Proactive Use of Highway Recorded Data via an Event Data Recorder (EDR) to Achieve Nationwide Seat Belt Usage in the 90th Percentile by 2002

Thomas Michael Kowalick
President of Click, Inc. Transportation Safety Technologies, Southern Pines, North Carolina

HIGHWAY TRANSPORTATION SAFETY TECHNOLOGIES

SYMPTOMS OF A PROBLEM

Automobiles have been in existence for over a hundred years (1898-1999). Today, we have over two hundred and fourteen million in America alone, and six hundred and ninety million worldwide. Nationwide, forty-seven million vehicles are continually in-motion during daytime usage. Within twenty years these numbers are expected to double. Last year, twenty-four million vehicles were involved in a crash or accident. Over 40,000 people died (115 daily) and the total economic cost is estimated at $150 billion annually. (Blincoe 1996) The personal, social, and economic costs of motor vehicle crashes include pain and suffering; direct costs sustained by the injured persons and their insurers; indirect costs to taxpayers for health care and public assistance; and for many victims, a lower standard of living and quality of life. During the past two decades, motor vehicles accounted for over 90 percent of all transportation fatalities, and an even larger percentage of accidents and injuries. Our increasingly mobile society exposes all age groups to the risks of crashes, as passengers, as drivers, and as pedestrians. The automobile is essential for the style of life we demand, and yet, motor vehicle crashes remain a major public health problem. In contemporary society automobiles play an indispensable role in transporting people and goods, and yet, the health care cost of motor vehicle crashes is a national financial burden that must and can be reduced. Worldwide, research and development is underway into systems that link highway infrastructure and telecommunications using emerging technologies via computers, electronics, and advanced sensing systems. While this paper will propose a highway safety counter-measure it will do so after reviewing the policy issues that created the current circumstances connected with occupant safety. Without this review it be impossible to understand the simplicity of the proposed counter-measure. This paper will identify methods for expanding the use of recorded data on highways to improve transportation safety by providing something that has yet to be achieved in the history of the automobile—a simple transportation safety technology capable of reducing fatalities of comparable magnitude. Thus, the primary objective is to technically explain this highway safety countermeasure designated Seat Belt Event Data Recorder (SB-EDR). It is noted that the author is an independent researcher with no association, alliance, or adherence to any transportation safety organization. What follows is an objective analysis of a national problem.

COMMON SENSE PRINCIPLES

The following common sense principles are well known to automobile safety designers, law enforcement personnel, and professionals in medical science and the automobile insurance industry. The sources for these principles are *The Official Driver's Handbook* (Ontario, Ministry of Transportation, 1995) and the *Presidential Initiative to Improve Seat Belt Usage* (1997).[i] Seat belts and child safety seats reduce the risk of injury or death in collisions. Seat belts help keep you behind the wheel and in control of the vehicle in a collision. In a vehicle with airbags, a seat belt keeps you in your seat so the airbag can protect you. Seat belts keep your head and body from hitting the inside of the vehicle or another person in the vehicle. When a vehicle hits a solid object the people inside keep moving until something stops them. If you are not wearing your seat belt, the steering wheel, windshield, dashboard or another person might be what stops you. This "human collision" often causes injury. Seat belts keep you inside the vehicle in a collision. People who are thrown from a vehicle have a much lower chance of surviving a collision. Fire or sinking in water is rare in collisions. If they do happen, seat belts help keep you conscious and unhurt, giving you a chance to get out of the vehicle. In a sudden stop or swerve, no one can hold onto a child who is not in a seat belt or child seat. Infants or children who are not wearing seat belts can be thrown against the vehicle's interior, collide with other people or be thrown onto the road. The *Presidential Initiative for Increasing Seat Belt Usage* cites, "….Seat belts and child safety seats work. Yet, fewer than 40 percent of both adults and children who died in traffic crashes were properly restrained. Seat belts work. They are the most effective means of reducing fatalities and serious injuries when traffic crashes occur and are estimated to save 9,5000 lives in America each year. Research has found that lap/shoulder belts, when used properly, reduce the risk of fatal injury in front seat car occupants by 45 percent and the risk of moderate-to-critical injury by 5o percent. For light trucks occupants, seat belts reduce the risk of fatal injury by 60 percent and moderate-to critical injury by 65 percent. Every 14 seconds someone in America is injured in a traffic crash and every 12 minutes someone is killed. When a traffic crash occurs, occupants are still traveling at the vehicle's original speed at the moment of impact. Just after the vehicle rapidly comes to a complete stop, unbelted occupants slam into the steering wheel, windshield, and other parts of the vehicle's interior. Seat belts are effective in reducing fatalities and injuries caused by this second collision, or "human collision," when the vehicle's occupants hit some part of the vehicle or other occupants. Seat belts provide the greatest protection against occupant ejection. In fatal crashes in 1995, only two percent of restrained passenger car occupants were ejected, compared to 25 percent of unrestrained occupants. Ejection from a vehicle is one of the most serious injurious events that can happen to a person in a crash. Three-quarters of the occupants who are ejected from passenger cars are killed."

TRANSPORTATION SAFETY ORGANIZATION MISSION STATEMENTS

The mission statements of the NTSB, NHTSA, and NSC are all directed toward improving transportation safety. [ii]The National Transportation Safety Board (NTSB) seeks to determine the "probable cause" of transportation accidents and to formulate safety recommendations to improve transportation safety. The National Safety Council (NSC), chartered by an act of Congress, is a nongovernmental, not-for-profit, public service organization devoted solely to educating and influencing society to adopt safety, health, and environmental policies, practices, and procedures that prevent and mitigate suffering and economic losses arising from preventable causes. The National Highway Traffic Safety Administration (NHTSA) *Strategic Execution Plan* (June 1996) cites that it's mission is to save lives, prevent injuries and reduce traffic related health care and other economic costs. This plan also states that "Translating the concepts of the National Highway Traffic Safety Administration's (NHTSA) Strategic Plan into programs is both easy and difficult. The easy part comes from the large body of proven tactics and approaches that are used to improve traffic and vehicle safety and from the extensive library of data and research results that can support new activities. It is difficult because highway causalities are becoming more challenging. We have taken steps that have reduced motor vehicle crash losses in recent years to the lowest levels in decades and their lowest rates in history. We must know look beyond our tradition of regulating industry and overseeing state and community programs. We must increasingly look toward stimulating public demand for vehicle and traffic safety, developing and applying new technologies (particularly computers, and communications, sensors, and advanced materials) to well defined problems, and forming more creative and productive relationships with the industry and other government bodies." These remarks by the Administrator of NHTSA recognize progress but admit that new methods must be tried to a well-defined problem—traffic injuries and fatalities. The intent of this paper is to promote one such counter-measure of combining emerging technologies.

PRESIDENTIAL INITIATIVE

On January 23, 1997 President Clinton directed the Secretary of Transportation to prepare a plan to increase seat belt use nationwide. This plan became known as the "*Presidential Initiative for Increasing Seat Belt Usage*." The report states that America must set ambitious seat belt and child safety seat use goals. It cites, "the unprecedented opportunity to save lives, prevent injuries, reduce health care and other costs, and improve the lives of all Americans—simply by increasing proper seat belt and child safety use. Furthermore, in order to reach these goals requires a bold initiative reaching beyond business as usual." The overall goals are:

- Increase national seat belt use to 85% by 2000 and 90% by 2005 from 68% in 1996
- Reduce child occupancy fatalities (0-4 years) by 15% in 2000 and by 25% in 2005 from a total of 685 in 1995

This report notes that the vast majority of all fatal and non-fatal injuries in America, including traffic injuries, are not acts of faith but are predictable and preventable. Key points are:

- Injuries are a major health care problem and are the leading cause of death for people age 1 to 42.
- Fatalities, however, are only a small part of the total injury picture.
- For each injury-related death, there are 19 hospitalizations for injury and another 300 injuries that require medical attention.
- Every year, one in four Americans will have a potentially preventable injury serious enough to require medical care.
- These injuries account for almost 10 percent of all hospital emergency department visits.
- Injury patterns vary by age group, gender, and cultural group.
- Injuries pose a significant drain on the health care system, incurring huge treatment, acute care, and rehabilitation costs.

The report concludes that, "Each year, traffic crashes in the United States claim over 40,000 lives and cost Americans $150 billion in economic costs, including $17 billion in medical and emergency expenses, lost productivity, and property loss. Traffic crashes aren't "accidents." They are both predictable and preventable. The quickest, easiest, and most effective way to prevent traffic injuries is to make certain that every vehicle occupant is properly buckled up on every trip. The motor vehicle injury problem affects all Americans. The cost of personal pain and suffering, the loss of a loved one, and serious injury to a family member cannot be measured. Every person in America also bears the economic cost of motor vehicle crashes—on average, $580 a year. These include the costs of the emergency response providers, higher medical and insurance costs, and lost productivity. When individuals don't wear seat belts, these costs increase considerably because the injuries are more serious."

MEASURING IMPROVEMENT

It is debatable as to how improvement is defined--yet nobody seems content with the fatality statistics. This paper recognizes two sources for statistics. They are the National Safety Council (NSC) publication *Accident Facts* 1998 Edition and The USDOT National Highway Traffic Safety Administration (NHTSA) publication entitled *Trafiic Safety Facts in 1997*. 1997 is regarded as the safest year in highways. Safety campaigns are being credited with pushing the highway death rate to an all-time low. Traffic accidents killed 41,967 people in 1997. Since people drove a little more than 2.5 trillion miles, the death rate was 1.6 per 100 million miles traveled according to the National Highway Traffic Safety Administration (NHTSA). Although the total number of fatalities has been lower in some other years, the higher mileage held down the rate, the lowest since NHTSA started keeping statistics 30 years ago. Traffic accidents killed 42,085 people in 1996, for a rate of 1.7 deaths per 100 million miles. Of those who were killed last year, 21,989 died in passenger car crashes. An additional 10,224 died in light truck crashes, while 2,106 were killed in motorcycle crashes, 717 in large truck crashes and 17 were killed in buses. The agency listed 640 deaths as "other" or "unknown" occupants of vehicles and 154 as "other" nonoccupants. In 1997, 5,307 deaths involved pedestrians, while 813 involved cyclists. All except for light trucks, large truck and cyclist deaths represented declines from 1996. Meanwhile, there were 2.38 million people injured in car accidents last year, while another 77,000 pedestrians were injured. It has been difficult and challenging to achieve occupant vehicle safety to reduce injuries and fatalities irregardless of the combined efforts of the National Transportation Safety Board (NTSB), The U.S. Department of Transportation (USDOT), and The National Highway Traffic Safety Administration (NHTSA) and The National Safety Council (NSC).

The simple fact is that although there have been advancements and improvements in seat belts and air bags over the years **it has not been possible to get motorists to willfully wear seat belts.** This failure to use seat belts is a nationwide problem.

EVENT DATA RECORDER (EDR) INITIATIVES OFFER NEW OPPORTUNITIES

Recent emphasis towards incorporating an Event Data Recorder (EDR) in future motor vehicles may serve as the missing link between seat belt usage, air bag safety and improved occupant protection. In 1997, the National

Transportation Safety Board (NTSB) issued recommendations to NHTSA, based partly on public hearing held on march 17-20, 1997, Public Forum on Air Bags and Child Passenger Safety, indicating that NHTSA should pursue crash information gathering using EDR's. In a safety recommendation letter to NHTSA on July 1, 1997, NTSB recommended:

"Develop and implement, in conjunction with the domestic and international manufacturers, a plan to gather better information on crash pulses and other crash parameters in actual crashes, utilizing current or augmented sensing and recording devices. (H-97-18)" [iii]

In NHTSA's response to the Safety Board, it indicated that it was currently obtaining data from EDR's through the cooperation of the manufacturer, for use in crash investigations. This cooperation is needed since the technology to "download" data from these devices is only available to the manufacturer. NTSB added the EDR recommendation on its "*10 Most Wanted List*" in May 1997. The current status of the NTSB recommendation to NHTSA is: H-97-18 Open-Unacceptable. Currently, NTSB is reviewing NHTSA's activities in this area to determine if the status should be changed to Open---Acceptable. [iv]

In 1997, NHTSA, under a joint agreement with National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) and NHTSA, contracted with JPL to:

"Evaluate air bag performance, establish the technological potential for improved air bag systems, and identify key expertise and technology within NASA that can potentially contribute significantly to the improved effectiveness of air bags.""

The JPL Executive Summary (April 1998) cites that "…This automobile system is injuring occupants because of the widely variable nature of motor vehicle crashes and the performance of current air bag systems. Crashes can happen at any speed and vary widely in character and severity. The occupants to be protected are typical of the population as a whole. They include men, women and children of all sizes and ages who may, or may not, be belted. A restraint system, such as an air bag, must respond to the highly varied and unpredictable need for protection. An inherent design feature of air bags is that they deploy rapidly toward occupants during a crash. This leads to the tendency to cause injuries. To deploy, air bags must burst through protective covers and expand in a very short time. The time from initial impact to full deployment must be on the order of 50ms."

The *JPL Report* [v] noted development on promising technologies to meet the air bag design challenges and forecast these intended improvements by model years 2001-2003. The following is a synopsis:

- 2001 - Improved crash sensors, belt use sensors, and seat position sensors.
- 2002 - Belt spool-out sensors and static display sensors.
- 2003 - Occupant weight and position sensors.

Regardless of these anticipated advancements, JPL noted that an un-belted out-of-position occupant would receive no protection if the air bag is suppressed or malfunctions. The importance of proper seat belt use is highly stressed as a critical issue. The JPL Report found manual restraint use (safety belts and child safety seats) to be critical to addressing the problems of air bags. Furthermore, it was noted that "if air bag designers could assume that occupants would be belted, air bags could be designed to give superior protection for far less hazard. Occupants need to be in optimal position to survive a crash; therefore people need to use seat belts."

The *JPL Report* also served as an impetus towards implementing on-board EDR's in vehicles. In the final report of this project, JPL recommended that NHTSA investigate EDR's, stating in recommendation (6):

"Study the feasibility of installing and obtaining crash data for safety analyses from crash recorders on vehicles. Crash recorders exist already on some vehicles with electronic air bag sensors, but the OEM's determines the data recorded. These recorders could be the basis for an evolving data-recording capability that could be expanded to serve other purposes, such as emergency rescues, where their information could be combined with occupant smart keys to provide critical crash and personal data to paramedics. The question of data ownership and data protection would have to be resolved, however. Where data ownership concerns arise, consultation with experts in the aviation community regarding the use of aircraft flight recorder is recommended."

Finally, the *JPL Report* noted that "Surveys of industry and NASA did not identify major new technologies or concepts. All of the technologies and concepts surveyed had been previously described in published papers, company brochure, etc., or were variations of these concepts and technologies. Improvement of restraint system safety and protectiveness is primarily one of evaluating and developing known technology options from a total systems perspective. Perhaps this report can be a catalyst for new ideas." It is the intent of the author to follow-up this suggestion by technically explaining a new idea and concept for significantly improving occupant safety via combining emerging technologies.

A Task Force was formed through the sponsorship of NHTSA and met on October 2, 1998 to address research requirements for on-vehicle event data recorders. [vi] Participants included representatives from NHTSA, FHWA, NTSB, TRB, the major American automobile, truck, and bus manufacturers, and several other vehicle manufacturers. The Task Force members recognized issues regarding liability and privacy. The objective offered by the NHTSA for the task Force was to facilitate the collection and utilization of collision avoidance and crash worthiness data from on-vehicle event data recorders (EDR). The scope was limited to research rather than regulatory initiatives. Current EDR systems are considered to be early generation systems with enormous potential for collecting and using pre-crash, crash, and post-crash data. EDR's are defined as devices capable of gathering, storing and displaying data elements from a vehicle in motion as pre-crash, crash and post-crash. Event data elements include but are not limited to active suspension measurements, advanced systems, air bag inflation time, air bag status, airbag on/off switch position, automatic collision notification, battery voltage, belt status of each passenger, brake status-service, brake status-ABS, collision avoidance, braking, steering, etc., crash pulse-longitudinal, crash-pulse lateral, CSS presence indicator, Delta-V-longitudinal, Delta-V-lateral, electronic compass heading, engine throttle status, engine RPM, environment as ice, wet, temperature, lamination & other, fuel level, lamp status, location via GPS data, number of occupants, principle direction of force, PRNDL position, roll angle, seat position, stability control, steering wheel angle, steering wheel tilt position, steering wheel rate, time and date, traction control, traction coefficient estimated from ABS computer, transmission selection, turn signal operation, vehicle mileage, vehicle speed, VIN, wheel speeds, windshield wiper status, yaw rate, turn-key start time, vehicle movement time, location at start, velocity at crash, trip time at collision or crash, fire in cabin, water in cabin, audio-clip at air bag deployment, etc.

KEY DATA ELEMENTS

Although an EDR may ideally provide any, or all, of the data elements mentioned above the most critical data elements are:

- Location
- Time
- Velocity
- Direction
- Seat Belt usage

CRASH PULSE

Crash pulse is an important concept used in analyzing crash data. A notice in the *Federal Register* [vii] regarding federal motor vehicle safety standards; occupant crash protection noted that "Crash pulse means the acceleration-time history of the occupant compartment of a vehicle during a crash. This is represented typically in terms of g's of acceleration plotted against time in milliseconds (1/1000 second). The crash pulse for a given test is a major determinant of the stringency of the test, and how representative the test is of how a particular vehicle will perform in particular kinds of real world crashes. Generally speaking, the occupant undergoes greater forces due to the secondary collisions with the vehicle interior and restraint systems if the crash pulse is shorter, which would lead to higher overall g's. In a relatively "hard" crash pulse, a vehicle's occupant compartment decelerates relatively abruptly, creating a high risk of death or serious injury. In a relatively "soft" crash pulse, there is a lower rate of deceleration and proportionately lower risk of death or serious injury. The nature of the crash pulse for a vehicle in a given frontal crash is affected by a number of factors, including vehicle speed, the extent to which the struck object collapses and absorbs injury, and, in the case of non-fixed objects, the relative mass of the vehicle and the struck object. Large cars typically have relatively mild crash pulses, while small cars and utility vehicles typically have more severe crash pulses."

COMBINING EMERGING TECHNOLOGIES

By combining simple technologies and incorporating these within the Event Data Recorder (EDR) Program it would be feasible and possible to introduce a nationwide plan of implementation that can willfully increase seat belt usage and make our roads the safest in the world. It will be further argued in this paper that the EDR program and implementation plan could and should include positive incentives and reward the motorist and occupants for wearing seat belts while at the same time decreasing the annual costs of negligence to society.

OLD PROBLEMS OFFER NEW OPPORTUNITIES

Past problems connected with seat belt usage rates and simple solutions combining emerging technologies may solve present and future problems connected with air bag technology. A great effort was devoted within the auto industry to improving air bag safety but there is no method reliable enough without restraining the driver and occupants via seat belts. This is especially true regarding young children. Air bags work best when seat belts are engaged. The bottom line to safety during a crash is keeping the occupants in position. There is absolutely no question that seat belts save lives. Seat belts are the most effective safety device available today, yet, only 66 percent of Americans actually use seat belts. Federal assistance programs such as Medicaid, Medicare and Aid ultimately pay many costs of motor vehicle crashes to Families with Dependent Children. Approximately one third of the cost of motor vehicle crashes is paid by tax dollars (source NHTSA). This enormous cost burden is a national problem. In 1996, this cost was estimated at 176.1 billion dollars. Today, despite the greater number of airbags in the vehicle fleet, the number of vehicle deaths and injuries have increased for three consecutive years, and slightly decreased in 1996. Despite significant efforts by the federal government to reverse this trend, deaths and injuries continue to rise. The time has come to utilize state-of-the-art technologies to address and eliminate this national tragedy. Numbers tell the story why we should use seat belts:

- 23,900,000 motor vehicle crashes are reported by law enforcement agencies each year in the United States.
- 17 million people and 12 million vehicles are involved in these crashes.
- About 43,200 deaths result in these crashes; that's an average of 115 deaths per day (similar to a major airline crash every day of the year).
- 21,989 passenger car occupants die every year (that's about 2,000 more than the total number of homicides that occur in the US each year).
- Motor vehicle crashes are the leading cause of death for persons between 6 and 33 years old.
- In 1989, if every front seat occupant had buckled up, an estimated 15,500 deaths and several hundred thousand serious injuries could have been prevented.
- Seat belts could save about half of the motorists who die unbelted in crashes each year, and prevent about half of the serious injuries unbelted motorists suffer.

SHORT HISTORY OF SEAT BELT USAGE IN THE UNITED STATES

The *Presidential Initiative for Improving Seat Belt Usage* states "…while automobile manufacturers installed the first seat belts in the 1950's, seat belt use was very low—only 10-15 percent nationwide—until the early 1980s. From 1984 through 1987, belt use increased from 14 to 42 percent as a result of the passage of seat belt use laws in 31 states. Then, from 1990 through 1992, belt use increased from 49 percent to 62 percent as a result of a national effort of highly visible enforcement and public education. Since then, belt use has risen slowly and some states have struggled to maintain seat belt use at current levels. In 1996, belt use nationwide was 68 percent, and ranged across the states from a high of 87 percent in California, to a low of 43 percent in North Dakota. Currently, 49 states, the District of Columbia, Puerto Rico and all the U.S. Territories have seat belt laws. New Hampshire is the only exception. (New Hampshire requires seat belt use up to age 12). In 37 states, the law provides only for "secondary" enforcement of seat belt violations, requiring an officer to stop a violator for another infraction before issuing a citation for failure to buckle up. Under primary enforcement, a citation can be written whenever a law enforcement officer observes an unbelted driver or passenger. Currently, 12 states, the U.S. territories, Puerto Rico, and the District of Columbia, all have primary (or standard) enforcement laws. California, Georgia, Louisiana, Maryland, the Virgin Islands, and the District of Columbia have a seat belt law that assesses driver license penalty points. Seat belt use in the 12 states with primary (standard) seat belt laws currently averages 15 percentage points higher than states with secondary laws."

AUDIBLE AND VISUAL SEAT BELT WARNING SIGNAL LAWS

There is federal law that permits and regulates audible and visual seat belt warning devices. There is a specific length of time after start-up that devices are permitted to perform. Afterwards, they are generally useless when a vehicle is in motion. No audible or visual signal reminds occupants that seat belts have been disconnected after a vehicle is moving. In one example, it is possible to buckle-up at start-up then un-buckle and drive unprotected without any warning or reminder. Therefore, lacking is the ability to constantly monitor seat belt usage. A public opinion poll conducted by Louis Harris for Advocates for Highway & Auto Safety, May 1996 surveys attitudes. [viii] Despite conventional wisdom that the public wants less government involvement in regulatory matters, decisive majorities of Americans feel it is important for the government to play a strong role in highway and automobile safety regulations. Among the key findings in this are that 94% say it is important to have federal regulations of car safety standards, with 77% stating such a presence is important. 80% feel a federal presence is important in passing laws that mandate seat belt use, with 61% saying federal involvement in this area is very important.

SEAT BELT DEFENSE CLAIMS AND ACCIDENT FRAUD

In 17 states (Alaska, Arizona, California, Colorado, Florida, Iowa, Kentucky, Michigan, Missouri, Nebraska, New Jersey, New York, North Dakota, Ohio, Oregon, West Virginia, and Wisconsin) safety belt defense is allowed. Damages collected by someone involved in a crash may be reduced if a person failed to use a belt. The reduction is permitted only for injuries caused by nonuse of belts, and in some cases the reduction may not exceed a fixed percentage for the damages. The Insurance research Council (IRC) [ix] estimates that between $5.2 and $6.3 billion is added each year to the bill of American auto insurance policyholders because of outright fraud and/or injury claim padding. A SB-EDR system that determines the number of occupants and other crash behavior would help reduce insurance fraud.

LEGAL IMPLICATIONS OF CRASH RECORDER DATA

The Office of Technology (OTA) assessment (1975) "*Automobile Collision Data: An Assessment of Needs and Methods of Acquisition*" [x] 1975 at cites the following:

"…On the question of whether crash recorder data should be admitted, the main point is whether the recorder is reliable, properly read out, and provides a record of the particular event in question. The data of itself is not dispositive of liability, but merely serves as certain evidence of the event. As indicated earlier in this report, there is good correlation between crash severity a recorder might measure and the extent of crash deformation to the vehicle in which it was installed; and it would be difficult to refuse evidence on the crash severity magnitude as interpreted from vehicle deformation. Thus if the recorder provides good evidence of the event, it seems appropriate that the evidence should be admitted. It may be possible to restrict through legislation the admissibility of crash recorder evidence, particularly if the recorders are government-owned and the records are retrieved and interpreted by government employees. Consider, however, the objective of a very simple and widely used integrating accelerometer that is conveniently and readily read by any police accident investigator without special training. It would appear difficult to prevent testimony by a layman – say a tow-truck operator or an auto mechanic—as to what he saw immediately after the accident. In summary, we believe that (1) the data from a crash recorder would be admissible, if it meets necessary qualifications, in a court of law; 2) the data should be admitted if it is good evidence; (3) it will be difficult to prevent admitting crash recorder data, even by Federal law, if the record can be easily read by an untrained person…"

RESPECT FOR OWNERSHIP OF THE DATA

Privacy is the most important issue regarding the success or failure of implementing the SB/EDR. In a position paper presented to the NHTSA EDR Working Group entitled *Information Privacy Principles for Event Data*

Recorder (EDR's) Technologies (Kowalick) 1998 noted individual motorists or others within motor vehicles have an explicit right to privacy. Although this right to privacy is not explicitly granted in the Constitution, it has been recognized that individual privacy is a basic prerequisite for the functioning of a democratic society. Indeed an individual's sense of freedom and identity depends a great deal on governmental respect for privacy. Therefore all efforts associated with introducing future EDR technologies must recognize and respect the individuals interests in privacy and information use. Thus, it is imperative to respect the individual's expectation of privacy and the opportunity to express choice. This requires disclosure and the opportunity for individuals to express choice, especially in regards to after-market products. OEM EDR technology limits an individual's expression of both privacy and choice. After-market value added EDR products permit free market competition and sense of ownership. Several stand-alone after market technologies can easily be combined to produce an after-market EDR virtually independent of the vehicle architecture thereby readily permitting a common standard for retrofitting to a vehicle fleet. Since individuals will operate and occupy vehicles equipped with EDR's that record data elements, subsequently it follows that information is created regarding both individuals and vehicles. Individuals should have the means of discovering how the data flows. A visible means of the type of data collected, how it is collected, what its uses are, and how it will be distributed is basic to consumer acceptance. Consumers should also have a choice in making this data available for post-crash analysis. Numerous studies cite the number one central concern of the public as understanding the reason they are being subjected to technology up-front, candidly and directly. Responsibility for disclosure should be high priority and may be achieved through methodologies via print-material formats, etc. Disclosure must be constant and consistent. Any data collected via EDR technologies should comply with state and federal laws governing privacy and information use. All data collected and stored should make use of data security technology and audit procedures appropriate to the sensitivity of the information. EDR technology data storage should include protocols that call for the purging of individual identifier information respectful of the individual's interest in privacy. Information collected should be relevant to the purpose and mission statement associated with the EDR disclosure statement. Consumers should have the reasonable assumption that they will not be ambushed by information they are providing. Information derived from EDR technologies absent personal identifiers may be used for other purposes clearly stated in the disclosure statement. Information including personal identifiers may be permissible if individuals receive effective disclosure and have a friendly means of opting out. Personal information should only be provided to organizations that agree to abide by the privacy principles stipulated in the disclosure statement. Should the EDR technologies be maintained in a government database Federal and State freedom of Information Act (FOIA) obligations require disclosure. Such databases should balance the individual's interest in privacy and the public's right to know. Permanent or temporary storage of data should preclude the possibility of identifying or tracking either individual citizens or private firms and should follow the principles suggested to the EDR Working group. A position paper presented at the Second World Congress of Intelligent Transport Systems (1995 Yokohama) entitled *Positioning Systems and Privacy* by C.R. Drane and C.A. Scott cites, "…We put forward for discussion a stronger version of the respect for ownership principle. The stronger version holds that the driver puts time, energy, and money into moving along the road network. Accordingly, the driver has ownership of the trajectory of this movement…The idea that movement data is owned by the person who exerts effort in generating the data is a rather abstract concept." A paper presented to the NHTSA EDR Working Group entitled *Privacy Concerns for the National Highway Traffic Safety Administration* by Sharon Y. Vaughn (NHTSA/OCC) concludes: "Following the same procedures that NHTSA implements with respect to operating the NASS, SCI and FARS programs, NHTSA would require a release from the owner of the vehicle in order to gain access to the data from an EDR. NHTSA would assure the owner of the vehicle that all personal information would be withheld from disclosure."

SOLUTION TO THE ISSUE OF WHO OWNS THE DATA

There are many problems and concerns connected with the question of ownership of the EDR and the data that is generated. It has been argued that vehicles are sold to consumers without any vestigial interests retained by manufacturers and thus the vehicle owner would presumably own the data as well. If this is true then the ability of public authorities to access the data is greatly reduced and may be impossible since the owner can withhold the data if they felt it would not serve self-interest. Another problem results when a supplier rather than a motor vehicle manufacturer retains ownership of the data and controls access by utilizing proprietary protocols that essentially prevent anyone else from accessing the data. However, suppliers may report the result of the data extraction. It has been suggested that these problems might be overcome if the manufacturer retained ownership or if an agreement allowing access to the data could be arranged with the owner of the vehicle. The complexity of these solutions would hamper implementation of a SB/EDR system. The simple solution is to design a system that transmits the data from the vehicle to a secure archive for post-crash analysis. By transmitting data through a secure encrypted digital cell link to an archive problems associated with permission from the owner and access to the vehicle are overcome. A simple release from the owner when the vehicle is registered is all that is legally required. Positive incentives for the owner could include reduced registration fees and a disclaimer that personal identifiers will not be collected and privacy will be preserved. An example reads:

THIS VEHICLE CONTAINS A SYSTEM TO TRANSMIT CRASH DATA ELEMENTS TO A SECURE ARCHIVE FOR POST-CRASH ANALYSIS. THE OWNER OF THIS VEHICLE MAY ACCESS THE DATA.

The infrastructure for such a system currently exists. The U.S. is linked with wireless cells (cell sectors) for cell phone communications. Cellular telephones are actually in operation more than most users think (if the phone is turned on, but not actually being used). To monitor the state of the network and be able to respond quickly when calls are made, the main cellular controlling switch periodically "pings" all cellular telephones. This pinging lets the switch know what users are in the area and where in the network the telephone is located. This information is used to give location. See *Wireless Technologies and the National Information Infrastructure* (see OTA –ITC-622). The Office of Technology Assessment has done several studies of aspects of telecommunications privacy and security. See U.S. Congress, Office of Technology *Assessment Security and Privacy in Network Environments*, OTA-TCT-606 (Washington, DC: U.S. Government Printing Office, September 1994). The next millennium will see a marriage between cell phone technologies and GPS location technologies. Inexpensive single chip embedded receivers are currently used in cell telephones. It would be feasible and practical to combine these emerging technologies to create a low cost SB-EDR. Another benefit of transmitting crash data is that it simplified the process of storing data and responding to requests for information. It also enables the U.S. Government to collect and store a large volume of crash data that can be accessed through chain-of-custody agreements for research. There are many emerging technologies that permit transfer of high-speed data. Basically, the point here is that when a vehicle crashes it collects data elements such as location, time, velocity, direction, number of occupants, seat belt usage, etc., and then stores these for extraction either via wireless Infrared or wireless RF. A wireless IR extraction can be utilized on-site without entering a vehicle if the on-board SB-EDR is located in the vicinity of the rearview mirror / front windshield.

RECENT DISSERTATION CITING A SHORT HISTORY OF EDR INITIATIVES

A recent dissertation provides a review of the worldwide initiatives to implement EDR's. Entitled "*Validity and Reliability of Vehicle Collision Data: Crash Pulse Recorders for Impact Severity and Injury Risk Assessments in Real-Life Frontal Impacts"* it was written by Andres Kullgren as a thesis for a degree of Doctor in Medical Sciences, Department of Clinical Neuroscience, Section for Personal Injury Prevention, Karolinska Institute, Stockholm, Sweden in December of 1999. Included within is a section that details a short history of crash recorder techniques (p14-15). The dissertation cites verbatim, "To be able to use adequate impact severity parameters and thus increase the accuracy of the impact severity; calculations in studies with traditional retrospective accident reconstruction techniques should be complemented by severity measurements recorded by on-board measurement devices. Several attempts to do this have already been introduced as described below. The first attempt to measure acceleration time history in real-life impacts with the aim of increasing the accuracy of impact severity measurements was carried out in 1971, when NHTSA started a project called Disc recorder Pilot Project (Hackbarth 1972), where 1050 crash recorders were installed in a fleet of vehicles in the U.S. In 1974 Teel et al (1974) presented results from recordings of 23 real-life impacts. The Disc Recorder measured acceleration in three dimensions in the crash phase with accelerometers based on a spring-mass-system, where the movements of the mass in the impact were recorded. The mass displacements were recorded on a rotating magnetic disc. The measurement range was +-50g, the accuracy was =-8 and the threshold was +-5g. In 1972 the U.S. Department of Transport started a project where a simple and low cost crash recorder was developed (Hudson 1972). Acceleration measurements in the impact phase were based on a photographic film by a light-emitting diode. The light from the diode was reflected in a mirror located on the mass, and then recorded on the film. A prototype of a crash recorder was built and tested, but with disappointing results. The measurement accuracy of the acceleration levels was too low. In 1979, on request from NHTSA, Sherwin and Kerr presented a new crash recorder, where longitudinal and lateral accelerations were measured with a range of +- and with an accuracy of +-8%. This recorder was purely electronic with no moving mechanical parts. The accelerations were measured with piezo-electrical sensors during 0.512 seconds, with a sampling rate of 500Hz and with a frequency response of 80 Hz. The cost per unit was in 1979 calculated to be approximately 50 USD. These recorders, and other simple and relatively inexpensive crash recorders presented before 1980, have been listed and analyzed by Meinton and Smith (1980). Since 1980 several other crash recorders for measuring the acceleration time history have been presented, see Wilkie et al (1989), Salomonsson and Kock (1991), Fincham et al. (1991), Barth et. Al (1994), Kullgren et al. (1995). And Norin (1995). The crash recorder by Wilkie et al. (1989) was intended for recording longitudinal and lateral accelerations and impact speeds. This electronic crash recorder measured acceleration with a sensor using piezoelectric film. In 1989, the cost per unit was calculated to be below 140 USD. One prototype was built and tested. The DRACO recorder proposed by Finchman et al. (1991) and the UDS recorder presented by Salomonsson and Kock (1991) and Barth et al. (1994) were intended to be used also for legal purposes. They can measure many parameters in the pre-crash, crash and post-crash phases. Accelerations and rotational accelerations in three dimensions are measured in the crash phase with a sampling frequency of 500Hz. 25 UDS recorders were fitted in police cars in London as a part of a wider study of vehicle recorders and driver behavior carried out by the European Union's DRIVE initiative on information technology applied to road transport (Fincham 1995). The UDS has been installed in a large fleet of vehicles but the accident information has not yet been presented or used in research projects. The crash recorder from the Swedish insurance company FOLKSAM measures the acceleration time history in one direction with a sampling frequency of 1000 Hz and with a threshold of approximately 2g. The measurements are based on recordings of the movements of a mass in a spring-mass-system in the impact phase. The recordings are done on a photographic film by means of a light emitting diode located on the mass. In 1995 the cost per unit was approximately 5 USD. The crash recorder used by Volvo (DARR) and presented by Norin (1995), records the signal from the airbag sensor for 105 ms with a sampling frequency of 600 Hz, and is activated when the airbag is deployed. A later version of the DARR measures the acceleration for 167 ms but with a lower sampling frequency (Broden and Olsson 1996). In validation tests the standard deviation of ∇V measurements has been found to be 1.1 km/h (2.5%) (Broden and Olsson 1996). Less costly crash recorders have been proposed by Warner et al. (1974) and Aldman and Tingvall (1987): the former measuring the change of velocity in two directions and the latter for measuring an impact severity parameter related to the change of velocity during part of the impact phase.

OTA ASSESSMENT

The Office of Technology Assessment (Washington, DC) issued a report in February of 1975 entitled "*Automobile Collision Data: An Assessment of Needs and Methods of Acquisition.*" The study was requested as an evaluation of the automotive crash recorder program proposed by the National Highway Traffic Safety Administration (NHTSA). Although this assessment is dated a close reading will reveal that many of the problems and concerns expressed within are still relevant. The assessment addressed the following issues:

- How much is NHTSA spending to gather accident data?
- Is that data sufficient, or is further data on the characteristics of automobile collision necessary for effective NHTSA standards setting?
- An evaluation of the type of data being produced by existing crash recorders and an explanation of how this data is being used by NHTSA.
- If a database is inadequated, how might an adequate database be obtained and what are the consequences associated with obtaining the data in different ways?
- What are the legal questions associated with the existence of actual physical data from an accident?

The final report divided into the following areas:

- The Need for More and Better Crash Data
- Characteristics of an Adequate data Collection Program
- Alternatives for Adequate Data Collection Program
- Federal Responsibility and Expenditures for Collision Data Gathering

Premises specific to crash data analysis in 1999 are:

- The conclusion that the current national accident database is inadequate to resolve the uncertainties in NHTSA's current and proposed motor vehicle safety programs.

- The major deficiency in data relating collision forces and actual fatalities and injuries.
- That a comprehensive accident data program must be designed with great care that is representative and avoid inherent biases to answer outstanding critical safety questions and provide uniformity in reporting and format.
- That the federal Government, not States, manufacturers or insurance companies, should support the central data collection activities whereby this is a national problem and that Motor Vehicle Safety Standards are promulgated by the federal government.
- Crash recorders provide data that may be admissible in a court of law.

AIR BAGS

The introduction of air bags has not solved the problems associated with occupant protection. Air bags have been installed in millions of cars and light trucks. As of the end of the model year 1996, driver air bags had been installed in over 56,000,000 vehicles and passenger air bags in over 27,000,000 vehicles. When occupants properly use seatbelts, air bags increase the chances of survival in severe frontal crashes. But air bags may pose dangers for some occupants in certain situations. About 35 million cars currently on the road are equipped with passenger-side air bags and each month approximately one million new cars equipped with air bags are manufactured. Between 1993 and mid-1998, 61 children died because they were struck by an air bag in what would otherwise have been a survivable crash. These occupants were in the danger zone when the air bag inflated. Forty-four adults were also killed by their air bags in crashes they could have survived. In 1996, the Safety Board completed a study on the performance and use of child restraint systems, seatbelts, and air bags for children in passenger vehicles. The study analyzed data from 120 crashes that occurred between 1994 and 1996. Vehicle occupants included 207 children under age 11. Of the 120 accidents, air bags deployed in 13 accidents in which a child was seated in the front passenger seat. The study focused on the dangers that passengers-side air bag pose to children; factors affecting injury severity; adequacy of federal standards regarding the design and installation of child restraint systems; need to improve seatbelt fit for children; adequacy of public information and education on child passenger protection; and adequacy of state child restraint use laws. The Safety Board also convened a public forum in March 1997 to discuss concerns related to the effectiveness of air bags and ways to increase seatbelt and child restraint use. Other issues discussed included air bag-induced injuries; role of air bags as a primary or secondary restraint system; deployment thresholds; complexity of implementing depowered air bags; switches, and suppression devices; advanced air bag technology; experience with air bags in other countries; evaluating the effectiveness of air bags; enforcement of restraint laws; design of child-friendly seats; and design of child restraints.

THE SEAT BELT EVENT DATA RECORDER (EDR) SYSTEM WOULD CONSTITUTE ONE OF THE MOST POWERFUL AND COST-EFFECTIVE AUTO SAFETY DEVICES EVER CONCEIVED.

A device combining occupant sensing technologies to encourage and monitor seat belt usage within an Event Data Recorder (EDR) is what is required to produce a large change in United States and worldwide auto fatalities. Such a device would do so by achieving something that has eluded motorists to date-- the widespread use of seat belts twenty-four hours a day. There is no question that if seat belts were used twenty-four hours a day, then there would be a substantial reduction in the number of fatalities and serious injuries. The insurance industry, health professionals, Law enforcement and the civil and criminal courts would applaud such a scenario. Paradoxically, the need to further reduce auto fatalities comes at a time when the United States mileage death rate is already at an all time low--the lowest in the world. Yet, the actual death rate is still considered a very unacceptable number. Worldwide, only one country, Sweden has an initiative to reduce traffic fatalities to zero. If a comprehensive Event Data Recorder (EDR) incorporating occupant sensing and restraint usage data elements is adapted and utilized then the mileage death rate will decrease even lower. A major, rapid shift in fatality trends will occur. Three times over the years fatalities have increased by 5,000 or more deaths in a relatively short time, and, conversely, four times deaths have fallen by 7,000 or more in a short time. B.J.Campbell [xi] notes, "It is interesting to speculate on the reasons for these massive changes. By the 1930's automobile accidents were already a considerable problem in the United States, and by 1937 deaths reached 39,643. The death rate per hundred million miles was more than five times greater than in 1986 (14.68 vs. 2.58). There was a large decrease (-7000) in 1937-38, seemingly not related to changes in exposure, for the mileage exposure before and after the decrease appears to have stayed virtually the same. This change is puzzling since it happened more or less in the middle of the Great Depression. On the other hand, it appears more likely that the up swing in deaths just before WW II reflects the economic expansion on the eve of the war with a consequent increase in exposure. There was an increase of 10% in mileage during the same period, but fatalities went up even more (up 5,000). The largest downswing in our nation's history, a decrease of 16,000 lives over a single year period, happened early in WW II, when mileage exposure dropped by more than one third. Gas rationing, tire rationing, a 35-mph speed limit, and millions of young men in armed services and off the highways all coincided with this period; all these factors presumably contributed. Actually, fatalities per unit exposure were about the same, as earlier, thus this improvement appears to have been almost entirely exposure driven. After the war, there was an increase of 9,000 traffic fatalities within two years at the time of de-mobilization. The reduced mileage exposure seen during the war was reduced. As with the previous large decline, the increase in fatalities was largely exposure driven, but fatalities actually increased somewhat less than exposure would have indicated, suggesting the simultaneous influence of other factors. The next upswing was very large, though spread over a longer period--an increase of nearly 15,000 in fatalities from 1961 to 1966. In 1961, the actual number of deaths in the U.S. was 38,091, fewer than the 39,643 recorded 24 years earlier in 1937. Thus, despite the growth in population and cars from the 1930;s to 1961, the death rate per hundred million miles had fallen so much that the raw number of fatalities remained relatively constant. Within the next five years, however, the rate soared such that in 1966 the raw number of deaths was 53,041.This rate is described by two phenomena: first, a great increase in cars and mileage exposure, and second, by a plateau in the improvement in mileage death rate. For approximately nine years the mileage death rate did not fall. In 1961, the death rate per hundred million vehicle miles was 5.16. In 1969, it was 5.21. This long-term stagnation in the death rate was unique to that point in history--a time when car ownership was soaring, speed limits were high, and powerful cars were a central fact of car marketing and owner preference. It was probably no coincidence that during this period calls for an increased Federal role in highway safety were growing more urgent, finally culminating in the activation of the National Highway Safety Board in 1967. The downswing in 1973-75 reflected a combination of the oil embargo, the related severe recession, and the 55-mph speed limit enacted in response. In that time, deaths dropped by about 9,000 despite the fact that exposure did not decrease proportionately. Likewise, during the recession of 1981-83, a drop in fatalities of 9,000 occurred though exposure remained much the same."

The point of the forgoing is that the occasional very large changes in United States highway fatalities have been "powered" by major societal forces--wars, recessions, or periods of great economic growth." B.J. Campbell and Francis A. Campbell come to the conclusion that *"It has not yet been possible to produce fatality changes of comparable magnitude by imposition of any specific highway safety countermeasure."* They are absolutely correct. The historical record confirms their beliefs.

TIME FOR A NEW IDEA TO PROMOTE SEAT BELT USAGE

Thus, the time has come for a new impetus, a new idea. It is time to reward the motorist for seat belt usage by positive incentives. An EDR tied to seat belt usage would make this possible. This would be a new innovation in auto safety with great potential towards reducing injuries and fatalities. Once available to motorists worldwide this device will provide the specific highway safety countermeasure required assuring that motorists are adequately protected. It is feasible to forecast a dramatic reduction in United States traffic fatalities due to the fact that motorists' will be reminded when the seat belts are engaged. Externally the existing and future-pending seat belt laws can now be adequately enforced twenty-four hours a day--all year long. This would help to achieve a major goal of the NTSB that of getting the states to pass and enforce primary seat belt laws. A conservative forecast is that approximately 10,000-20,000 fatalities can be avoided within one year of implementation nationwide and perhaps a quarter million motorists injuries worldwide can be prevented. This device has the potential of literally saving millions and millions of motorists as we enter the 21st Century. An EDR system tied to seat belt usage has tremendous value for society. This idea for a SB-EDR can be reduced to a tangible form. Perhaps, the simplest way to determine is such a device would be an asset to society is to observe motorists--any where and at any time. Ask yourself how many of these motorists are actually wearing seat belts and how you know this to be true? Observe the various traffic flows, the ever changing lighting and visibility conditions and the seeminglessly endless number of motorists who for whatever reason fail to buckle-up. Remind yourself that seatbelts have been around for a long time, that they do save lives, and yet that for odds-and-ends reasons motorists avoid them. Doesn't it make sense to install an economical, carefree, user-friendly safety device to eliminate all the odds-and-ends excuses of non-usage and make everyone's highway safer? By promoting usage of the Seat Belt Event Data Recorder (SB-EDR) System through positive incentives such as a reduction in automobile insurance and a nationwide uniform and reduced penalty for motor vehicle violations, the SB-EDR device would make the world motorways safer and save thousands of lives.

DESCRIPTION OF THE TECHNOLOGY

Reduced to a tangible form the SB-EDR is a system to:

- Record, in real time, seat belt usage, vehicle speed, trip duration, and direction of travel using Global Positioning System (GPS) technology;
- Detect seat belt usage using infrared (IR) technology, making it difficult or impossible for the driver or vehicle occupants to fool the seat belt usage detection system; and
- Display lights indicating seat belt usage through the front and/or rear windshield from the location of the rearview mirror.

The SB-EDR system consists of the following basic components:

- IR seat belt detection system;
- Seat belt usage display system;
- Data recording system;
- Data transfer via wireless IR or RF

The IR seat belt usage detection system consists of a wide-angle IR emitter, retroreflective material on the seat and seat belt webbing, and a wide-angle IR detector. Mounted in the rearview mirror assembly, the emitter continually irradiates the seat area with a wide beam of infrared radiation whenever the vehicle is on. IR retroreflectors on the seats and/or seat belt webbing reflect some radiation back to the wide-angle IR detector, which is mounted next to the emitter. The detector determines if the seat is occupied and if the seat belt is in use by calculating the proper angles expected to be reflected back to the detector. Additional detection systems can be mounted on the ceiling to monitor seat belt usage in the rear seats. The display system consists of forward and/or rearward indicator lights that are illuminated when the system concludes that all mounted occupants are using seat belts. The forward light, preferably blue neon, is mounted flush against the windshield and intensity-adjusted by coupling it with a photovoltaic cell. The rearward indicator light, preferably a red laser or light-emitting diode, is mounted adjacent to the rearview mirror. An illuminated forward light indicates proper seat belt use, while the rearward light indicates at least one seat belt that is not in proper use. An override button could be provided to turn off the rear indicator light to avoid alerting others, including law enforcement personnel, that the seats are not in proper use. Although the indicator may be turned off, the system continues to monitor and record seat belt usage. Occupants will be reminded to buckle up as they see the oncoming cars' seat belt indicator lights. Furthermore, it is anticipated that when the SB-EDR system is widely implemented, oncoming drivers will flash their headlights to remind forgetful occupants to fasten their seat belts. The data recording system consists of GPS circuitry, a microprocessor, and a removable memory module that contains "at least one Meg" of encodable, erasable, programmable memory. The microprocessor controls the IR seat belt usage detection and display systems and receives and records data. Four GPS antennae receive satellite signals—two antennae mount the system housing to the windshield and two house interfaces. GPS circuitry provides the microprocessor with vehicle velocity, longitude, latitude, travel duration, direction, and time information. This information as well as data on occupant seating, seat belt use, and override button are stored in memory. Law enforcement may remove the memory unit for use during crash investigation. The memory unit may be secured with a special lock accessible only to appropriate personnel to prevent tampering with the crucial data for determining liability. The system housing would be ruggedized to survive vehicle crash. Another functionality is the ability to transmit stored data elements to a secure archive by utilizing digital wireless IR transfer or wireless RF transfer.

The seat belt monitoring system would be implemented in partnership with insurance companies, who will benefit in several ways. By increasing seat belt usage, the system decreases the costs associated with vehicle crashes. By providing information on occupancy and travel direction/speed/duration, the system may reduce the costs associated with insurance fraud. Insurance companies may be able to reduce costs by denying claims when the system indicates that an occupant was not wearing a seat belt at the time of the crash. Law enforcement would also benefit because the system enables easier identification of seat belt infractions. The judicial system would benefit from having additional data on which to base decisions.

CONCEPT OF THE SB/EDR SYSTEM COUNTER MEASURE

The objective of the SB-EDR System is to increase seat belt usage worldwide within the six hundred and ninety million vehicles on the planet earth by getting people to willfully wear seat belts. The SB-EDR is essentially a real-time vehicle event data recorder similar in concept to a flight recorder utilized in air travel. The device consists of passive safety apparatus that will display an interior and exterior visual signal that indicates whether seat belts are being used. This interior/exterior visual signal (telltale light) will be seen by the motorist and also by traffic. On interstate highways a motorist may face hundreds of cars for each mile traveled. This unique light source will become an icon for vehicle occupant safety. This visual signal will serve to advise others to buckle up, much in the same manner, as when other motorists turn on their headlights, eventually all motorists do. Oncoming traffic flow varies from 1 to 200 vehicles per mile. Each vehicle would serve to advise and remind motorists to buckle-up. Once, one motorist notices that the other motorists have engaged their seat belts, perhaps, he/she will engage seat belts. This would have to be a completely voluntary act, not subject to fine or punishment. The major inducement to buckle up would occur from the reminder of others who have done so, and through positive incentives for doing so. Positive incentives will encourage motorists to buckle-up. Currently, there are no positive incentives to have motorists buckle-up other than the message that seat belts save lives and reduce injuries. Although this message is rather common sense it has been ineffective and usage rates have not reached potential level.

Positive incentives would include reduced automobile insurance rates endorsed by such organizations as Private Citizen and The Insurance Institute for Highway Safety. Private Citizen is a coalition of consumer, health, safety, law enforcement and insurance companies, organizations and agents working together to support the adoption of laws and programs to reduce deaths and injuries on our highways. The Insurance Institute for Highway Safety is an independent, nonprofit, scientific and educational organization. It is dedicated to reducing the losses--deaths, injuries, and property damage--resulting from crashes on the nation's highways. Another initiative for encouraging positive incentives for seat belt usage would be a nationwide reduction in motor vehicle violation fines for those motorists who were cited and who happened to be buckled-up. The motorist would be rewarded, not penalized and would thus willfully wear seat belts which is the overall objective of the SB-EDR.

Motorists' usage of seat belts would increase thereby saving lives and reducing injury and related medical costs. Highway travel would become safer. This device would receive support, approval, and endorsement of all. The device could be installed as a simple after-market retrofit verifiable within the states that enforce the annual inspection of vehicles. Usage of this device would provide added protection and reduced insurance rates for motorists. Theoretically, seat belt usage will increase worldwide, and the nations' highways would become safer. Motorists will be aware of when they have engaged seat belts and motorists nationwide, during daylight and evening hours, will be constantly reminded to buckle up without law enforcement intervening. Law enforcement would be greatly aided in the responsibility of enforcing seat belt laws in those states that choose to penalize non-usage rather than reward usage. The SB-EDR device would also permit monitoring of seat belt usage at night, during a time when a large percentage of accidents occur. To date, it has been impractical, if not impossible to either monitor usage or enforce the primary seat belt laws at night. Such a device could be installed in the general location of the windshield mirror in such a manner that it would not interfere with vision or conveyances. It could emit a light signal inside the vehicle that would also be visible to rear traffic, and simultaneously emit a visual signal that would be noticeable to on-coming traffic.

HOW THE SB-EDR WORKS

When the automobile is parked and the ignition is turned-off the SB-EDR is non-operational. When the driver enters the vehicle and is seated behind the steering wheel, and when he/she starts the ignition the SB-EDR becomes operational. The SB-EDR becomes operational when the automobile is started and electrical power reaches the unit. A small, LED light emits a red signal from the unit located within the rearview mirror housing that is clearly visible to the motorist and other occupants of the vehicle. At this point, any and all audio or visual reminders or warning devices to buckle-up, which were initially designed by the manufacturer within the vehicle, will be engaged as usual. Thus, at this point the driver has the choice or buckling the seat belt as required by law or not buckling-up before driving the vehicle. If the driver chose to engage the seat belt then an interior reminder light, located near the mirror on the windshield will turn-off. Simultaneously, a second exterior light, emitting a stable blue neon light, located in the same vicinity, but radiating outward toward the front of the vehicle in the direction of on-coming traffic flow will be lit. But, if the driver intentionally chose not to engage the seat belt or unintentionally forget to do so, then the initial interior red light would continue to stay lit as a constant reminder to buckle-up. Should the light become a constant irritant to the driver or passengers they have the option of turning it off by a lit push switch. This option preserves privacy and prevents any abuse of civil liberties or self-incrimination. However, the decision to by-pass buckling-up will be recorded on the microprocessor for future post-crash analysis. Simultaneously, at the point where the SB-EDR becomes operational it begins to receive a data signal from a series of Global Positioning System satellites (GPS). The GPS is a constellation of 24 satellites operated by the Department of Defense, providing travelers with a constant fix on their location. Thus, it is possible to provide the following data time, position in longitude and latitude, velocity, direction, and seat belts engaged on disengaged.

Once the vehicle moves the SB-EDR will continue to monitor and begins to record real time data. This real time data is recorded on a microprocessor attached to the GPS unit. While the vehicle is moving the following real-time data cited above is being monitored. Seat-belt usage is monitored via an infrared light transmitter and detector and recorded in real time data. The SB-EDR is self-contained in a small compact unit that is capable of surviving a crash. It is reliable, tamper-proof, environmentally suitable, maintenance free, and is designed to record real time data for analysis before, during, or after usage of the vehicle. This real time data would be invaluable following a collision or crash. The data could be retrieved on-site by IR extraction without entering the vehicle. Or, accessing a secure archive where it was forwarded via a cell link transmission could retrieve the data. Either way the data is secure and encrypted in digital format. Under normal operational conditions (other than a crash or collision) once the vehicle is stopped and the ignition is turned-off the SB-EDR becomes non-operational. The driver has the option to erase the data stored in the microprocessor by pushing an erase button. If the data is not erased it will be saved. This functionality further preserves civil liberties, protects privacy and eliminates self-incrimination, etc. Finally, if the driver or occupants disengage seat belts during normal operation of the vehicle then the SB-EDR would stop emitting the forward lighting and begin emitting the interior lighting which designated that seat belts are disengaged. This feature would help parents keep young children properly in position throughout the trip and especially at the time of a crash or collision.

ENDORSEMENTS

A SB-EDR encouraging seat belt usage would receive endorsement from the following:

- NTSB & NHTSA interested in achieving nationwide seat belt usage and finding it very difficult to convince the state legislatures to pass primary seat belt laws.
- State legislatures interested in passing and enforcing primary seat belt laws. Prior to incorporation of such a device there was no accurate accountability, especially after dark when ½ of all accidents occur.
- State legislatures interested in enforcing time curfew for teen age drivers to reduce fatality rates. As example, North Carolina has a graduated license system that prohibits teen-age drivers from driving after 9:00 p.m.
- Automobile Insurance Industry which is harassed by insurance fraud. There is a growing trend in America in the area of staged accidents that result in enormous medical claims and increased insurance costs for everyone.
- Legal profession connected with accident reconstruction and liability claims.
- The medical professions connected with Emergency Medical Services (EMS, EMT) etc.
- Auto manufacturers interested in safer vehicle occupant protection.
- Automobile, truck and trailer rental, and leasing companies.
- Vehicle fleets such as FedEx & UPS, etc.
- Consumer and advocacy groups interested in automobile safety.
- Law enforcement community.
- Professional societies.
- Public Health and Injury Control Organizations/Associations.
- State Highway Safety Offices

Last but not least—The American public, which is paying for auto insurance and suffering too much from traffic injuries and fatalities.

RECOMMENDATION: INTRODUCE THE SB-EDR AS A FMVSS

Clearly, if seat belts were used thousands of lives would be saved, as would billions of dollars of social and economic costs of these collisions. And yet, seat belts are not adequately used. An Event Data Recorder (EDR) incorporating and combining occupant sensing and restraint usage as data elements will correct this problem. Such a device could be introduced to vehicles in a manner similar to the Center High-Mounted Stop Lights. As early as 1975, the Safety Board recommended that automobile brake lights be mounted high enough to separate the function of brake lights from tail lights so that a following driver could see the lights of at least two vehicles directly ahead. Center high-mounted stop lights have been required on all new passenger cars sold in the United States since the 1986 model year and all new light trucks since the 1994 model year.

In March 1998, NHTSA issued a report on their effectiveness. The study concluded that center brake lights prevent 92,000 to 137,000 police-reported crashes, 58,000 to 70,000 nonfatal injuries, and $655 million in property damage a year. It also estimates that the lamps save $3.18 in property damage for every dollar they cost. The point here is that this safety device has been extremely effective because it was introduced nationwide via a Federal Motor Vehicle Highway Safety Standard. It is the strong suggestion and recommendation that SB-EDR's be introduced in a similar fashion. If these EDR's include a module for encouraging, monitoring, and recording seat belt usage then this initiative will greatly improve seat belt usage rates nationwide. It will also be possible to increase and monitor seat belt usage twenty-four hours a day globally.

VALUE OF THE SYSTEM

- Encourage seat belt usage and provide monitoring and accountability at all times of day and night worldwide.
- Increase nationwide seat belt usage by positive incentives and consumer acceptance.
- Permit agencies and manufactures to analyze crashes and collisions with real time data similar to those utilized in Aviation as in-flight recorders.
- Provide insurance companies with required accountability to rebate motorists who utilize this passive auto safety apparatus to enhance vehicle occupant safety.

RAMIFICATIONS AND SCOPE

- Accordingly, the SB-EDR will increase the number of motorists that will use seat belts from the approximate sixty-eight percent at present. 37,221 fatal motor vehicles crashes occurred in the United States in 1995 and 41,789 deaths occurred in these crashes--up from 40,676 deaths in 36,223 crashes in 1994. From 1994 to 1995 motor-vehicle deaths increased three percent, thus there were 43,900 deaths, 2,300,000 disabling injuries and a cost of $170.6 billion dollars to society. The 1996 statistics reflect 43,330 deaths associated with motor vehicles and a cost to society of 176.1 billion dollars.

- The SB-EDR System will support and encourage State Legislatures to pass and enforce primary seat belt laws by providing real time accountability with a simple, efficient, non-obtrusive method of determining which motorists are wearing seat belts. Currently, belt use laws in only 12 jurisdictions (California, Connecticut, Georgia, Hawaii, Iowa, Louisiana, Maryland, New Mexico, North Carolina, Oregon, and Texas) are "primary," meaning police that may stop vehicles solely for seat belt violations.

- The SB-EDR System will encourage seat belt usage during nighttime hours when many accidents occur in which occupants are not wearing seat belts. Prior to this system, it was not feasible to encourage use of or enforce the seat belt laws after dark. About half of all motor-vehicle deaths occur during the day and thus the other half occur at night.

- The SB-EDR System will decrease the number of serious injuries and fatalities in traffic accidents associated with not wearing seat belts. The estimated motor-vehicle accident costs reported in *Accident Facts* (1995) cite comprehensive costs in 1994 on a per person basis as $2,890,00 (death), $193,000 (incapacitating injury), $44,000 (non-incapacitating evident injury), $23,000 (possible injury) and $2,600 (no injury). Disabling injuries in motor-vehicle accidents totaled $2,100,000 in 1994, and total motor-vehicle costs were estimated at $176.5 million.

- ❖ The SB-EDR System will provide a visible reminder and motivation seen by millions of motorists thousands of times throughout the day and night. It will become a national icon--a symbol of auto safety. It will reinforce the habit of wearing seat belts amongst adults and will encourage young children and future motorists of the inherent value of wearing seat belts.

- ❖ The SB-EDR System will provide new impetus and added opportunities to local, state, national, and international organizations to promote highway safety and especially seat belt usage. The SB-EDR System would permit the possibilities of providing positive incentives to motorists who use seat belts by encouraging insurance companies to offer reduced automobile insurance rates due to the reduction in medical claims and to permit Legislatures to reduce traffic citation fines. These common sense, doable, positive initiatives combined with the utilization of the system will promote and improve highway safety.

- ❖ The SB-EDR System would provide a means whereby law enforcement agencies and insurance companies could verify if the motorists and other occupants of the motor-vehicle had seat belts engaged or disengaged at the time of the traffic accident. To date, no such method exists. Such data would be extremely useful in deterring hazardous locations, and reducing accident fraud.

- ❖ This system will do something that has not yet been possible: To produce fatality changes of comparable magnitude by imposition of a highway safety countermeasure. The SB-EDR System would achieve this goal if the National Highway Traffic Safety Administration (NHTSA) designated the device a Federal Motor Vehicle Safety Standard. It is recommended that this transpires in a manner similar to when the NHTSA amended Safety Standard No. 103 which thereby required all vehicles to utilize a single-center, high-mounted stoplamp on passenger cars, in addition to the stoplamps presently required. The system would serve as the missing link in the long history of auto safety devices and will enhance all existing devices thereby promoting the general welfare of motorists.

CONCLUSIONS

Unconventional ideas are likeliest to pop up in dis-establishment places. This paper is a classic example of a genuinely good idea expressed by a concerned independent researcher with a vision for "unlimited impossibilities" towards improving occupant safety. Few technical papers possess the power to leave the reader with that feeling of awareness that we call a sense of revelation. This is one of those papers. In this brief work a series of insights and perceptions provide compelling rationale to the objective of improving occupant safety via combining emerging technologies. The overall paper expresses social conscience based on human need. The 20th Century will be remembered as a time of tremendous technological advancements. It will also be recalled as the time when moral barriers were crossed permitting endless carnage on the highways of the world. Perhaps historians will refer to this period in transportation history as an "autocaust" and if so, the time has come to reverse this trend. Implementation of the safety counter measure (SB-EDR) identified in this paper will result in increased nationwide seat belt usage and improve vehicle transportation safety.

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BIOGRAPHIES

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