual crash types are provided later in the paper as part of the discussion associated with the development of performance guidelines for collision avoidance countermeasures.

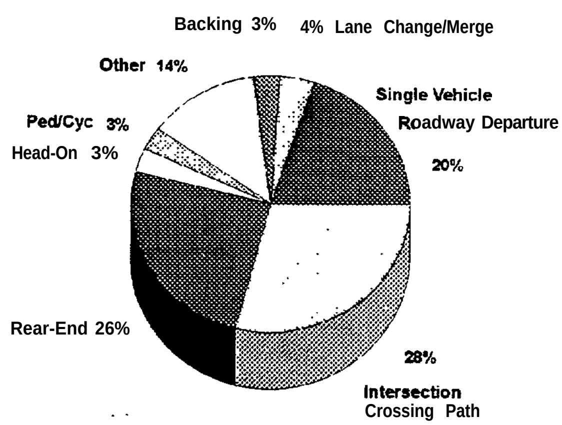

Figure 5. Distribution of Major Target Crash Types

THRUST NUMBER 3: DEMONSTRATE PROOF OF CONCEPTS FOR CRASH AVOIDANCE

NHTSA's goals are to see continual development of new products that provide enhanced information about the driving environment, instruct the driver to take immediate collision avoidance action, or take control of the vehicle and to develop guidelines that will help and encourage industry to develop and deploy such IVHS collision avoidance systems Projects under this thrust have been specifically designed to help compress the time frame for product development. The early development of performance guidelines will also lessen the risk of hazardous side effects and help ensure that safety enhancement goals are achieved. Proof of the technical feasibility, operational practicality, and economic viability of crash avoidance systems is necessary for any concept to be commercialized.

There is a narrow margin between driver responses that do not result in collisions and those that do. Instances where a driver does not take appropriate collision avoidance action are opportunities for intervention by driver augmentation systems Such systems fill the gap between “actual” and “needed“ action.

To effectively prevent collisions, they must interact with the driver in a timely and effective way. They must also be designed to address specific collision circumstances,

To foster the development and use of a wide array of technologies for reducing or compensating for driver errors and limitations, NHTSA is establishing the functional requirements for various collision avoidance safety systems in performance terms. This will include performance parameters such as sensor detection range and sensitivity, signal processing capabilities, requirements for presentation of information to drivers, vehicle control modes, data architecture standards, and system reliability and durability These specifications of functional requirements will serve as design targets for industrial development of IVHS hardware and as the basis for evaluation of the safety impact

The development of performance specifications follows a systematic approach which includes the following key factors:

- o Thorough analysis of the crash problem,
- o Establishment of functional goals for system(s) to address the identified crash problem, including both engineering and human factors considerations,
- o Testing and evaluation of existing systems (commercially available and prototypes); including driver interfaces,
- o Development of preliminary performance specifications,
- o Evaluation of the state-of-the-art of enabling technologies needed to achieve particular collision avoidance safety performance,
- o Design and construction of a test bed for use in assessing concepts which can meet the preliminary performance specifications, and
- o Use of the test bed and other facilities to conduct vehicle and human factors testing to support finalization of the performance specification.

These projects are investigating the feasibility of equipping motor vehicles with systems to assist drivers in safely carrying out the maneuvers of interest. They will determine the performance required of one or more feasible countermeasure systems and define the specifications in performance terms without constraining the systems to particular devices or technologies. Although the major focus will be on systems which will be self-contained within the vehicles, cooperative systems which would require or would be improved by auxiliary equipment in the road **or in other** vehicles are also being addressed.

NHTSA currently has underway seven performance specification development projects:

Countermeasures Against Lane Change, Merging, and Backing Collisions

Approximately 400,000 police-reported collisions (and an even greater number of non-police-reported collisions) of these types occurred in 1992. This is about 7 percent of all collisions. These collisions are characterized by vehicles having low relative velocity and being in close proximity during normal operation

Most lane change/merge crashes are angle or sideswipe collisions. Most lane change/merge crashes occur during dry, clear, daylight conditions Just over half occur on divided highways. A large percentage of this type of collision involve recognition failure by the lane changing/merging driver, i e., the driver “did not see” the other vehicle until the crash was unavoidable (Knipling, 1993)

Analysis of backing crash scenarios reveals two distinct subtypes - “encroachment” and “crossing path” crashes. Encroachment backing crashes involve slow closing speeds and a stationary (or slowly moving) struck pedestrian, object, or vehicle. In contrast, crossing path backing crashes generally involve higher closing speeds. For example, a vehicle backs out of a driveway and strikes [or is struck by) another vehicle moving at speed on the roadway. Approximately 43 percent of all backing crashes are encroachment crashes; the remaining 57 percent are crossing path crashes. Approximately 90 percent of drivers involved in backing crashes (as the driver of the backing vehicle) were unaware of the presence of what they hit (Knipling, 1993).

This project is investigating the feasibility of equipping motor vehicles with systems to assist drivers in safely carrying out lane change, merging, and backing maneuvers. A number of such systems have already been developed to improve the performance of drivers in situations **relevant to** these crashes. The ready availability of potential systems is a primary reason for including these collisions in the initial set of problem areas.

Countermeasures Against Rear-End Collisions

In 1992, rear-end collisions accounted for about 1.4 million police-reported collisions and perhaps more than 2 million non-police-reported crashes. Approximately two-thirds of the crashes are lead vehicle stopped crashes, while the remaining one-third are lead vehicle moving crashes. That is, most rear-end crashes do not mvolve “coupled” vehicles that collide due to a sudden deceleration by the lead vehicle. Rather, in most rear-end crashes a moving vehicle collides with a stopped vehicle in its forward travel path (Knipling, 1993).

The most common causal factor associated with rear-end crashes is driver inattention to the driving task. A second, and overlapping, major causal factor is following too closely. One or both of these factors are present in approximately 90 percent of rear-end crashes

Systems to address rear-end collisions have been under serious development for about 2 years. Some of the concepts which have been investigated include intelligent cruise control systems which automatically maintain headway by throttle closure and/or downshifting of the transmission, systems which provide information about distance and speed of other vehicles, headway maintenance systems which rely on driver action, and automatic braking systems, In the future, there may be systems which provide full automatic control of longitudinal motion These system concepts all rely on the ability to sense the relative velocity and distance of vehicles which are travellmg in the same direction

Countermeasures Against Roadway Departure Collisions

Single-vehicle roadway departure crashes represent a significant highway safety problem. There were 1.2 million smgle-vehicle roadway departure crashes in 1992, representing 20 percent of all crashes Further, approximately 16.000 annual fatalities (36 percent of all traffic fatalities) are associated with these crashes.

Causal factors associated with single-vehicle roadway departure crashes include slippery road conditions, excessive speed/reckless maneuver, driver inattentiveness, evasive maneuver in response to an external crash threat, driver drowsiness, and driver intoxication. With so many diverse crash causes, multiple countermeasure concepts are likely to be applicable to this significant crash type (Knipling, 1993).

The requirements for the sensing element for these systems will include the ability to provide data on lateral lane position, presence of low coefficient-of-friction, and driver condition. It may be more efficient and practical to provide some of this information with sensors that are part of the highway infrastructure rather than in the individual vehicles. These capabilities are different than the primary need of determining speed and location of the vehicle which the preceding systems have. Thus, these systems may be complementary to the other systems’ and form a key component in an integrated collision avoidance system.

Countermeasures Against Intersection Collisions

Crossing path crashes at intersections represent a very large crash problem; nearly 30 percent of all crashes and 15 percent of all fatalities.

Figure 6 illustrates three major intersection crash scenarios. Below is a summary of principal causal factors identified for each:

- Perpendicular crossing path crashes at signalized intersections involve, by definition, a signal violation by one of the vehicles. Principal causal factors include: deliberately ran signal (ran red light or tried to beat signal change), inattentive driver (did not see red light), and driver intoxication.

- Perpendicular crossing path crashes at unsignalized intersections (e.g., controlled by stop signs) include cases where the at-fault driver ran the stop sign without stopping (42 percent) and those where the driver stopped but then proceeded against crossing traffic (58 percent). The principal causal factors for “ran stop sign” crashes include driver inattention and vision obstruction (e.g., sign obscured by foliage or parked vehicle). Principal causal factors for the “proceeded against crossing traffic” subtype include faulty perception (“looked but did not see”), misjudgment of gap/velocity, and vision obstruction.

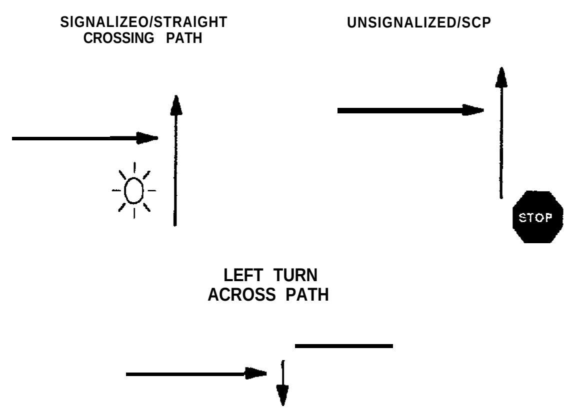

Figure 6. Intersection/Crossing Path Crashes: 3 Major Subtypes

- Left turn across path (from initial opposite direction) crashes involve similar causal factors whether they occur at a signalized or unsignalized intersection. These factors include "looked but did not see," misjudgment of gap/velocity, and vision obstruction (generally due to an intervening vehicle).

Intersection collisions generally involve vehicles which are moving at 90 degrees from each other and often at high relative speeds. This poses a tremendous challenge for the sensing and processing elements of any countermeasure to provide meaningful and timely collision avoidance assistance to drivers. The combination of two-dimensional motion, high relative speeds, large separation distances, and multiple vehicles with the potential for conflict make these systems potentially more complex than the preceding systems. For this reason, this project is addressing autonomous, vehicle-based systems, vehicle-to-vehicle communication systems, and/or cooperative highway-vehicle systemsrequiringinstrumentation of intersections.

The potential role of cooperative vehicle-highway systems means that communication needs must be determined early in order to influence key system architecture decisions. Moreover, to efficiently incorporate collision management into the highway infrastructure, it will be necessary to begin developing functional and institutional interfaces, as well as the technology interface, as early as possible

Vision Enhancement Systems for Nighttime and Inclement Weather

In 1992, approximately 44 percent of crashes (and 60 percent of fatal crashes) occurred during some degraded visibility condition, e.g., dawn, dusk, night, snow, rain, fog The 2.6 million police-reported crashes and 23,472 fatalities represent target crashes for which visibility may be a contributing factor.

A number of mterwoven factors contribute to the high crash rate at night, including alcohol, fatigue, and reduced visibility. Driver sensory impairments brought on by aging, glare, and loss of peripheral vision further degrade night vision/recognition tasks.

This project is investigating the feasibility of equipping motor vehicles with vision enhancement systems to help drivers avoid collisions at night and in inclement weather because of reduced visibility. It will address the visual information requirements for successful crash avoidance, as well as driver useability requirements, to ensure that supplementary vision enhancement systems do not distract drivers or otherwise degrade their overall driving performance.

Driver Status and Performance Monitoring

Agency statistics for 1992 indicate that there are approximately 50,000 police-reported crashes in which driver drowsiness/fatigue was cited as a potential contributing factor. Associated with these were approximately 1450 fatalities (4 percent of all fatalities). Due to underreporting, the actual involvement of driver drowsiness/fatigue in traffic crashes may be greater.

Research has shown that loss of driver alertness is preceded by measurable changes in performance and psychophysiological status The NHTSA-supported research is addressing the concept of a vehicle-based device to unobtrusively monitor driver performance and potentially, psychophysiological status. The device will monitor driver status/performance, detect degraded performance, and provide an appropriate warning signal or other countermeasure to prevent its continuance. The current program is developing detection algorithms for reduced driver performance symptomatic of drowsiness/fatigue. Figure 7 shows a schematic of the envisioned vehicle-based drowsy driver detection system (Knipling and Wierwille, 1993; Knipling and Wierwille, 1994).

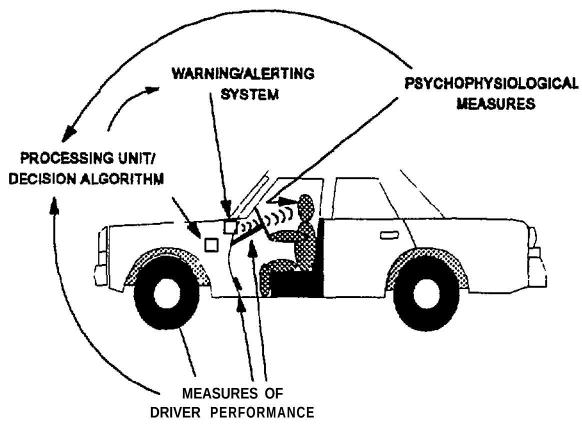

Figure 7. Vehicle Based Drowsy Driver Detection System Schematic

Enhanced Emergency Medical Service (EMS) Response

About 24 percent of collisions and 56 percent of fatal crashes occur in rural areas. Many of these crashes, especially single vehicle road departure crashes, occur in places where there are no easily-available communications facilities to alert emergency personnel of the need for emergency assistance. The objectives of this project are to investigate the feasibility of equipping motor vehicles with high-technology sensing and communications systems for automatically informing EMS dispatchers of the occurrence and location of a collision and to conduct an operational test in a rural area of systems to improve EMS response. The system tested would have the capability to automatically request emergency assistance.

Even in non-rural areas, these systems should speed EMS response by providing exact crash location, effectively reducing the injury consequences of the crash. The goal of this work is to provide improved notification and delivery capability that will help provide hospital-level medical care as early as possible following onset of the trauma. The patient's chances of survival decline rapidly with time. IVHS technologies should be able to reduce this time significantly.

THRUST NUMBER 4: FACILITATE DEVELOPMENT OF CRASH AVOIDANCE PRODUCTS TOWARD COMMERCIALIZATION

In order for safety to be improved, vehicle-based and/or cooperative collision avoidance systems must be available to, and purchased by, the motoring public, either as standard or optional equipment on new vehicles, or in the aftermarket To facilitate product development and early deployment of IVHS-based, safety-enhancing systems, the agency is supporting industry initiatives by working cooperatively to accelerate development. NHTSA will also work with the industry to assess the performance, reliability, maintainability, failure modes/consequences, driver acceptance costs, and market readiness of promising systems under real world operating conditions.

In order to foster the development, evaluation and deployment of collision avoidance enabling technologies. products, and systems and to expand the knowledge base of collision avoidance, the agency has recently entered into cost-sharing, cooperative research efforts with five technology and product developers and research organizations.

Human Factors Aspects of Autonomous Intelligent Cruise Control

This project is addressing the range of human factorsldriveracceptancelssuesassociatedwithimplementation of an autonomous intelligent cruise control (AICC) system Industrial partners are Ford Motor Company and Systems Technology Inc

Forward Crash Avoidance Systems

This project, being conducted by the University of Michigan Transportation Research Institute and Leica, is utilizing Leica's infrared-based AICC to evaluate varying levels of deceleration, through throttle closure, transmission down-shifting, and utilization of service braking as critical components of either AICC or crash avoidance systems.

Forward Looking Automotive Radar Sensors

The Environmental Research Institute of Michigan (ERIM) and TRW are contributing to the understanding of radar sensing in the roadway environment by collecting radar-cross-section data of representative motor vehicles and roadway objects, in both laboratory and freeway settings Such data will assist developers of forward looking collision avoidance systems which utilize radar sensors.

Lane Detection

Lane tracking is a primary measure of driving performance; impaired drivers typically show increased fluctuations in lateral lane position. Inexpensive, reliable vehicle-based lane position detection is necessary for many of the prospective collision avoidance systems. No such devices currently exist. In this project, Rockwell International is evaluating a prototype machine vision lane detection sensor for this purpose.

Automatic Braking for Heavy Vehicles

Eaton is studying the issues associated with the automatic application of service brakes on heavy commercial vehicles Results from this project will establish the feasibility of the concept of automatic braking for heavy vehicles, identify design requirements necessary to accomplish assisted braking through modification of existing ABS/traction control system components including associated costs/benefits for potential accident reductions, and provide an early indication of driver reaction to assisted braking under controlled conditions.

THRUST NUMBER 5: ASSESS THE SAFETY OF OTHER IVHS CONCEPTS

There are many IVHS concepts which entail functions other than crash avoidance, but nevertheless influence the driving task. Both for driver convenience and the avoidance of traffic congestion, driver information, and route guidance/navigation systems are likely to be marketed in substantial numbers by the mid-nineties. In Thrust 5, NHTSA fulfills its mission to ensure that such hardware is implemented in a safety-compatible manner by developing and applying evaluation protocols to assess the safety impact of introducing such systems into motor vehicles.

The fundamental safety questions being addressed in these evaluations are:

- Do drivers drive more, or less, safely with the system than without it, in ways related to the system?
- Do vehicles equipped with the system have fewer, or more, collisions than vehicles without the system?
- If all vehicles in the fleet were equipped with the system, would there be a decrease, or increase, in the total number of collisions and collision-related deaths and injuries?

NHTSA is actively participating with the Federal Highway Administration (FHWA) in the safety assessment of such systems to ensure that protocols exist for evaluating the benefits of such technologies with regard to safety, and, most importantly, to ensure that safety is not inadvertently compromised by the systems. Of particular interest are those systems which pose unusual forms of driver workload and/or distraction. In addition, NHTSA is supporting FHWA in implementing the congressionally mandated program for automated highways demonstration by 1997. The agency will continue to be an active participant in this demonstration of automated highway technology addressing the safety and human factors implications of such systems.

NHTSA is currently involved in the safety evaluation of four operational tests. These are briefly described below:

Three of the projects are evaluating route guidance/navigation systems For these systems there are two additional subquestions to be addressed:

- Whether the system directs the driver to a route which has a lower likelihood of collision, and

- Whether the driver interface enhances safety by providing information in a way that relieves the driver of some navigational workload or degrades safety due to distraction.

TravTek

TravTek is an operational test of an advanced motorist information system in 100 test vehicles which combines vehicle navigation and tourist information with up-to-the-minute traffic data to improve driver efficiency. TravTek is a joint venture of General Motors, the American kutomobile Association, the State of Florida, the City of Orlando, and the U.S. Department of Transportation. The primary objectives of this demonstration project is to determme the technical feasibility of such a system, user acceptance, and reduction in travel times.

The l-year test concluded in March 1993: evaluation of the test data continues. The final evaluation report IS scheduled to be completed in June 1994.

Advanced Driver and Vehicle Advisory Navigation Concept (ADVANCE)

The Illinois Department of Transportation, Motorola, Inc., Illinois Universities Transportation Research Consortium, and the U.S. Department of Transportation are involved in a large-scale cooperative effort to evaluate the performance of a dynamic route guidance system. Up to 5,000 private and commercial vehicles in the northwestern suburbs of Chicago, Illinois, will be equipped with in-vehicle navigation and route guidance systems. Vehicles will serve as probes, providing travel time data to a traffic information center. This information will then be transmitted to the equipped vehicles and used to develop a preferred route. The routing information will be presented to the driver in the form of dynamic route instructions.

The safety issues in ADVANCE are substantially the same as those addressed in TravTek. ADVANCE differs from TravTek in that it involves a much larger population of equipped vehicles and the in-vehicle equipment is installed in existing vehicles rather than engineered into a new vehicle. The use of existing vehicles raises additional ergonomic/human factors issues such as the effect of various locations in or near the instrument panel and ease of use.

Faster and Safer Travel Through Traffic Routing and Advanced Controls (FAST-TRAC)

This operational test in Oakland County, Michigan, is evaluating the Australian SCATS traffic adaptive control system, Autoscope video-image processing technology for traffic detection in support of real-time traffic control, and vehicles equipped with the Siemans Ali-Scout route guidance and driver information system. Infrared beacons will be installed at critical locations in the network to provide for a continuous exchange of real-time traffic and route guidance information. Partners in this endeavor include the Michigan Department of Transportation, Siemans Automotive, General Motors, Ford, Chrysler, Road Commission for Oakland County, the University of Michigan, and the U.S. Department of Transportation

Travel Aid

The Washington State Department of Transportation, Farradyne Systems, Inc., and the U.S. Department of Transportation are evaluating the effectiveness of variable message/speed limit signs and in-vehicle communication equipment to improve the safety along a 40-mile stretch of heavily travelled I-90 across Snoqualmie Pass, a rural area of Washington State that is prone to snow, ice, and poor visibility. Electronic sensing and equipment will be installed to monitor traffic, speeds, and road/weather conditions. This information will be the basis for determining appropriate speeds for conditions. Variable message/speed signs will broadcast warnings about road conditions, accidents, or slow-moving equipment, as well as appropriate speeds. In addition, the use of a relatively simple, low cost in-vehicle device which will display to the driver a text message similar to that displayed by the variable message signs will also be evaluated. Up to 200 vehicles will be equipped with the in-vehicle devices.

The in-vehicle equipment will be available for testing in the winter of 1994; the variable message signs a year later. Key safety questions to be addressed in this operational test are the safety impact of the in-vehicle information system and the effect of the information provided on reducing vehicle speed.

SUMMARY

Although extensive research, development, test, and evaluation programs will be necessary to produce reliable, cost-effective intelligent collision avoidance systems, it is believed that effective systems can be developed without the need for major technological breakthroughs. The major challenge will be to ensure the characteristics of the IVHS systems match the capabilities and limitations of the drivers who must use these systems. If the systems are not “user-friendly,” the potential safety benefits will likely not be fully realized. The NHTSA IVHS program described in this paper is providing the engineering and human factors research necessary to accelerate the development and deployment of collision avoidance systems by the industry and to achieve the potential safety benefits promised by such systems.

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