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Reducing Impaired-Driving Recidivism Using Advanced Vehicle-Based Alcohol Detection Systems

A Report to Congress

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16. Abstract

Vehicle-based alcohol detection systems use technologies designed to detect the presence of alcohol in a driver. Technology suitable for use in all vehicles that will detect an impaired driver faces many challenges including public acceptability, passive operation (not requiring the active cooperation of the driver), invulnerability to circumvention and tampering, the ability to verify that the test was performed on the driver, and the capability to perform accurately and reliably throughout the life of the vehicle without excessive requirements for maintenance.

Several alcohol detection technologies were reviewed in the report: Breath sample analysis, tissue spectroscopy, transdermal perspiration measurement, eye movements, detecting alcohol vapor in the vehicle, driver and driving performance measurement. Technology for use with impaired-driving offenders (i.e., breath alcohol ignition interlock systems) is currently in use, and is practical, accurate, reliable, and relatively low-cost. The report offers suggestions for potential next steps including increasing the use of breath alcohol ignition interlocks among DWI offenders and continuing research and development on tissue spectroscopy and other transparent and non-invasive methods of measuring alcohol in drivers.

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<u>Executive Summary</u>

Section 2003(h) of the Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU, Public Law 109-59, 2005), titled "Reducing Impaired Driving Recidivism," directs the Secretary of Transportation to "conduct a study on reducing the incidence of alcohol-related motor vehicle crashes and fatalities through research of advanced vehicle-based alcohol detection systems, including an assessment of the practicability and cost effectiveness of such systems." This report documents the study's findings.

System Description

Vehicle-based alcohol detection systems use various forms of technology designed to detect the presence of alcohol in a driver. Some systems are designed to measure the amount of alcohol present in the driver (typically referred to as the driver's blood alcohol concentration, or BAC, though most systems currently in use measure breath alcohol concentration or BrAC). For simplicity, the term BAC will be used in this report to refer to both blood alcohol concentration and breath alcohol concentration, even though they are not the same thing. Some of these systems are designed to prevent the vehicle from starting if the driver's BAC exceeds a predetermined level. Some systems operate while the vehicle is in motion and can take various actions if alcohol is detected.

Technology Designed for All Vehicles versus Use With Special Populations

Technology suitable for use in all vehicles that will detect an impaired driver faces many difficult challenges including public acceptability, passive operation (not requiring the active cooperation of the driver), invulnerability to circumvention and tampering, the ability to verify that the test was performed on the driver, and the capability to perform accurately and reliably throughout the life of the vehicle without excessive requirements for maintenance. Technology designed for use with special populations, such as impaired-driving offenders, underage drivers, and people with alcohol use disorders, face many fewer hurdles. Use with these special populations may be acceptable even if the technology is not completely non-intrusive (i.e., requires actions by the driver), imposes certain burdens to insure against tampering and circumvention, contains features designed to verify the driver is the person being tested, and imposes additional requirements for equipment maintenance necessary for accurate and reliable performance.

Technology for use in all vehicles is not currently available, and while many of the technical issues that will need to be addressed are likely to be resolvable over time, it is unlikely that these issues can be resolved in the short term (next 5 to 10 years). Technology for use with impaired-driving offenders is currently in use and is practical, accurate, reliable, and relatively low-cost. Improvements to current technology are feasible in the near term, especially with regard to program design. Since Section 2003(h) of SAFETEA-LU is titled “Reducing Impaired Driving Recidivism,” this report will focus on the use of technology for impaired driving offenders and other special populations (e.g., teen drivers, drivers with alcohol use disorders). Because widespread deployment is unlikely to occur in the next several years, this report will not discuss technology for use in all vehicles with all drivers.

ALCOHOL DETECTION TECHNOLOGIES

Breath Sample Analysis**.** A person’s BAC can be determined accurately by measuring alcohol presence in a breath sample. Breath alcohol sensors have been used in alcohol interlocks in the United States for over 20 years. Current models primarily use the same fuel cell technology as many evidential breath test devices.[1] All breath alcohol sensors require the driver’s active involvement to provide a breath sample. Accurate measurement of BAC in breath requires a deep lung sample of breath; mouth or bronchial breath does not necessarily provide an accurate measurement of BAC.

Tissue Spectroscopy**.** A person’s BAC can be determined accurately using light reflected from capillaries in the skin. Currently, the use of a prototype BAC measurement device requires a person being tested to place his forearm on a lighted sensor pad. The pad contains a spectroscope which measures the amount of near-infrared reflected light of different wavelengths from the capillaries in the skin and calculates the person’s BAC. Tissue spectroscopy devices are being tested in clinical settings. Current devices require multiple readings over a couple of minutes. Tissue spectroscopy could be used for vehicle-based alcohol detection in the future if devices can be developed that are considerably smaller, faster, and cheaper than the current clinical devices. If so, they would be non-invasive and more convenient than breath test devices, requiring only a touch instead of a breath sample.

Transdermal Perspiration Measurement. A portion of any alcohol present in the body appears in perspiration and can be used to detect the presence of alcohol vapor exuded from the skin. This technology currently is used in a device strapped to the ankle to monitor alcohol consumption in persons who are required not to drink. Transdermal measurement of alcohol vapor appears less promising than tissue spectroscopy because transdermal alcohol measurements do not correlate well with BAC measurements made from blood or breath and because alcohol cannot be detected in this fashion for at least 30 minutes after drinking. While transdermal alcohol measurement devices could be placed in a vehicle’s steering wheel, this technology faces significant challenges in accurately measuring BAC.

Eye Movements**.** Alcohol affects some eye movements. Measuring eye movements requires in-vehicle cameras or similar equipment. While this approach may prove to be technologically feasible, it will take significant technological advances and research efforts to get to a practical and acceptable technology in a reasonable timeframe.

Detecting Alcohol Vapor in the Vehicle. Alcohol in the passenger compartment air can be measured. There are a number of new technologies that have been developed to detect ethanol

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[1] Evidential breath test devices are breath test devices that meet or exceed standards set by the National Highway Traffic Safety Administration for the accuracy and reliability of these devices.

vapor that might be used as an in-vehicle alcohol detector: these include tunable-diode laser spectroscopy, carbon nanotubes, nano-crystalline Perovskite oxides, and solid-polymer-electolyte sensors. The detection of alcohol vapor in the vehicle interior alone is unlikely to be useful as an in-vehicle device because it will measure alcohol from any source, not just the driver. An in-vehicle passive alcohol monitoring system, used as a trigger for an active measuring device, might allow the detection of alcohol use by a driver, but would not necessarily function to prevent operation of the vehicle.

Driver and Driving Performance Measurement. Another approach might be based on the fact that alcohol's effect on a driver can be observed in various vehicle movements such as lane position, steering actions, and visual scanning. However, other factors such as a driver's skill, experience, fatigue, and mental state also affect these vehicle movements, so it might prove extremely difficult to use this approach to accurately predict the presence or level of alcohol in a driver. These types of systems might prove to be useful in detecting impairment related to alcohol and could activate warning systems, but are unlikely to be useful in preventing an impaired operator from starting the vehicle.

VEHICLE-BASED ALCOHOL DETECTION SYSTEM USES

DWI Offenders. Breath alcohol interlocks have been used in the United States for over 20 years for some persons convicted of driving while impaired by alcohol (DWI). As of June 2007, almost all States and the District of Columbia allow or require breath alcohol interlocks for some DWI offenders and about 100,000 interlocks are in service nationwide. An interlock prevents a vehicle from starting unless the driver's BAC is lower than a pre-set limit, typically .02 or .025. These breath alcohol interlock devices contain many special features not found in typical breath alcohol measurement devices designed to produce an accurate reading and insure the integrity of the test. For example, the breath sample must typically conform to certain parameters for pressure and temperature to protect against use of "fake" samples (e.g., from children or mechanical devices). Additional breath samples must be provided at random intervals after the vehicle has been started, to detect whether the driver's BAC level remains below the pre-set limit.

DWI offenders using an interlock vehicle must pay installation and maintenance fees, must have their interlock serviced regularly every 1 to 3 months, and must provide breath samples every time they drive. They agree to these conditions because the interlock is required as a condition of probation or driver license reinstatement. The restriction to use only an alcohol ignition interlock equipped vehicle is typically noted on the offender's driver license or driver record.

Breath alcohol ignition interlocks have typically been used with offenders who are at high risk of recidivating; those with multiple prior offenses or drivers with a high BAC at arrest (generally >.15 g/dL). Typical installation periods range from 6 to 24 months. Interlock programs are administered by courts or departments of motor vehicles. Ignition interlock programs are not typically tied explicitly to substance abuse treatment programs.

Interlock program structures and administration differ substantially. Participation rates frequently are low. When participation is voluntary, many offenders choose not to participate.

This usually means that their driver's license remains suspended or revoked, but many continue to drive unlicensed. Even when participation is required by law, some judges do not assign interlocks and many offenders claim not to own a vehicle at time of sentencing. There is no evidence that courts and probation departments monitor offenders required to use interlock vehicles to assure that they comply.

VEHICLE-BASED ALCOHOL DETECTION SYSTEM COSTS AND BENEFITS

Vehicle-Based Alcohol Detection System Costs

Breath alcohol ignition interlocks are the only system currently in use and the only system for which costs and benefits can be estimated accurately. Breath alcohol interlock programs are managed by several private vendors who provide, install, and service the interlocks. Typical costs, paid by the user, are about $70-$175 to install the interlock and about $2.25 per day while the interlock is in use.

Vehicle-Based Alcohol Detection System Benefits

DWI Offenders. Substantial research shows that breath alcohol interlocks reduce the occurrence of DWI arrests for selected groups of offenders compared to similar DWI offenders without interlocks during the time the interlock is on the offender's vehicle (Beirness and Marques, 2004; Willis, Lybrand, and Bellamy, 2004). However, the beneficial effect dissipates once the interlock is removed (Beirness and Marques, 2004). In their current use, the effect of breath alcohol ignition interlocks does not appear to be rehabilitative, rather it appears to be restrictive. Many offenders on interlock programs have a long series of failed attempts to start their vehicle (where the ignition was locked due to the presence of alcohol in the breath sample). Offenders required to use breath alcohol ignition interlocks do not appear to be developing a habit of not driving after drinking; instead they are simply being prevented from doing so by the interlock. If offenders were required to demonstrate a substantial period in which there were no failed attempts to start the vehicle (due to the presence of alcohol) before their interlock was removed, perhaps in conjunction with an alcohol treatment program, longer-lasting effects may be possible.

It appears that fewer than 10 percent of convicted DWI offenders currently use interlocks,[2] so the current effect of interlocks on alcohol-related crashes, injuries, and fatalities is small. Current use of interlocks appears to be primarily with "hardcore" drinking drivers (repeated offenders, offenders with serious alcohol abuse problems). The effectiveness of interlocks with other offender populations is currently unknown. However, interlocks are likely to be effective in any population where implementation is feasible. It is difficult to estimate the benefits if interlocks were used by all DWI offenders because interlocks may change driving practices in unpredictable ways.

[2] This estimate is based on the industry estimate that approximately 100,000 interlocks are currently in use at any one time and that there are approximately 1.4 million people arrested for impaired driving each year, not all of whom are convicted.

Estimating the benefits of expanded use involves considerable uncertainty, given the limitations of current interlock use patterns (i.e., mainly with offenders) and the limitations of available research on the effectiveness of interlocks (self-selection biases due to the voluntary nature of existing programs) combined with the difficulty of generalizing to lower risk offenders or from mandatory use. However, to illustrate the potential benefits of requiring interlocks for all DWI offenders, calculations were performed with the assumption that there will be a 65-percent reduction in DWI crashes while the interlock is on the vehicle. These calculations produce a 55-percent reduction in the number of total fatalities that result from crashes involving a driver with a positive BAC. Stated somewhat differently, an interlock requirement for all DWI offenders in place for a full 3 years might have saved about 753 lives in 2005.

NEXT STEPS

Breath Test Alcohol Ignition Interlocks: Increase Use Among DWI Offenders. Use of existing breath alcohol ignition interlock devices could be expanded to a greater percentage of the more than one million DWI offenders convicted every year (Federal Bureau of Investigation: Crime in the United States, 2005). To do this, States should consider law and policy changes to require or permit interlock use by most or all offenders and to assure that interlocks are installed on offenders' vehicles promptly. An active judicial education program should inform judges of the benefits of interlocks. Offenders using interlocks would need to be monitored much more closely than is current practice and significant consequences imposed when offenders attempt to start their vehicle after drinking. A firm requirement for use of an interlock as a condition for license reinstatement after a DWI conviction would greatly expand use of these devices. However, these steps require a substantial administrative effort for the courts or departments of motor vehicles to administer the program and closely monitor the offenders.

The National Highway Traffic Safety Administration (NHTSA) is in the process of revising its model specifications for breath test interlocks to bring them up to date with the developing technology and is considering issuing a Conforming Products List of models that meet these specifications. The agency is also planning to provide States with information and recommendations on State interlock program operations. Important topics include the following: which offenders should be eligible for or required to use interlocks, how long the interlock should remain on the offender's vehicle, what sanctions should be imposed for violating interlock program provisions, how the interlock can be integrated with alcohol treatment and rehabilitation programs so that a period of alcohol-free driving is required before the interlock is removed, and how effective interlock programs are managed. NHTSA is also supporting judicial education on use of ignition interlock devices. Research will continue to determine if solid-state technologies can produce smaller and more convenient breath test devices that are specific to alcohol and do not need frequent maintenance and recalibration.

Tissue Spectroscopy: Research and Development. Tissue spectroscopy offers some promise as an accurate, non-invasive, and unobtrusive means to detect alcohol in drivers. However, substantial research and development challenges must be met to bring the technology from today's clinical-setting prototype to full production of a vehicle-based device. Until this research and development has been completed it is not certain if a successful device can be developed that will meet industry and government standards (e.g., reliability over many years, fail-safe operation, etc.).

SUMMARY AND CONCLUSIONS

Breath alcohol ignition interlocks have shown effectiveness in reducing DWI arrest rates while installed on offender vehicles. Expanded use of breath alcohol ignition interlocks, when coupled with close monitoring and supervision, would likely lead to reductions in crash rates of DWI offenders while the interlocks are on their vehicles. Alternate alcohol measurement technologies have potential for future use with DWI offenders and may offer some benefits over breath alcohol measurement, but would require substantial research and development before they are ready for use.

A limitation of breath alcohol ignition interlocks is that the benefit of their use by offenders disappears once they are removed from the vehicle. Finding a way to extend the reduced recidivism seen when interlocks are installed on the offender's vehicle, by lengthening the time use is required, by closer integration of the interlock program with alcohol abuse treatment, or for the most serious offenders (with multiple repeat offenses) being given a permanent requirement to use an interlock as a condition of licensure, may greatly enhance the effectiveness of interlocks in reducing alcohol-related crashes.

A fully effective breath alcohol ignition interlock program would include closer monitoring of offenders, perhaps a requirement for no failed tests during the previous 12 months as a condition of removal of the interlock, and some method to eliminate noncompliance.

The Future

A government-industry cooperative research program is in the process of being formed to conduct research and development for in-vehicle alcohol detection technology. This cooperative research effort has as its goal the development of prototype devices ready for bench testing within 5 years. Only when practical vehicle-based alcohol detection devices are developed and field tested can their effect on alcohol-related crashes, injuries, and fatalities be estimated. Obviously, the potential effectiveness of such systems will depend on how they are implemented.

Reducing Impaired-Driving Recidivism Using Advanced Vehicle-Based Alcohol Detection Systems: A Report to Congress

INTRODUCTION

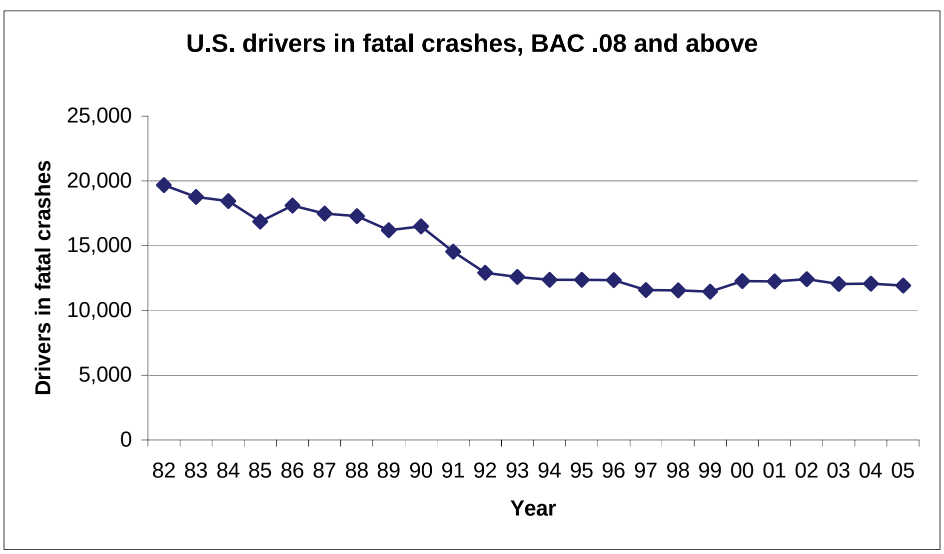
Section 2003(h) of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), enacted on August 10, 2005, directs the Secretary of Transportation to study advanced vehicle-based alcohol detection systems:

> 2003 (h) Reducing Impaired Driving Recidivism.--
> (1) Study.--The Secretary shall conduct a study on reducing the incidence of alcohol-related motor vehicle crashes and fatalities through research of advanced vehicle-based alcohol detection systems, including an assessment of the practicability and cost effectiveness of such systems.
> (2) Report.--Not later than 2 years after the date of enactment of this Act, the Secretary shall transmit to the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report on the results of the study.

This report documents the study's findings.

Alcohol-Impaired Driving and its Consequences

In 2005, there were 14,068 drivers in fatal crashes and about 169,000 drivers in injury crashes who had a positive blood alcohol concentration (BAC) (NHTSA, 2006b, Table 80). In fatal crashes, 11,921 drivers had a BAC over the legal limit of .08 g/dL (NHTSA, 2006b, Table 19), and 12,783 persons died in these crashes (NHTSA, 2006c, Table 1). Alcohol affects a driver's concentration, perceptions, judgment, decision-making, and reactions so that the risk of a crash increases rapidly as a driver's BAC increases. If these drivers had not been drinking, many, and probably most, of these crashes, injuries, and fatalities would not have occurred.



Source: NHTSA 2006b, Table 19

Society has attempted to prevent alcohol-impaired driving primarily through a system of laws, enforcement, and sanctions. Laws in every State make it illegal to drive while impaired by alcohol. In addition, laws in every State establish that every driver is impaired at the *per se* BAC level of .08, so that it is illegal to drive with a BAC of .08 or greater. Unfortunately, these laws are violated frequently. Surveys suggest that drinking drivers made between 809 million and one billion trips in 2001 and drivers with a BAC of .08 and above made between 40 and 50 million trips (NHTSA, 2003). With approximately 1.4 million drivers arrested for alcohol-impaired driving annually (FBI, 2005), the chances of arrest on any trip for a driver who has been drinking are less than 1 in 550 and the chances for a driver with a BAC over .08 are less than 1 in 30. Perhaps because most alcohol-impaired drivers are not detected and arrested at a higher frequency, the number of traffic fatalities involving a driver with a BAC over .08 has not decreased any significant amount in the past decade. Enforcement of course is not the only means of preventing alcohol-related crashes. Education, engineering, design, and individual responsibility can also potentially contribute to the reduction in alcohol-related crashes.

Vehicle-Based Alcohol Detection Systems

There would be no alcohol-impaired driving, and no crashes, injuries, or fatalities involving alcohol, if it were impossible for a person with a positive BAC to start or operate a vehicle. Vehicle-based alcohol detection systems attempt to achieve this goal. The systems use different technological methods to detect alcohol in a vehicle's driver. Systems that test a driver's breath have been used for over 20 years. Systems being investigated or proposed would detect alcohol from measurements taken through the driver's skin using tissue spectroscopy, from eye movements, or from driving performance. Some systems measure the driver's BAC quite accurately. Some systems prevent the vehicle from starting if the driver's BAC exceeds a predetermined level. Some systems operate while the vehicle is in motion and can take various actions if alcohol is detected.

In the United States, current alcohol detection systems are used almost exclusively on the vehicles of convicted DWI offenders as a condition of probation or driver license reinstatement. A few parents of teenage drivers are known to have arranged installation on their children's vehicles.

Structure of This Report

This report first discusses the different technologies that are being used or have been proposed for measuring the presence of alcohol in drivers. It found that breath test systems have demonstrated their value, tissue spectroscopy systems offer promise, and other technologies require significant development to meet societal standards of practicality and acceptability in the foreseeable future. The report then examines how breath test systems are used and how both breath test and tissue spectroscopy systems could be used in the future to detect and measure the presence of alcohol. It provides data on breath test system costs; tissue spectroscopy systems are at such an early development stage that cost estimates are not possible. It estimates the potential benefits if alcohol detection systems were used in the vehicles of all DWI offenders or in all vehicles. Finally, the report proposes approaches to expand the use of current breath test systems and discusses the research and development needed for tissue spectroscopy systems.

NHTSA contracted with the Volpe National Transportation Systems Center to conduct a thorough review and evaluation of current and proposed vehicle-based alcohol detection technologies and systems. The Volpe Center staff reviewed relevant research studies and interviewed stakeholders. They evaluated and compared the potential of several alternative technologies and examined a wide variety of implementation issues. This report draws heavily on their findings (Pollard et al., 2007). In addition, this report uses information from presentations at Mothers Against Drunk Driving's (MADD) International Technology Symposium, *A Nation Without Drunk Driving* (MADD, 2006a), from an extensive collection of research and evaluation studies of breath test systems summarized in Beirness and Marques (2004), and from breath interlock information prepared for judges (Robertson et al., 2006).

As Congress requested, this report discusses vehicle-based alcohol detection systems. It does not discuss technologies that are not vehicle-based, such as Passive Alcohol Sensors (used by law enforcement officers at a vehicle's window to detect alcohol in the passenger compartment). It briefly mentions vehicle-based systems that are not specific to alcohol, such as systems that attempt to determine when a driver is fatigued or impaired in some way by evaluating overall driver performance using lane position, steering wheel movements, speed changes, and similar measurements.

Technology Designed for All Vehicles versus Use With Special Populations

Technology suitable for use in all vehicles that will detect an impaired driver faces many difficult challenges including public acceptability, passive operation (not requiring the active cooperation of the driver), invulnerability to circumvention and tampering, the ability to verify that a test was performed on the driver, and the capability to perform accurately and reliably throughout the life of the vehicle without excessive requirements for maintenance. Technology designed for use with special populations, like impaired-driving offenders, underage drinking drivers, and people with alcohol use disorders, face many fewer hurdles. Use with these special populations may be acceptable even if the technology is not completely non-intrusive (i.e., requires the active cooperation of the driver), imposes certain burdens to insure against tampering and circumvention, contains features designed to verify the driver is the person being tested, and imposes additional requirements for equipment maintenance necessary for accurate and reliable performance.

Technology for use in all vehicles is not currently available, and while many of the technical issues that will need to be addressed are likely to be resolvable over time, it is unlikely these issues can be resolved in the short term (next 5 to 10 years). Technology for use with impaired-driving offenders is currently in use and is practical, accurate, and reliable and relatively low-cost. Improvements to current technology are feasible in the near term, especially in terms of program design. This report will focus on the use of technology for impaired-driving offenders, with passing mention of other special populations (e.g., teen drivers, drivers with alcohol use disorders).

TECHNOLOGIES FOR VEHICLE-BASED ALCOHOL DETECTION SYSTEMS

Breath Testing

Breath alcohol measurement devices for use in police stations were developed in the 1950s. They now are the standard method for establishing a driver's BAC as evidence in an alcohol-impaired-driving case. NHTSA publishes model specifications for these Evidential Breath Testing Devices, tests the commercially-available devices against these specifications, and publishes a list of the many individual models, produced by 22 companies, that meet them (NHTSA, 2004). The most widely used devices use infrared spectrometry to measure alcohol; others use fuel cells.

Evidential breath test devices are highly accurate. NHTSA's specifications require a standard deviation of no more than .0042 in measurements at several alcohol levels under laboratory conditions. In practical terms, this means that there is only a very small chance of an error of more than .01, which would be more than two standard deviations; thus a reading of .08 almost certainly comes from an alcohol concentration between .07 and .09. Manufacturers typically publish standard deviations of about .003, which is more accurate than NHTSA's specifications (Pollard et al., 2006, Sec. 4.1.2).

Alcohol concentration in breath differs slightly from alcohol concentration in the body, or BAC. The ratio of breath alcohol to BAC, known as the "partition ratio," varies by as much as 10 percent from individual to individual and also within the same individual depending on factors such as body temperature, exercise, and time since the last drink. To assure that breath test devices do not overstate the true BAC, they are calibrated to report a slightly lower BAC than the value they measure (Pollard et al., 2006, Sec. 4.1.2).

Current vehicle-based breath alcohol detection systems (breath alcohol ignition interlock devices) use either fuel cell or solid-state (semiconductor) sensors. Most current interlocks use the well-established fuel cell technology employed in many evidential breath test devices. Fuel cells are specific to alcohol and do not react to other organic solvents (Dubowski, 1992; Robertson et al., 2006). A heater unit, connected to the vehicle's battery, is required to warm the fuel cell to breath temperature before use (Pollard et al., 2006, Sec. 4.1.1).

Fuel cell interlock sensors are quite accurate. NHTSA's model specifications, published in 1992 (57 FR 11772; see NHTSA, 2006a), require the devices to lock the vehicle's ignition 90 percent of the time when the driver's alcohol level exceeds a "set point" level of .025 by .01; in other words, 90 percent of the time a driver with a BAC of .035 or higher will not be able to start the vehicle. At extreme temperatures (-40º and +185º) the allowable deviation from the set point increases to .02, so that the 90 percent locking requirement applies to a BAC of .045 or higher.

Older interlocks used solid-state sensors, and some of these older interlocks are still in use. Solid-state sensors are smaller than fuel cells, require less power, and do not need to be heated. When they have been calibrated recently they are almost as accurate as fuel cells, but they lose considerable accuracy over time. They also are not specific to alcohol as they react to other volatile organic solvents. For these reasons, solid-state sensors are not used in evidential breath test systems. Two European automobile manufacturers, Saab and Volvo have developed prototypes for a new solid-state breath test device intended for use in an ignition interlock system. The device is built into a key fob so it can be carried with the driver instead of attached to the vehicle. It communicates electronically with the vehicle's ignition system. It is not yet known whether this device can overcome the two primary limitations of the older solid-state sensors: their need for frequent recalibration and their sensitivity to substances other than alcohol (Pollard et al., 2007, Sec. 4.2).

Tissue Spectroscopy

A person's BAC can be measured using light reflected from capillaries in the middle layers of the skin. Infrared light easily penetrates several millimeters of tissue. The alcohol concentration of the capillaries changes the amount of certain infrared light wavelengths that is reflected. A person being tested places his forearm on a lighted sensor pad. The pad contains a spectroscope which measures the amount of reflected light of different wavelengths and then calculates the person's BAC. The process takes 30 seconds or less (Pollard et al., 2007, Sec. 6.3).

Because the reflected spectrum is affected by many other chemicals present in the skin, the estimation of BAC is based on a complex statistical procedure. In short, a regression analysis of the light reflected from the subject's skin is compared to a matrix of spectra from samples with known BACs. The accuracy of any statistical estimation procedure is a function of the quantity and quality of the input data. The quantity is a function of the number of different wavelengths that are measured and the number of samples. The quality of the data is a function of the physical properties of the detector and substrate being sampled.

Tissue spectroscopy devices are being tested in clinical settings. These clinical devices appear to measure BAC at least as accurately as breath alcohol interlocks. They use the subject's forearm and are quite large (Pollard et al., 2007, Sec. 5.1).

It is possible that tissue spectroscopy could be used for in-vehicle alcohol test devices if a number of challenges can be met. First, an effort must be made to develop and test a prototype that uses the driver's finger or hand rather than forearm and that is considerably smaller, faster, and cheaper than the current clinical devices. If embedded in the steering wheel, a tissue spectroscopy device might be passive in the sense that it would only require the driver's hands to be on the wheel. However, a number of issues will have to be addressed in order for near-infrared spectroscopic BAC measurement to be feasible and practical through the hand or fingers. Obstacles include the thickness of the skin on the hand and fingers, presence of calluses, and the density of the bones in the fingers that may prevent accurate BAC readings. It is possible measurement can be made in the webbing between fingers, but the logistics of how this would be accomplished is unknown. In addition, this approach would not be completely passive because it would not function if the driver wore gloves or covered the steering wheel with a cloth.

Second, the prototype must be tested and refined to assure that it is accurate, reliable, and durable under a wide range of driving conditions and environmental conditions, produces virtually no false positive readings, and requires no more maintenance than other vehicle components.

Given the requirement for multiple sampling, it is not clear how much faster a tissue spectroscopy test can be performed. If these challenges can be met, tissue spectroscopy devices might be easier to use and less invasive than breath test devices because they would require only a touch on the sensor pad, not a breath sample. They also would be faster than breath test devices because they do not require a warm-up period.

Transdermal Alcohol Measurement

A portion of any alcohol present in the body is exuded through the skin, often in perspiration, and the proportion of alcohol vapor found near the skin can be used to estimate BAC. This technology is used to monitor alcohol consumption in persons who are required not to drink. A device in use since 2004, the Secure Continuous Remote Alcohol Monitor (SCRAM) uses a fuel cell sensor which is strapped to the user's ankle. It transmits BAC data periodically to the agency monitoring the user through a wireless link. A second device, currently being tested in prototype, is small enough to be worn on the wrist (Pollard et al., 2006, Sec. 5.2.2 and 6.1). One company has developed a prototype perspiration alcohol measurement device that can be embedded in a vehicle's steering wheel (MADD, 2006).

Transdermal alcohol measurement appears less promising than tissue spectroscopy for vehicle-based alcohol detection. Transdermal BAC estimates from perspiration are less accurate than tissue spectroscopy measurements. Because alcohol does not appear in perspiration for at least 30 minutes after drinking, transdermal BAC measurements underestimate the true BAC when the user is drinking and BAC is rising and may overestimate true BAC when it is falling (Pollard et al, 2006, Sec. 5.2.2, 5.2.3). Perspiration measurement may be difficult in very cold temperatures (due to reduced transdermal release of alcohol and the use of protective clothing).

Eye Movements

Research has demonstrated that alcohol and certain other drugs affect some eye movements. Horizontal Gaze Nystagmus (HGN), which describes involuntary eye movements when looking out of the corner of the eye, is the most accurate of the three components of the Standard Field Sobriety Tests used by law enforcement officers every day at the roadside as an initial indication of alcohol impairment. Machines have been developed to measure HGN automatically. They require the subject's eyes to track a target. Some other eye movements are affected by alcohol. They can be measured without the subject's active participation but do not provide accurate BAC estimates.

Measuring eye movements requires in-vehicle cameras or similar equipment. These systems may be acceptable for offender populations. In addition, eye movements are affected by other drugs, so eye movement measurements cannot conclusively identify alcohol as the source of impairment (Pollard et al., 2006, Sec. 5.4.1, 5.4.2).

Other Potential Technologies

Two other methods for detecting alcohol in drivers have been suggested but do not appear practical for vehicle-based alcohol detection systems at this time.

Passenger Compartment Air: Alcohol in the air can be measured. This method is used in the Passive Alcohol Sensor (PAS), an instrument used by a law enforcement officer at a vehicle's window to test for alcohol presence in the passenger compartment. An in-vehicle device using PAS technology could detect alcohol presence in the passenger compartment but could not determine if the alcohol was linked to the driver, a passenger, an open container of alcohol, or some other source. PAS system alcohol measurements are also affected by air flowing through the passenger compartment from ventilation systems or open windows (Pollard et al., Sec. 5.3). It is possible that for offender populations, a two-tier system could be developed that would involve a PAS to detect alcohol in the passenger compartment of the vehicle followed by a second test when alcohol vapor is detected to determine driver BAC.

Driver Performance Measurement: Alcohol's effect on driving can be observed in various vehicle movements such as lane position, steering actions, and speed. However, other factors such as a driver's skill, experience, fatigue, mental state, and impairment by medications or drugs also affect these vehicle movements, so that they do not necessarily predict a driver's alcohol use or BAC level. Driver performance measurement cannot detect abnormal behavior (vehicle movements) until some amount of driving has occurred (Pollard et al., Sec. 5.4.3). Thus, driver performance measurement is not likely to be useful in preventing the vehicle from being started by an impaired motorist unless some form of active performance testing was required prior to ignition activation. For monitoring and warning systems it is likely that driver-performance-based systems can be developed that use an individual driver's normal or baseline driving performance to determine alcohol use and impairment. Performance measurement systems based on a general algorithm will have to find a way to overcome the individual differences in skill, experience, fatigue, etc.

USES OF VEHICLE-BASED ALCOHOL DETECTION SYSTEMS

Alcohol Ignition Interlocks: Operation

A vehicle-based breath alcohol ignition interlock prevents a vehicle from starting unless the driver provides a breath sample with a BAC lower than a pre-set level. It consists of a handheld breath test device connected to a control unit, usually mounted under the dashboard, which is hardwired into the vehicle's ignition and power system. The driver blows into the breath test unit, which measures alcohol in the breath sample and determines whether it is lower than the pre-set limit.

Current alcohol ignition interlocks are designed for use by convicted DWI offenders under court or administrative supervision who are required to drive only vehicles equipped with an alcohol interlock. Several commercial manufacturers are active in the United States (see Appendix A). Their interlocks all operate similarly, with slightly different features (Pollard et al., 2006, Sec. 4.1.1).

- Every time a driver wishes to start the vehicle, the control unit first turns on the fuel cell's heater. The fuel cell requires about 30 seconds to warm up in mild weather and may require 3 minutes or more in very cold weather. Some manufacturers are adding an additional heater to reduce the warm-up time for units used in cold conditions.
- When the fuel cell is ready, the driver blows a breath sample into the breath test unit. This requires the driver to take a deep breath and blow firmly and steadily.
- The breath test sensor determines if the driver's BAC is lower than the pre-set limit and displays an appropriate message such as "start vehicle" or "lockout" on either the breath test or control unit.
- If the driver's BAC is below the preset level, typically .02 or .025, the vehicle can be started. The level is set slightly above zero to assure that small instrumentation error will not prevent a driver with a zero BAC from starting the vehicle.
- If the driver's BAC exceeds the preset level, the ignition is locked for a period of time, typically 5 to 30 minutes. The driver may then start over again and provide another sample.
- Interlocks require a "retest" periodically. After driving has begun, the control unit signals the driver at random intervals from a few minutes to nearly an hour that the driver must provide an additional breath sample. The driver is given several minutes to pull over safely and stop the car before taking the test.
- The control unit contains a data log which records the date, time, and BAC of every breath test as well as attempts to circumvent the interlock and other information.
- Override switch: Some jurisdictions require interlocks to have an override switch that will bypass the interlock and allow the vehicle to be started without a breath test (Marples, 2005). This allows the vehicle to be started in emergency situations or if the alcohol sensor has failed. All overrides are reported on the data log. Some current interlock programs allow only one use of the override switch; the interlock must then be taken for servicing, and the override is reported to the authorities. Other interlock programs report overrides at the next regular service.

Interlock systems are rented from an interlock service provider, who installs the system. At regular intervals, typically every 1 to 3 months, the driver must bring the vehicle to an interlock service center where the system is checked, recalibrated, and the data log information is downloaded for review by interlock program monitors such as probation officers. These regular checkups assure that the interlock is operating properly and that the user is complying with program requirements.

Interlock systems have several features to prevent circumvention.

- Providing a breath sample: Some training is required to provide an acceptable breath sample. Some interlock models include a microphone and require the driver to hum into it while blowing, making it even more difficult for an untrained person to provide an acceptable sample. Many models contain pressure and temperature sensors to insure that the breath sample is being provided by a person, not an air pump or other artificial source. A timer ensures that the driver blows long enough to provide a sufficient sample of air from deep in the lungs. Both the pressure sensor and the timer can be adjusted for drivers who have difficulty providing a normal breath sample.
- Retests: At random intervals after the vehicle is started the driver is required to take a retest. This feature prevents a driver from starting the vehicle with a zero BAC and then drinking while driving, or leaving the vehicle running outside a bar. All retest requests and BAC test results are recorded on the data log. In some interlock programs, failed or ignored retests are reported at the interlock's next regular service. In others, a failed or ignored rolling retest sends the interlock into "immediate recall" mode in which the vehicle must be taken to the service center within a short period of time; if not, the vehicle cannot be started. Under both methods, interlock program authorities will take whatever action they have specified for ignoring or failing a retest.
- Disabling the interlock: A competent mechanic can disable an interlock by rewiring the vehicle's ignition system to its original condition. The interlock's wiring and circuitry are sealed so that any disabling or tampering can be detected easily (Robertson et al., 2006). Current interlock programs detect a disabled interlock at the regular interlock services.

The most obvious means of circumvention for persons required to drive an interlock vehicle is simply to drive a different vehicle. The interlock's data log may help prevent this by recording every trip, so that the data log record shows if the interlock vehicle has an abnormal pattern of use.

Alcohol Ignition Interlocks: Use

Breath alcohol interlocks currently are used by convicted DWI offenders under court or administrative supervision who are required to drive only interlock vehicles. As of June 2007, almost all States and the District of Columbia allowed or required interlocks to be used for some offenders (MADD, 2006b).

Most DWI offenders in most States have their drivers' licenses suspended or revoked for some period of time. Interlocks are used when the offender is again eligible for a license. Interlocks can be provided or required in four ways:

1) Required by individual judges as a condition of probation for some offenders;
2) As a voluntary option for some offenders in return for a shorter license suspension;
3) Required by State law for some or all repeat offenders as a condition of license reinstatement; or
4) Required by State law for all offenders as a condition of license reinstatement. New Mexico and Arizona are the only States requiring interlocks for all first offenders

(MADD, 2006a). Texas required interlocks as a condition of bail bond for second and subsequent DWI arrests (Lifesaver Interlock, 2006).

At present, all interlock requirements in the United States operate for a fixed period of time, such as 1 year, regardless of the driver's actions during this time, unless a judge extends the requirement.

Some State interlock programs are administrative, managed by a Department of Motor Vehicles. Most are judicial, managed by courts and probation departments. About 100,000 interlocks were in service in 2006 (MADD, 2006a).

Potential Expanded Uses Of In-Vehicle Alcohol Detection Systems

Alcohol Ignition Interlocks could be used on a voluntary basis on vehicle fleets or for sale as aftermarket or optional original equipment.

Breath test interlocks have been installed in several vehicle fleets in Sweden, beginning in 1999 with a taxi company, a bus company, and a trucking company (Lönegren and Jakobsson, 2005). In 2005, a survey of 85 municipalities showed that 22 percent had installed interlocks on some municipal vehicles, especially vehicles used to transport schoolchildren (MADD, 2006a). The Swedish government is considering proposals to increase the use of interlocks in fleets. Field trials have been conducted with German truck drivers and Norwegian and Spanish bus drivers (Drevet et al., 2004).

The main obstacle to using breath test interlocks as aftermarket or optional equipment for individuals (e.g., teen drivers) is that they are both invasive and obtrusive: they require the driver's active participation to provide a breath sample. In addition, current breath test interlocks can be slow, requiring 3 minutes or more before they have warmed up to operating temperature when ambient air is cold. In addition, there are costs associated with installation and maintenance of these devices and they require regular servicing.

Additional issues that must be addressed if alcohol ignition interlocks are to be used more widely include the following (Pollard, et al., 2006, Sec. 7).

- BAC threshold: Current interlocks are intended to prevent driving after any drinking and are set at a BAC of .02 or .025. Non-offender drivers may be unwilling to accept interlocks set at these levels. On the other hand, interlocks set at .08 would allow driving at BACs slightly below .08, a level at which drivers can be substantially impaired (Moskowitz and Fiorentino, 2000). An interlock set at .08 would not guarantee that a driver who is able to start the car is necessarily below the legal .08 limit because of the instrument's potential measurement error.
- Alcohol detected while driving: In an expanded ignition interlock program the issue will need to be addressed of whether retests should be used and, if so, what the consequence of ignoring or failing a retest should be.
- Reporting: Without some means to report ignored or failed retests, interlock override switch use, or interlock disabling, interlocks will have little value. The only comparable

system currently in place to examine whether vehicle safety systems are functioning properly is State motor vehicle inspections. Fewer than half the States inspect all vehicles regularly and then typically only once each year (AAA, 2005). Another possibility would be to report these actions through some easily-visible warning system, as discussed below.

- Public Acceptability: Previous experience with seat belt ignition interlocks on all vehicles resulted in considerable negative public reaction, resulting in passage of a statutory prohibition against seat belt ignition interlocks (49 U.S.C. 30124). Any consideration of installing interlocks on all vehicles should be preceded by public acceptance of the need for this approach.

Warning systems provide another potential use for alcohol detection systems. Instead of locking the vehicle's ignition, a system that detects a driver with a positive BAC, a BAC above .08, or an interlock that is disabled or overridden could report that information to the vehicle's occupants through warning lights, much like warning lights that inform the driver if the vehicle's oil pressure is low or if a front-seat occupant's seat belt is unbuckled. Determining the effectiveness of an internal warning system would require such a system to be developed and evaluated.

A much more public warning would be to flash the vehicle's parking lights or sound the horn, assuming the general driving public had been informed that such an event in a moving vehicle signified the presence on an impaired driver. While such a system may be acceptable to warn the public that the driver has a BAC over the legal limit of .08 or has disabled or overridden an interlock, only through prototype development and field testing can it be determined whether such a system would be effective.

COSTS AND BENEFITS OF VEHICLE-BASED ALCOHOL DETECTION SYSTEMS

Costs: Breath Test Interlocks

Average interlock costs in 2006 consisted of a one-time fee of $70-$175 to install the interlock and a fee of about $2.25 per day while the interlock was in service on the vehicle (MADD, 2006a; Robertson et al., 2006). Offenders are expected to pay these costs. Some jurisdictions offset some costs for indigent offenders. Costs of interlocks using tissue spectroscopy or other alcohol detection technology cannot be estimated because prototypes for use in a vehicle environment have not been developed.

Benefits: Breath Test Interlocks

Interlock program evaluations consistently show that interlocks reduce alcohol-impaired driving, as measured by DWI offenses, while they are installed on DWI offenders' vehicles, but that the effect disappears when the interlock is removed. Willis et al. (2004) conducted a thorough search and identified 14 evaluation studies. One study used the most rigorous study design in which the offenders required to use an interlock were chosen at random. This study found that interlocks reduced DWI recidivism by 65 percent compared to similar offenders not required to use interlocks.

The other 13 studies were not able to use this randomized design for several reasons, in particular because many judges were unwilling to impose sanctions or probation requirements at random. These studies compared offenders assigned to the interlock with other offenders chosen to be as similar as possible. All 13 found that the offenders assigned to the interlock had lower recidivism rates. The reductions ranged from 20 percent to 95 percent, with 8 studies finding reductions of 62 percent to 81 percent. In reviewing 11 of these studies, Beirness and Marques (2004) noted that the wide variation in the effects may be related to the types of offenders who participate in the different programs and how the programs are administered. Robertson et al. (2006) contains a similar summary of these evaluation studies.

These studies provide evidence that interlocks reduce alcohol-impaired driving for selected groups of offenders compared to similar DWI offenders without interlocks, while they are installed on the driver's vehicle. They also show that the effect disappears when the interlock is removed, when recidivism rates revert to levels similar to those of DWI offenders who did not use interlocks. Interlocks reduce alcohol-impaired driving substantially, as they are intended to do, but there is no evidence that interlocks by themselves have long-term effects on drinking or on driving after drinking. Thus, in their current use the effect of breath alcohol ignition interlocks does not appear to be rehabilitative, rather it appears to be restrictive.

Many offenders on interlock programs have a long series of failed attempts to start their vehicle (where the ignition was locked due to the presence of alcohol in the breath sample). Offenders required to use breath alcohol ignition interlocks do not appear to be developing a habit of not driving after drinking; instead they are simply being prevented from doing so by the interlock. Studies show that the rate of failed BAC tests (above the preset level of .02 or .025) recorded on an interlock's data log while the interlock is installed accurately predicts the likelihood of DWI convictions after the interlock is removed from the offender's vehicle (Beirness and Marques, 2004). This suggests that interlocks should not be removed from offenders' vehicles until they have demonstrated a substantial period of driving with no failed BAC tests. Evidence from a voluntary interlock program in Sweden supports this conclusion. Participants are required to drive only interlock vehicles for 2 years. They are dropped from the program for two or more positive BAC tests in the first year or for any positive test in the second year. Two years after their interlock was removed, successful program participants had substantially fewer DWI arrests and crashes than they did before they entered the program (Bjerre, 2003).

Another promising approach is to assign a DWI offender to drive an interlock vehicle and also to participate in an alcohol treatment and rehabilitation program. The interlock would be removed only after the offender has completed the program successfully and also has driven for a substantial period of time without a failed interlock breath test.

Potential Benefits of Expanded Use

DWI Offenders. Fewer than 10 percent of convicted DWI offenders currently use interlocks, so the current effect of interlocks on total alcohol-related crashes, injuries, and fatalities is small. Current use of interlocks appears to be primarily with "hardcore" drinking drivers (repeat offenders and those with significant alcohol abuse problems). The effectiveness of interlocks with other offender populations is currently unknown. However, interlocks are likely to be effective in any population where implementation is feasible. In addition, many of the available effectiveness studies are not of the highest quality, making estimation of the effects of expanded use problematic. It is also difficult to estimate the benefits if interlocks were used by all DWI offenders because interlocks may change driving practices in unpredictable ways.

Given the limitations of current use patterns with DWI offenders, the limitations of available research on the effectiveness of interlocks (self-selection biases) and the difficulty of generalizing to lower risk offenders or from mandatory use, estimating the benefits of expanded use involves considerable uncertainty. In the illustration of potential benefits of requiring interlocks for all DWI offenders below, a 65-percent reduction in DWI recidivism is used in the calculations. It is important to note that many studies have found a lower reduction in recidivism than this. The illustration uses a possible benefit (in the middle of the range found in a number of studies). This is not necessarily the anticipated benefit.

Consider a fatal crash involving a DWI offender on his way home after drinking at a party on a Saturday night. If this offender had been required to use an interlock, there may have been at least three quite different outcomes.

1) He may have circumvented the interlock requirement by driving a different vehicle or by some other means. In this case his drinking and driving would not have been affected and the fatal crash would have occurred. The evidence cited above suggests that interlocks reduce a driver's DWI recidivism by about 65 percent, so perhaps the remaining 35 percent of crashes involving DWI offenders would not be affected by interlocks and would have occurred.

2) He may have driven his interlock vehicle to attend the same party and driven home at the same time. In this case the interlock would have prevented him from drinking so that his BAC would have been zero in the potential crash situation. This does not mean that a crash would not have occurred but only that the likelihood of a crash would have been much less. Compared to a driver with a zero BAC, the relative risk of a fatal crash rises rapidly as the driver's BAC rises (see for example Zador et al., 2000). Using these relative risks, about 85 percent of fatal crashes in 2004 involving drivers with a positive BAC would not have occurred if all drivers had a BAC of zero (MADD, 2006a, Lund).

3) He may have ridden with someone else to the party, or decided not to attend the party at all. In this case he would not have been driving in the potential crash situation and presumably the crash would not have occurred.

In 2005, about 1,363 traffic fatalities occurred in crashes involving a driver with a positive BAC who had at least one DWI conviction in the previous 3 years (NHTSA, 2006c, Table 8 and Fig. 2). Suppose that every DWI offender was required to use an interlock for 3 full years. For a conservative estimate of benefits, assume that 35 percent of the offenders would circumvent their interlock requirement, as in #1 above. Thus, the 35 percent who circumvented the interlock requirement would have still died in an alcohol-related fatal crash. That is 35 percent of 1,363 or 477 fatalities. Assume further that the remaining 65 percent of the offenders would use their interlock but not change their driving patterns, as in #2. Of their 65 percent of the 1,363 fatalities – 886 – only 15 percent, or 133, would have occurred. Under these assumptions, total fatalities would have been about 610 (477 plus 133), a reduction of 55 percent from 1,363. Thus, an interlock requirement for all DWI offenders for 3 full years might have saved about 753 lives in 2005. If interlocks were required for less than 3 full years, then the savings would be less.

NEXT STEPS

Breath Test Interlocks: Increase Use Among DWI Offenders. Breath alcohol interlocks have proven their effectiveness at reducing impaired-driving arrests while on the vehicles of relatively hardcore offenders. In 2006, they controlled and monitored the driving of about 100,000 DWI offenders. The use of ignition interlocks could be expanded to the more than one million DWI offenders convicted every year. To do this, States should consider law and policy changes to require or permit interlock use by most or all offenders and to assure that interlocks are installed on offenders' vehicles promptly. An active judicial education program should inform judges of the benefits of interlocks. Use of interlocks should require appropriate substance abuse treatment. Offenders using interlocks should be supervised and monitored much more closely than is current practice and significant consequences should be imposed when offenders attempt to start their vehicle after drinking. A firm requirement for use of an interlock as a condition for license reinstatement after a DWI conviction would greatly expand use of these devices. However, these steps may require a substantial administrative effort for the courts or DMV to administer the program and closely monitor the offenders.

The effectiveness of ignition interlocks may vary when they are used with a wider variety of offenders. It is possible that the effectiveness of ignition interlocks will vary by whether the user is a first or multiple offender; the existence and extent of an alcohol-use disorder; and by age, gender, and socioeconomic status.

NHTSA is in the process of revising its model specifications for breath test interlocks to bring them up to date with the developing technology and is considering issuing a Conforming Products List of models that meet these specifications. NHTSA is also planning on providing States with information and recommendations on State interlock program operations. Important topics include which offenders should be eligible for or required to use interlocks, how long the interlock should remain on the offender's vehicle, what sanctions should be imposed for violating interlock program provisions, how the interlock should be integrated with alcohol treatment and rehabilitation programs (to treat the underlying alcohol abuse problem) so that a period of alcohol-free driving is required before the interlock is removed, and how effective interlock programs are managed. Research will continue to determine if solid-state technologies can produce smaller and more convenient breath test devices that are specific to alcohol and do not need frequent maintenance and recalibration.

Tissue Spectroscopy: Research and Development. Tissue spectroscopy offers promise as an accurate, non-invasive, and unobtrusive means to detect alcohol in drivers. However, it faces substantial research and development challenges to bring the technology from today's clinical-setting prototype to full production of a vehicle-based device. Until this research and development has been completed it is not certain if a successful and useful device can be developed that will meet industry and government standards (e.g., reliability over many years, fail-safe operation, etc.).

SUMMARY AND CONCLUSIONS

Breath alcohol ignition interlocks have shown effectiveness in reducing impaired-driving arrests while on the vehicles of convicted DWI offenders. Expanded use of these devices would likely lead to further reductions in crash rates of DWI offenders. Alternate alcohol measurement technologies have potential for use with DWI offenders and may offer some benefits over breath alcohol measurement but would require substantial research and development before they are ready for use.

A limitation of breath alcohol ignition interlocks is that the benefit of their use by offenders disappears once they are removed from the vehicle. It may be possible to greatly enhance the effectiveness of interlocks in reducing alcohol-related crashes by finding ways to extend the reduced recidivism seen when interlocks are installed on the offender’s vehicle. Some alternatives include lengthening the time use is required, more closely integrating the interlock program with alcohol abuse treatment, or for the most serious offenders (with multiple repeat offenses) permanently requiring use of an interlock as a condition of licensure.

There are many interlock program aspects that could be strengthened that are likely to increase the effectiveness of interlock programs, including closer monitoring of offenders, a requirement for no failed tests during the previous 12 months as a condition of removal of the interlock, and some method to eliminate noncompliance (e.g., monitoring vehicle use patterns).

The Future

A government-industry cooperative research program is in the process of being formed to assist research and development for in-vehicle alcohol detection technology. This cooperative research effort has as its goal the development of prototype devices ready for bench testing within 5 years. Only when practical vehicle-based alcohol detection devices are developed and field-tested can their effect on alcohol-related crashes, injuries, and fatalities be estimated. Obviously, the potential effectiveness of such systems will depend on how they are implemented.

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APPENDIX

Interlock Manufacturers and Providers in the United States

Alcohol Countermeasure Systems	www.acs-corp.com
Autosense International	(no Web link available)
Consumer Safety Technology	www.intoxalock.com
Draeger Safety Diagnostics, Inc.	www.draeger-breathalyzer.com
Guardian Interlock Systems	www.guardianinterlock.com
LifeSafer Interlock	www.lifesafer.com
Monitech Inc.	www.monitechnc.com
Smart Start Inc.	www.smartstartinc.com

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