Volume 1, Issue 1

May, 2011

Arizona Police Science Journal

A publication of the Arizona Governor's Office of Highway Safety

Truth in Science

Inside this issue:

Message from the Director: An Introduction

Welcome to the first issue of the Arizona Police Science Journal. The Governor's Office of Highway Safety (GOHS) is pleased to have provided the support and the necessary equipment that published this Journal for you, the Criminal Justice professionals in our great State of Arizona.

This publication was the dream of a few dedicated law enforcement officers at the Department of Public Safety - Vehicular Crimes Unit.

After a year of meetings, deadlines and with the encouragement and support from other VCU officers as well as GOHS staff, prosecutors, criminalists and educational institution staff and writers from different organizations, here it is, the new Arizona Police Science Journal.

We encourage other agencies, departments, associations and individuals to review and comment on its content and recommend future articles of interest.

Great job guys, Arizona will be better served! Thank you, Daven and crew, for your persistence and drive, all accomplished on their own time. What a great effort.

Alberto Gutier

Director

Governor's Office of Highway Safety

Phoenix

The Journal Mission

Daven Byrd

As Executive Editor for the Arizona Police Science Journal, let me welcome you to this inaugural issue. The mission of APSJ is twofold; one, provide excellent and relevant training to Arizona's Criminal Justice community and two, provide a forum for members of that community to complete research and publish their findings.

This twofold mission enables us as a community to more readily share vital information and useful data.

Law Enforcement Officers and Criminalists often have the training and experience to provide expert testimony in court, such as with collision reconstruction or driving impairment. APSJ provides these experts, or experts in training, a way to complete independent research and then publish this information in a peer-reviewed journal.

APSJ will include peer-reviewed scientific articles, as well as legal and legislative updates and training articles. Every article, whether strictly scientific, or editorial in format, will undergo a rigorous multi-tiered review. Quality of information contained in this journal is crucial to all of us, especially since as experts, we are likely to see anything we have writ-

The Journal Mission (continued from page 1)

ten, later in court.

I believe information must be timely to be of practical use. It is the goal of this publication to provide information on current drug trends and new collision reconstruction techniques, as well as any other area of science that impacts or influences law enforcement.

I attribute the success of this project and the year of work which has prefaced this issue, to GOHS Director Alberto Gutier, and the editorial staff; Dan Collins, Frank Griego, Mark Malinski , and Cam Siewert. Without the support of Director Gutier and the many hours of work by the editorial staff, this work would not have been completed.

In addition to bringing you articles and research from scientists and engineers, a main focus of APSJ is to solicit, peer-review, and publish articles from within the Arizona Criminal Justice community.

So, welcome to the Arizona Police Science Journal. We welcome your comments, suggestions, thoughts and even complaints. You have our commitment that we will provide quality, timely and unbiased information and articles.

- Executive Editor

Training Program Integrity is First Priority

Bridget Reutter

Providing resources for training and a process to assist with meeting standards for testimony are the two primary goals the Arizona Police Science Journal strives to meet. As training is the standard to which an officer performs and testifies, the officer understands the significance of knowing training material well enough to explain it to another.

Maintaining the integrity of program training standards is imperative to providing the prosecution with credible evidence as well as effective testimony. Whether in the performance of Standardized Field Sobriety Tests or Collision Reconstruction, the use of scientific evidence to support observations and physical evidence still hinges on the expectation of adherence to training standards. I encourage you to reinforce the importance of compliance in training standards and their role in the maintenance of program integrity.

Bridget Reuter serves as the Governor's Office of Highway Safety (GOHS) Impaired Driving Projects Coordinator. In that capacity she coordinates the Law Enforcement Phlebotomy Program, the Drug Evaluation and Classification Program, and the Drug Impairment Training for Educational Professionals Training Program, as well as other training programs. Bridget Reutter also serves as a member of this Journal's Advisory Board and is committed to providing excellence in training to law enforcement officers throughout Arizona.

When Crush Energy Becomes the "Truth Maker"

Rudy Limpert, Dennis Andrews, Franco Gamero

We will discuss two inline crashes where crush energy was used to assist in favorably settling the cases. In each case, well-qualified defense experts did not ask the important question: Does my opinion make sense? Judges and jurors will always ask this question.

Relative Speed at Impact

Energy balance and in-line momentum can be combined to derive an equation for relative speed at impact, revealing crush energy as the truth maker (Ref. 1):

$$V_{11} - V_{21} = \{2E_c(m_1 + m_2)/[m_1 m_2(1 - e^2)]\}^{1/2};\ \text{ft/sec}$$

Eq. 1

V_{11} is the velocity of vehicle V1 while rear ending vehicle V2 which is traveling at velocity V_{21} at that moment. For two given vehicles with masses m_1 and m_2 the relative velocity $V_{11} - V_{21}$ or difference in velocity of vehicle V1 and vehicle V2 at impact is a function of the combined crush energy E_c and the coefficient of restitution e. Inspection of Eq. 1 reveals that, for example, an impact speed of 40 mph against a stopped vehicle produces the same crush energy as if it traveled at 100 mph while the other vehicle traveled at 60 mph. Consequently, when we know the crush energy of V1 and V2 and e, we will know the relative velocity. For many accidents, the crash will be plastic, that is, $e = 0$. Even for $e = 0.2$, the crush energy will only decrease by 6%, indicating that a near-plastic impact analysis fairly accurately predicts collision speeds for all but very low impact speeds (Ref. 1 and 2).

Crush Energy Basics

In any crash, it must be determined which load-carrying components absorbed crush energy. Side impacts must be analyzed with respect to impact location such as A-pillars, doors, floors, etc. Stiffness values may vary significantly. Buckling of roof lines, floor boards, and door overlapping may indicate more crush energy than maximum crush depths of soft components. Measuring 1000 damage points electronically may demonstrate great technical skills, while three or four carefully measured points of crush load-carrying components tell the "energy story".

In rear-end collisions involving over-riding the trunk floor structure of the struck vehicle, crush energy is approximately 40% of the full crush energy calculated from maximum crush depth. It is recommended that crash test films are reviewed for possible data refinement. Lawyers and experts must determine whether any pre-accident repairs to the crush energy-absorbing components of the car were made.

When testing to determine crush energy in a unique case, such as a cow-windshield header impact, design the test as simply as possible to accomplish desired objectives effectively and efficiently. Case specific testing is not intended to do fundamental research. It must not be used to communicate incorrect data or to mislead the jury. In one particular cow impact crash the windshield header was crushed approximately 16 inches. The defense expert conducted two crash tests using two different large vehicles owned by the plaintiff's roof design expert and his wife. The test were severe enough to tear one roof off the vehicle, while in the other test the entire roof was peeled back like a sardine can. What was the purpose of these tests? To demonstrate that roofs can be torn off with enough weight penetrating through the windshield, and that even the expert and his wife owned unsafe cars? When the plaintiff's expert wanted to show the defense test videos to the jury, even the defense lawyer objected to the introduction of his own tests.

CASE 1:

The police report showed the following: A 1994 Mitsubishi Eclipse with five occupants was traveling on a two-lane 50 mph highway at night. The car struck a cow that had entered the roadway. After impact the car continued off the road through a fence and a pasture for a total of 1818 ft. The car left approximately 40 ft of braking skids before impact with the cow. When the car came to rest, it burst into flames. According to the police report, there was total front end

Figure 1. Overall damage of Eclipse.

and top damage. The impact was severe enough to kill one occupant and produce incapacitating injuries to another one. The five-year old black cow, weighing 1200 lb, came to rest 200 ft from the point of impact in the right shoulder of the highway.

The damage of the car is shown in the following photographs. Figure 1 indicates that the cow impacted the hood and then the windshield header tearing the spot welds without deforming the A- and B-pillars.

Figure 2 shows no damage to the left side of the car and the peeling back of the roof panel by tearing the spot welds.

Figure 2. Peeling back of roof panel.

Figure 3 shows no significant damage to the load carrying components of the front bumper. The radiator cross bracket, left front fender and related hardware are pushed backwards and down.

Figure 3. No crush damage by major load carrying components.

RECONSTRUCTION:
The expert for the defense calculated an impact speed of approximately 88 mph primarily based upon an arbitrarily assumed after-impact drag factor of 0.08g for a distance of 1818ft, calculating a speed after impact of approximately 66 mph. If these speeds were correct, then the crush energy E_c (Eq. 1) should be 233,389 lbft using a car mass of 113.4 (3650/32.2) and cow mass of 37.3 lbsec^2/ft (1200/32.2).

At this point of the reconstruction it becomes important to accurately determine the probable crush energy sustained by the Mitsubishi. We had investigated and reconstructed a similar car/cow crash involving a 1991Hyundai Sonata. Figure 4 illustrates hood and roof damage. The maximum down and backward crush of the windshield header was approximately16 in.

Figure 4. 1991 Hyundai Sonata cow crash damage.

The roof spot welds did not tear. Case-specific pendulum crash tests with a 900 lb weight to simulate the cow weight against the header showed that approximately 8,000 to 10,000 lbft of energy were required to produce a similar crush profile. Accounting for crush damage of the hood, radiator bracket, etc, cow friction on the hood, as well as the potential energy of the cow raising it up against the header resulted in a total energy of approximately 21,000 lbft absorbed by the Hyundai.

Although both cow crashes indicate similar crush deformations, we used a total crush energy range of E_c = 30,000 to 40,000 lbft in our Mitsubishi analysis. Eq.1 yields an impact speed range of 32 to 36 mph. The after-impacts speeds ranged between 24 and 27 mph. Using a pre-impact braking drag factor of 0.8g and 40 ft of skid marks yields a maximum speed at beginning of skidding of 48 mph. The only valid conclusion to be drawn based upon the facts of this case is that the vehicle developed continued drive thrust while traveling for 1818 ft, either by inadvertent gas pedal application by the injured driver, or more likely, by damage to the throttle linkage.

CASE 2:
When freeway traffic had stopped, a tractor-semitrailer crashed into a stationary SUV.

Figure 5 shows the rear end damage. The rear end crush depth on the right side was approximately 48 in., on the left side 32 in. The expert for the defense of the tractor-trailer had analyzed the EDR down load of the tractor, shown in Figure 6, concluding that the impact speed was approximately 35 to 38 mph.

Figure 5. Rear-end damage of white SUV.

When we reconstructed the crash based upon crush depth values and crush energy, Eq. 1 "told" us a probable impact speed of approximately 57 mph. Doing additional "does it make sense" research led us to several publications which showed that the EDR engine data of the particular Caterpillar engine used in the subject tractor of Case 2 had a wrong time scale of the vehicle speed-time diagram down load (Ref. 3 and 4). Inspection revealed that the "Quick-Stop-Data" used an incorrect time scale resulting in wrong low braking deceleration values, and hence, incorrect lower impact speed (Ref. 5).

CONCLUSIONS:

Crush energy becomes a powerful tool when answering the "Does-it-Make-Sense" question. This question should always be asked and answered during the formulation and analysis of a case, and not after a report has been written, or more embarrassingly after deposition or trial testimony.

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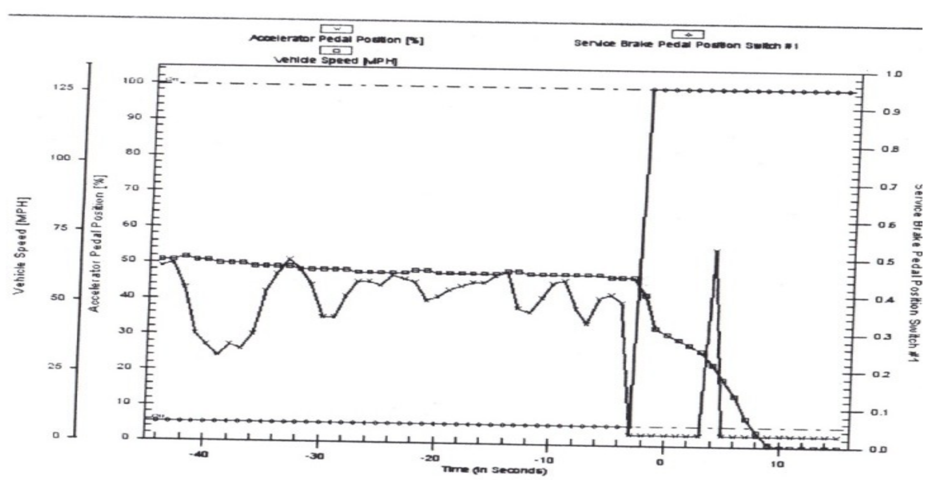
Figure 6. EDR data velocity-time down load.



PLAINTIFF'S EXHIBIT

Law Enforcement Phlebotomy: The Importance of the Basics

Nancy Jefferys

Law Enforcement Phlebotomy is a well-established practice in Arizona. While many other states are still struggling with the time and expense of using medical personnel in their blood evidence collection procedure, many jurisdictions in Arizona have discovered the advantages of training law enforcement personnel to obtain this evidence in a safe, timely, and legal manner. Objections to this practice are still raised, but rather than dismissing the criticism as the reactions of the ignorant or misinformed, such objections should serve as a reminder to those officers who perform venipunctures of the importance of adhering to the standards and maintaining skill proficiency.

Venipuncture is, at its source, a clinical procedure. When used for law enforcement, it is also a legal evidence collection procedure. These two are not mutually exclusive, and the standards for both must be followed. While a law enforcement phlebotomist is not collecting blood that will be used for any medical procedure, the standards that were developed by medical sources to ensure the proper steps and safety of the procedure are still applicable. This is why the phlebotomy curriculum taught at Phoenix College is based on the Clinical and Laboratory Standards Institute (CLSI) Guidelines & OSHA regulations, developed for the clinical world but fully adaptable for the law enforcement field.

Proper law enforcement phlebotomy requires an awareness and understanding of all applicable standards. Law enforcement officers receive instruction in the OSHA Bloodborne Pathogens standard, search and seizure, and evidence collection as part of their training. Proper phlebotomy training includes additional biohazard safety information and instruction using the nationally developed standards. Like OSHA, CLSI provides for the safety of the phlebotomist, but it also deals with requirements for the safety of the subject being drawn. Safety comes first, all the time, every time.

"Seated, Safe and Secure" was added to the Phoenix College Law Enforcement Phlebotomy initial training and refresher curriculum in order to provide criminal justice personnel with a set of parameters for evaluating and setting up the environment in which they do venipunctures. Based on the CLSI standards, these parameters consider the safety of both the phlebotomist and the subject and provide guidance that exceeds the policies of most civilian outreach phlebotomy programs. The objective is to provide an avenue for performing safe, compliant, reasonable venipunctures that yield solid, legally viable evidence.

SEATED:

"Seated" is simple; it is defined as *not standing*. There is no good clinical or law enforcement reason for a subject to be standing during a blood draw. Light-headedness and fainting are well-known potential complications of venipuncture and a standing subject is at risk for an abrupt fall even if they are feeling fine prior to the draw. Additionally, since most law enforcement draws are performed as part of DUI enforcement, subjects who have been already documented as being unsteady on their feet or swaying during standardized field sobriety tests can hardly be considered to be steady enough to hold their arms still and/or maintain their balance while on their feet. A subject needs to be sitting or lying down during venipuncture. How and where they should be positioned is an additional safety consideration.

SAFE:

Safety is the main goal of the whole training curriculum, but in the context of these parameters, it refers to three main characteristics to consider: the "chair", the location, and cleanliness.

The "Chair". As already discussed, the subject should be seated or lying down, but the considerations for positioning do not stop there. The subject has to be made secure from falling. The CLSI Approved Standard H03-A6 (2007), *Procedures for the Collection of Diagnostic Blood Specimens by Venipuncture*, states a chair for venipuncture should have a safety feature such as armrests to prevent falls. Most clinical sites use commercially-made specialized phlebotomy chairs, but there is no requirement to have such a specific chair, only one from which falls can be prevented.

The national guidelines clearly assume that venipunctures are taking place in a clinical environment; however, the growth of off-site (non-clinical setting) phlebotomy such as in home health situations, assisted living facilities, and the variable locations of mobile health screenings and forensic draws means that the spirit of the guidelines needs to be addressed when the exact letter of the guidelines cannot be reproduced. In these cases, a seating area that is modified to prevent falls fulfills this requirement. A chair should be selected that is of sufficient weight and construction so that it cannot be easily overturned. A solid office chair without wheels is a likely candidate; a folding camp chair, unless it has further support to prevent tipping, is probably not going to be a good choice. A chair without arms can be positioned so that it still provides support. For example, it can be placed with its back against a wall and between two sturdy tables that function as “arms”. Another possibility is placing the chair between a table on one side and a wall on the other. Still another option might be to have a table on one side while an additional officer serves as an “arm” on the other. In this option, the phlebotomist should make certain that the assisting officer possesses both the knowledge and ability to support the suspect during and immediately following the venipuncture.

If no suitable chair is available, then the subject can lie down. A bed, gurney, or even the floor can be used as long as it can be rendered reasonably clean and the subject is secure from falling.

LOCATION:

Location, the site for the blood draw, is a key part of safety. As stated, off-site phlebotomy is not confined to law enforcement. Blood collection for laboratory testing takes place daily in home health and assisted-living facilities, and during insurance exams that are performed in a variety of home and workplace settings. Many variables exist in these areas: conference room versus front office, common room versus patient’s room, bedroom versus living room. Off-site phlebotomy is by definition not tied to a specific place, and criminal justice personnel also have choices as to location such as patrol vehicles, DUI processing vans, stations, and jails. Law enforcement phlebotomists should be able to choose among their options in order to provide the best environment available at the time and under the existing circumstances. An officer faced with a choice between doing a venipuncture in a patrol vehicle at night or transporting the subject a short distance to well-lighted police station may have difficulty articulating a decision to draw in his vehicle. However, a rural deputy driving a well-equipped utility vehicle with the proper venipuncture resources at hand and the nearest station located an extended distance away must be able to articulate the need to collect the blood evidence on-site prior to transport. An officer whose suspect is about to be transported out-of-state for medical care may find the back of an ambulance to be nearly ready-made for venipuncture. DUI processing vans that are equipped with a secure seating area, adequately lit and supplied, and constructed with materials conducive to cleaning can be an excellent alternative for those with access to one. Some agencies with the means to do so have bought phlebotomy chairs, placed them in low traffic jail areas or dedicated rooms, and budgeted for additional phlebotomy supplies such as butterflies and benzalkonium chloride, providing trained personnel with an acceptable replica of a clinical environment that they need only pre-clean in order to use. Whatever the location, the decision should be based on a sound evaluation of its relative safety for both the phlebotomist and the subject.

CLEANLINESS:

Cleanliness of the person and the surroundings is another important aspect of safety that cannot be ignored. Basic phlebotomy procedures include requirements for hand-cleansing before and after the draw. Proper cleaning of the venipuncture site is also essential. Adequate cleaning with an appropriate antiseptic is vital to preventing the introduction of foreign microbes into the skin puncture. Care must also be taken to avoid contaminating the site prior to the venipuncture; no fanning, blowing, or wiping of the site with unsterile materials, and no touching the site with an unclean finger.

Cleanliness of the immediate area is also a consideration. Clinical facilities have institutional policies and accreditation agency guidelines to govern what to clean with and how often cleaning is required in patient areas. In off-site locations, cleaning should be performed before and after venipuncture, preferably with an EPA-approved sodium hypochlorite disinfectant, although a freshly prepared solution of 10% bleach will work as well. At a minimum, the area cleaned should include where the arm will be supported and where venipuncture equipment will be laid. Ideally, the chair and any supporting table or counter used should be wiped down prior to the draw. A surface not conducive to thorough cleaning, such as fabric, should be covered with clean cloth, plastic, or a plastic-backed pad of the type often used in ambulances and hospitals. The area should be cleaned again after the draw to prevent the possibility of leaving behind blood droplets or other contaminants.

Cleanliness for venipuncture areas cannot be ignored simply for lack of convenience. In emergency medicine, seconds can matter in saving a life and intravenous lines are sometimes started in unclean environments because infection risk is outweighed by the immediate traumatic or medical hazards to a person’s health. In venipuncture, even exigent circumstances (such as drawing for inhalant levels) are not so pressing as to prevent a short time devoted to cleaning or covering an area. Unlike EMS IV starts, where a person’s continued or improved condition depends on the intravenous procedure, an evidentiary procedure must not deliberately pose a unreasonable risk of infection.

SECURE:

The “Secure” part of “Seated, Safe, and Secure” is a reminder to reevaluate the site choices prior to doing the draw. “Secure” the area; look it over. Is the scene safe? If the chair is located in an area where the phlebotomist likely to be bumped into or jostled during the draw? Can the subject fall from the position he/she has been placed in? Is the seat steady? Does it provide enough support? Is the arm adequately supported? Are phlebotomist, assistants, and subject all safe?

Law enforcement phlebotomy is more than just the technical procurement of the blood sample. The blood sample must be safely and properly obtained according to applicable rules in order to be admissible in court. Arizona Revised Statutes 28-1388A states that "…only a physician, a registered nurse or another qualified person may withdraw blood for the purpose of determining the alcohol concentration or drug content in the blood." State courts have upheld that a law enforcement phlebotomist is a "qualified person" based on training and experience. Specifically, it is the training in venipuncture, not the training in criminal justice matters, that qualifies a person under this statute, and it is assumed that a "qualified person" is adhering to the standards taught in training. A "qualified person" knows that the basic tenets of phlebotomy are following standards, using guidelines for quality decision-making, and maintaining proficiency. Adherence to this foundation is the way to ensure that law enforcement phlebotomy remains a viable tool in the enforcement of DUI law in Arizona and paves the road to sharing this important tool with other states.

Nancy Jefferys, PBT (ASCP)

Nancy Jefferys is Adjunct Faculty in the Phlebotomy Program at Phoenix College and a consultant for Nu-Health Educators.

Blood and Breath Alcohol Testing: Part 1

Michael Sloneker and Ron Skwartz

This will be the first article in a four-part series discussing forensic blood and breath alcohol testing as it relates to the medico-legal field. The series will investigate and explain the background behind some commonly raised topics in DUI trials. An examination of the history, scientific relevance, and scientific consensus will be covered for each topic. This first article will focus on breath alcohol testing and the blood to breath alcohol ratio.

Knowledge of the existence of a relationship between blood and breath is not new to the scientific community. In 1927 Emil Bogen M.D. published a paper entitled "The Diagnosis of Drunkenness." The paper was the recipient of much accolade including a one hundred and fifty dollar research prize. The paper compared a number of ways to estimate the amount of alcohol in the blood. Bogen concluded that testing urine was not considered a reliable method of determining a person's alcohol concentration. However, breath was a "very attractive-looking substitute." (1)

The first stable instrument for breath-alcohol testing was called the *Drunkometer* and was reported by Dr. Rolla N. Harger in 1938 (2). This technology relied upon the chemical oxidation of alcohol and an accompanying color change similar to the chlorine and pH test for swimming pools. This instrument, while considered archaic by today's standards, allowed law enforcement to quantify a person's breath alcohol concentration for the first time. In the early 1950s, Professor Robert F. Borkenstein invented what became to be known as the *Breathalyzer*. Relying on the same technology as the *Drunkometer*, the *Breathalyzer* provided law enforcement with a more portable and robust instrument. Using infrared spectroscopy for breath alcohol testing debuted in 1971 in a device called the Intoxilyzer 4011 (3). Since that point in time, infrared spectroscopy has become the primary analytical technology for evidentiary breath-alcohol testing (4, 5).

As breath testing instruments became more commonplace in the courtroom, more questions arose about the practice of converting a breath alcohol concentration into a blood alcohol concentration for each individual person. In 1976 it was suggested by prominent forensic alcohol researchers, Dubowski and Mason, that this practice be stopped. They recommended instead to follow a model already in use in the United Kingdom and Northern Ireland in which the unfitness to drive was statutorily defined in terms of breath alcohol concentration (6, 7). By defining breath and blood alcohol units separately, the argument over individual differences in blood to breath alcohol ratios should be a non-issue in a DUI trial. Arizona law defines blood and breath concentrations separately and, therefore, does not convert breath alcohol results to a blood alcohol concentration.

Every breath testing instrument uses an assumed blood to breath ratio that is based on scientific research. Henry's Law is a scientific gas law that explains the behavior of volatile substances in both liquids and gases. Specifically, the law states that if a liquid contains a volatile substance, like ethanol, some of that chemical will escape from the liquid and make its way into the air above the liquid. Henry further explained that if this liquid is in a closed system, eventually the number of molecules escaping the liquid will equal the number of molecules falling back into the liquid. This is called equilibrium. The system must be in equilibrium in order to reliably calculate the amount of a volatile substance in a liquid by measuring the amount of that substance in the air above the liquid. With respect to the blood to breath alcohol ratio, the lungs act as if they are a closed system and correlation studies that measure both blood and breath have proven that equilibrium is established between a person's blood and their deep lung air.

One of the largest correlation studies ever performed examined the blood to breath alcohol ratios in over 21,000 subjects. The calculated average partition ratio was 2440 to 1. This means that, on average, for every one part of alcohol found in the person's breath there are 2440 parts of alcohol in the person's blood.(6) This partition ratio is consistent with the 2350 to 1 partition ratio that had been the accepted average partition ratio for years.

Of course it is impossible to know any one person's exact partition ratio at any given time. Because of this, the US Department of Transportation mandates that a 2100 to 1 ratio be used for all breath testing devices in the United States (Title 49 Code of Federal Regulations 382.107; issued in 1973). By using a 2100 to 1 partition ratio, a breath result will underestimate a blood result 95 percent of the time (9). In addition, a person's breath test result will typically be about 10 percent lower than their actual blood test result. Despite this overwhelming amount of scientific support showing that the use of a 2100 to 1 partition ratio benefits the vast majority of defendants, not knowing a person's exact partition ratio at the time of the breath test is one of the most common arguments brought up by defense in a DUI trial. Time is often spent in trial discussing the very small probability that the defendant's partition ratio is significantly different than the normal population.

A person's body temperature at the time of the breath test is another common argument made in trial. Theoretically, body temperature affects the partition ratio by either making it more difficult for the ethanol to leave the blood or easier. If a person has a fever, then it would be expected that more ethanol would be leaving the blood and going into the air in the lungs. The opposite would be true if a person's body temperature were below normal. In other words, the higher the person's body temperature the more likely the possibility of a breath test being greater than a corresponding blood test.

In theory, for every degree Celsius (^oC) of fever that someone has, the breath alcohol concentration will rise by 6.5% over their breath alcohol concentration at normal body temperature (10). Taking into account that using the 2100: to 1 ratio already underestimates the BAC by ten percent, even a breath alcohol concentration for a person with a mild fever of 100.4 Fahrenheit (^oF) is still 3.5% below their blood alcohol concentration. The exact percentage increase caused by a fever is often debated due to the lack of scientific articles on this topic. A study performed in 1989 indicated an 8.6% increase per degree Celsius fever (11). However, this study was never duplicated and as such the 6.5% increase stands as a more reliable estimate. To confuse matters even more, a recent study demonstrated that within the normal range of body temperatures, between 96.8^{o}F – 99.68^{o}F, the breath alcohol results were not affected (12).

Similar arguments have been made that all revolve around possible changes in a person's blood to breath alcohol ratio; a person holding their breath, normal circadian rhythms, and menses to name a few. Combining these factors together, while possibly altering a person's blood to breath alcohol ratio slightly, have never been scientifically shown to have the additive effect that is often claimed in court. Both the relevant scientific community and Arizona law do not support a need to adjust breath test results for theoretical differences in one's blood to breath alcohol ratio.

Michael Sloneker has worked in Criminalistics for over 11 years. Prior to working for the Arizona Department of Public Safety he was employed by the San Diego Police Department's Crime Lab. He has done case work in both Forensic Alcohol and Controlled Substances. He has presented at The Arizona Prosecuting Attorneys' Advisory Council (APAAC) summer symposium and The International Association for Chemical Testing (IACT) annual convention. He is currently assigned to the Forensic Alcohol Unit at DPS where he acts as the Court Coordinator.

Ron Skwartz is a Criminalist with the Forensic Alcohol Unit at the Arizona Department of Public Safety Central Regional Crime Laboratory in Phoenix. Ron attended University of Arizona and received a Bachelor's of Science in biochemistry. Prior to the Arizona Department of Public Safety, Ron worked as a Certifying Scientist for J2 Laboratories in Tucson Arizona performing drug toxicology analysis. Ron currently holds permits for: Blood Alcohol Analysis, Intoxilyzer 5000 & 8000 Operator, Intoxilyzer 5000 & 8000 Quality Assurance Specialist and Intoxilyzer 5000 & 8000 Instructor. Ron has also completed Intoxilyzer 5000 & 8000 factory maintenance and repair training.

He has successfully completed both HGN/SFST and DRE schools and is a certified General Instructor. Ron regularly instructs statewide on the field of inhalants, breath & blood alcohol and their effects. Courses he has instructed include DITEP, DRE School, DRE In-Service and ARIDE. He has also been invited to instruct at HGN and DRE Instructor Schools. He has qualified as an expert witness in the field of forensic alcohol in superior, municipal and justice level courts in the State of Arizona.

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Expert Resources to Aid in the Fair Resolution of Criminal Cases: Analysis of Accident Databases

Franco Gamero and Rudy Limpert

Objective and accurate information obtained from accident databases is a powerful tool for case preparation and resolution.

Why are conclusions and opinions based upon accident statistics helpful? In some cases, they are the single deciding factor for a jury or judge to render a fair verdict. The reason is very simple. The data are routinely collected by government agencies without any bias to certain vehicle manufactures, drivers or roadways. Consider the following: Expert A says the defect caused the crash, expert B says no. Both experts are equally qualified. The jury is desperately looking for a "truth maker". If an accurate query of the accident databases shows a significant over-involvement of the particular design issues involved, in nearly all cases the jury will use the government data to support its verdict.

The National Accident Databases.

The two main databases are NASS and FARS.

The National Accident Statistic Sampling database (NASS) is a sampling of accidents collecting approximately 5000 accidents annually. It represents a statistically weighted frequency whose analysis projects the national experience and helps in projecting performance.

The Fatality Analysis Reporting System (FARS) (formerly Fatal Accident Reporting System), is a collection of files documenting all qualifying fatal crashes since 1975 that occurred within the 50 States, the District of Columbia, and Puerto Rico. To be included in this census of crashes, a crash had to involve a motor vehicle traveling on a traffic way customarily open to the public, and must result in the death of a person (occupant of a vehicle or a non motorist) within 30 days of a crash.

A comprehensive coding manual is produced each year. It provides written instructions to every FARS analyst on how to transfer the data from a police accident/crash report (PAR) to the FARS system.

The Manual is extremely important as it contains all the parameters, variables, and terminology used in all the police reports in all the states and Puerto Rico, along with its definitions.

What is FARS?

In 1972, NHTSA began to collect key information on all fatal crashes occurring in the U.S. The fatality had to occur within 30 days of the accident. The basis for this information comes from the Police Accident Report (PAR) with participation from all states. It is coded and entered in a Government database by FARS analysts. FARS is a CENSUS, a frequency count.

Criteria: a crash must involve a motor vehicle travelling on a traffic way customarily open to the public, and result in the death of a person (either an occupant of a vehicle or a non-motorist) within 30 days of the crash.

What does FARS contain?

It contains accident records. Each record has variables that correspond to all the information that is contained in a Police Report. This information is sanitized, that is, all the personal information such as names and addresses are not shown. They also contain the most updated variables such as texting, cell phone usage, etc., as part of distracted driving violations. It contains statistical relationships that, when "discovered" and correctly analyzed by an expert, may reveal surprising details about accident or injury causation.

Accident databases were used in the two following cases. How did the statistical data assist the lawyer(s) involved in effectively formulating their case? Proper case formulation requires knowledge about all information possibly relating to the case. In most cases, accident data are helpful in clarifying certain issues involved. In some cases a single conclusion derived from the accident data proves extremely helpful.

The vehicle-pedestrian accident falls into the first category: Clarification of several influence factors.

Vehicle-Pedestrian Night-Time Accident

An SUV struck an elderly 75-year-old pedestrian after dark at approximately 11 pm, injuring her fatally. The pedestrian was crossing a highway near an unmarked, unlighted T-intersection. She and her husband had just left a Christmas party, and she was carrying a bag filled with food. Her husband followed approximately 10 feet behind. The intersection was dark with some Christmas lights illuminated approximately 20 feet from the edge of the road. The pedestrian passed from the left to the right in front of the approaching SUV. The critical aspect of the case was that the driver of the SUV had consumed two beers, resulting in a blood alcohol level of approximately 0.05. The defense attorney wanted to know what information FARS could provide to better understand other influence factors.

General accident statistics show that approximately 5300 pedestrians are killed in the United States each year in traffic accidents. In terms of time, the peak of fatal accidents occurs between 7 and 8 p.m. Approximately 30 to 40 percent of the fatally injured pedestrians older than 15 years had been drinking. A detailed data analysis of FARS revealed the accident statistics apply to crossing at an intersection, as well as to crossing elsewhere. The data queried summarize the average risk of fatal injury based on the last five years of FARS (1997 - 2001). The FARS analyst for this case, tried to duplicate the conditions existing at the time of the accident with respect to the actions and characteristics of the pedestrian.

Inspection of the results reveals that an elderly pedestrian (75 years or older) has a 64.2 percent probability of being killed (FARS collects fatalities only) by a car when crossing other than at an intersection, as compared with 35.7 percent when crossing at an intersection. Additionally, those crossing during 9 to 12 p.m. on a weekend have a 27 percent probability of being killed regardless of age. Finally, improper crossing results in a 29 percent probability of being killed regardless of age or time of day.

An even more detailed analysis can show how many elderly pedestrians are killed in the weekend group in a 24-hour day, and when related to the non-intersection elderly pedestrian group, yields a probability exceeding 64.2 percent, possibly 68 percent (not very many elderly people are expected to be walking the streets around midnight).

What is the overall conclusion to be drawn in this case based upon the objective FARS data shown? - The probability of an elderly pedestrian being killed while crossing an unlighted highway, not at an intersection, around midnight, during the weekend is approximately 68 percent (Ref. 1).

Combined Braking/Steering Data Analysis: Clarification of a Single Design Issue.

In general, Diesel engine trucks equipped with hydraulic brakes use a hydro-boost braking system to provide power brakes to the driver. In the hydro-boost system, a single hydraulic pump is used to provide the boost energy for both the brakes and power steering system. In some designs, if the driver carries out a combined braking and steering maneuver, the steering system loses its assist effectiveness. Stated differently, the brakes when applied with a certain pedal force level use all or nearly all of the pump pressure, depending on the specific pedal forces involved (Refs. 1 and 2).

The NASS data were accessed to look at only certain trucks in terms of manufacturer, model years, Diesel or gasoline engine (gasoline engines have a standard vacuum booster using engine vacuum for power brakes rather than the steering pump), and which of the two engines, and therefore brake design versions, had higher involvement in accidents when a combined braking and steering maneuver was attempted prior to the accident.

The results reveal that when a combined braking-right turn maneuver was attempted to avoid the crash, 85.1 percent were Diesel engine trucks, compared to 14.9 percent gasoline trucks. For combined braking-left turn maneuver, the percentages were 38.9 and 61.1 percent, respectively. If both steering directions are combined, the trucks using a hydro-boost brake system (Diesel engine) are approximately 63 percent more

Attempted Avoidance Maneuver: Actions taken by the driver's vehicle in response to the Critical Precrash Event, within the critical Precrash envelope that occurred just prior to impact.

Researcher-determined based on vehicle and scene evidence, Police Report, and interviews.

	Braking & Steering Left	**Braking & Steering Right**
Unknown	**0.0**	**0.0**
Diesel	**38.9**	**85.1**
Gas	**61.1**	**14.9**

Interpretation of results:

Braking & Steering Left

Diesel **38.9%** A Steering-and-Braking action to the left was the attempted avoidance maneuver.

Gas **61.1%** A Steering-and-Braking action to the left was the attempted avoidance maneuver.

Braking & Steering Right

Diesel **85.1%** A Steering-and-Braking action to the right was the attempted avoidance maneuver.

Gas **14.9%** A Steering-and-Braking action to the right was the attempted avoidance maneuver.

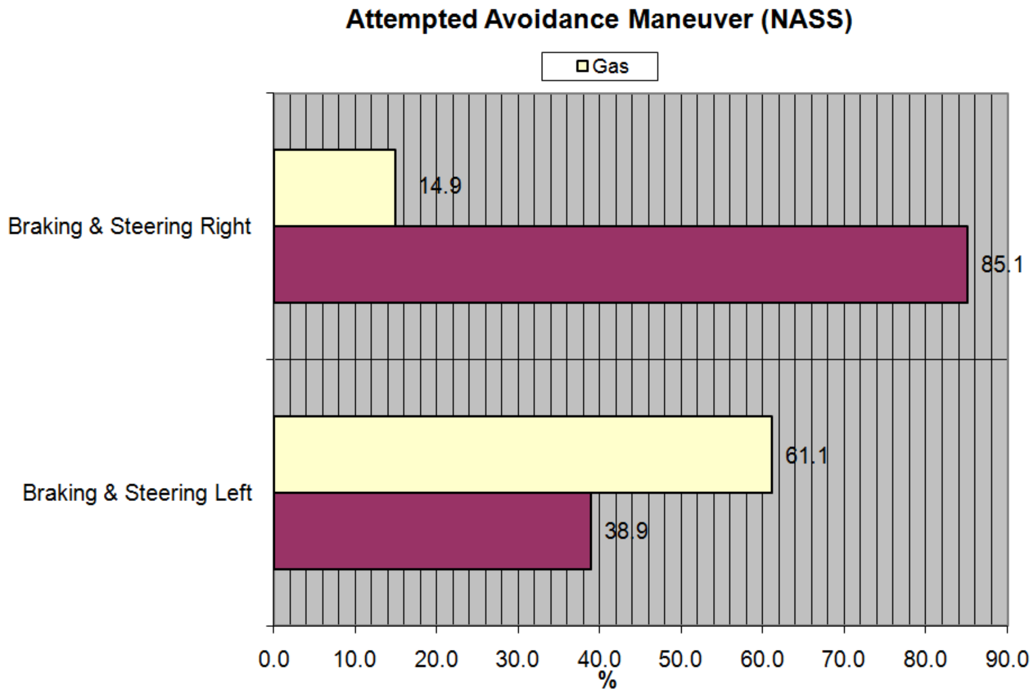

Figure 1. Percentage Accident Involvement for Combined Braking-Steering.

involved in combined braking-steering maneuvers than their vacuum-brakes (gasoline engines) counterparts.

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Analysis of the Pursuit Intervention Technique Using HVE SIMON Simulations

Daven Byrd and Cam Siewert

Abstract

The Pursuit Intervention Technique (PIT), also known as the Precision Immobilization Technique, is a tool used by various law enforcement agencies throughout the United States to dynamically terminate the pursuit of fleeing criminals or the dangerous driving behavior of a motorist. The PIT maneuver is widely used by some agencies and prohibited by others due to varying case law and courts' definitions of what is considered "reasonable". Agency and civilian oversight interpretation of different cost benefits and risk analyses are also a major factor in adopting or prohibiting the PIT. This article, and the research it is based on, addresses two primary questions; does the probability of the pursued vehicle (target vehicle) tripping and overturning increase purely as a function of speed, and what amount of damage to the pursuing vehicle is likely to occur as a result of a properly performed PIT. The question of whether the damage to the pursuing vehicle is a function of speed is also answered.

Introduction

The research outlined in this work, and the subsequent conclusions, were completed to address questions commonly voiced by line officers and senior management, as well as experienced driving instructors and litigators regarding the use of the PIT. The authors have routinely been "informed" that the greater the speed of the target vehicle in a pursuit, the greater chance of the target vehicle rolling purely as a result of the increased speed. The assertion that significant damage to the pursuing vehicle will occur during a PIT, especially at higher speeds, has also been raised. Both of these questions are addressed by this work through numerous actual PIT applications and then a significant number of computer, physics based simulations.

There is little dispute that the pursuit of a vehicle by law enforcement is a high risk activity that often results in a collision. The Pursuit Management Task Force concluded in 1998 that "more than 50 percent of all pursuit collisions (as reported by agencies statewide) occurred during the first 2 minutes of a pursuit. More than 70 percent of all collisions occurred before the 6th minute of a pursuit" (Pursuit Management Task Force, 1998). The data compiled and analyzed in the above study were obtained from every level of law enforcement agency in Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, Utah, and Washington. This data shows that the sooner a strategy or technique used by officers to end a pursuit is deployed, the greater the chance the pursuit can end without a significant collision or injury.

Officers will often have more than one method or tool available to them to end or assist in ending a pursuit. Stop-sticks, air support, deployable global positioning system (GPS) tracking instruments, etc. This work does not address these alternative methods; only the PIT.

The first law enforcement agency to utilize the PIT as an approved way to end pursuits was the Fairfax County Police Department of Virginia in 1985 (Zhou, Lu and Peng 2008). Since first utilized in 1985, many other agencies have employed this method to safely end pursuits. The decision to use and proper utilization of the PIT necessitates first and foremost adequate and proper training. Also important is the choice of a proper location to PIT the target vehicle, correct timing and vehicle placement, and having a plan of what to do once the PIT has been performed. It stands to reason that like most other functions of law enforcement, proper training is the most important prerequisite to performing the PIT.

Analysis

A short description and explanation of the PIT is useful before data analysis begins. The PIT is usually accomplished by the police vehicle approaching the target vehicle from the rear. At some point, the police vehicle offsets and approaches the suspect vehicle from one of the rear corners (Stage 1). The police vehicle is then positioned directly next to, in contact with, or close proximity to the target vehicle. The officer then inputs steering toward the side of the target vehicle (Stage 2). The police vehicle creates lateral movement between the rear wheel tire patches of the target vehicle and the ground, causing the target vehicle to (yaw) spin out (Stage 3). In the example below, the target vehicle yaws out in a positive yaw angle. The officer brakes the police vehicle once yaw is induced into the target vehicle, minimizing or eliminating damage to the front of the police vehicle and the side of the target vehicle (Stage 4). The officer can accelerate through the PIT zone or brake and conduct a high risk traffic stop, etc. (Figure 1)

The field testing for this study of the PIT was con-

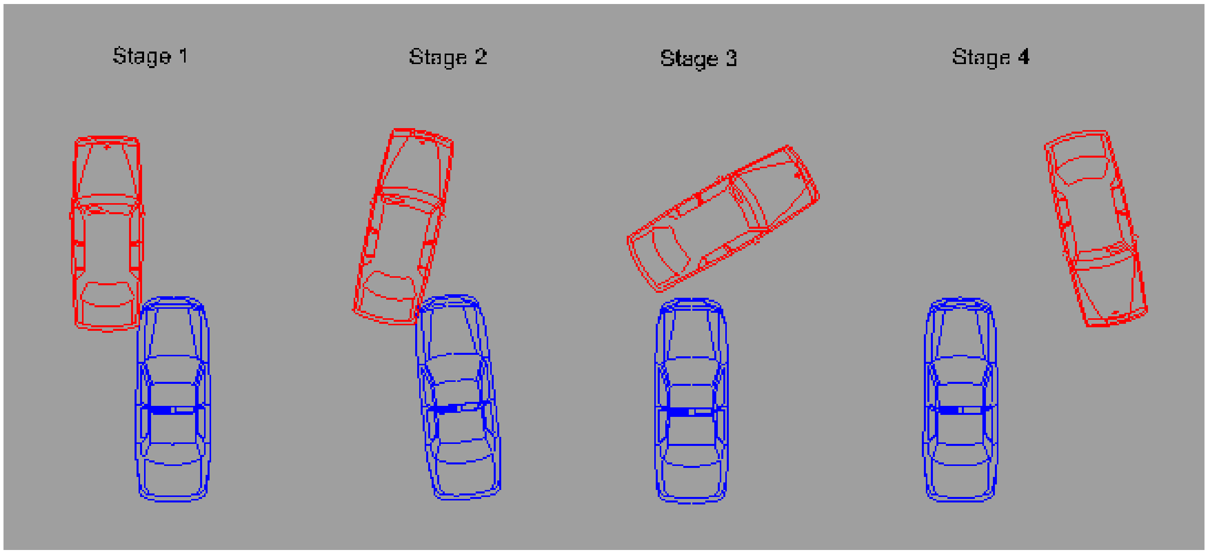


Figure 1

ducted at the Phoenix Police Department Driving Track with the aid of experienced Phoenix Police Department and Arizona Department of Public Safety Driving Instructors trained and qualified (based on their training and experience) in the PIT. The purpose of the field testing was two-fold; one, to observe and experience repeated PITs in a real world, dynamic state and two, to gather data regarding angle of attack between the two vehicles, steering inputs from the pursuing vehicle, and measure response to the PIT at varying speeds. The vehicles utilized in the PIT field testing were both Ford Crown Victorias equipped with metal bars protecting the PIT vehicles from damage during the testing. Numerous tests were conducted at speeds ranging from 20 MPH to 50 MPH; approximately 40 tests in total.

As referenced above, the need for real world, reliable data was vital to realistic results and accurate simulations. The PIT tests were either video recorded or recorded with continuous digital photographs. From the actual tests, video data and photographs, the attack angle, a range of steer angle inputs to the pursuing vehicle, and a range of times for the steer angle input were documented.

Angle of Attack for the purposes of this study is defined as simply the difference between the heading angles of the two vehicles just prior to steering input, or the PIT.

The angle of attack for the field tests were all approximately zero. No significant angles were present after initial contact and just prior to steering input.

The example above (Figure 2) simply shows if there was an attack angle, how it would be measured for our purposes.

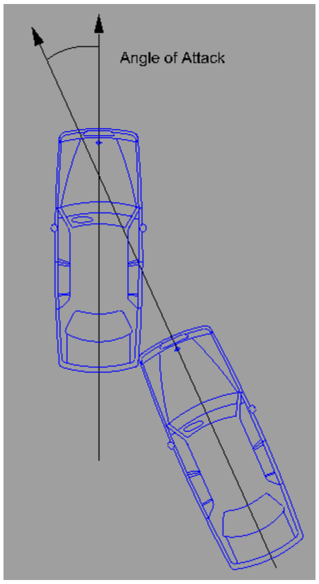


Figure 2

Steering input was first calculated by measuring “play” or the rotational travel distance present in the steering wheel without translating input in the steering system. A range of steering inputs were measured during field tests. The range varied from approximately 40 degrees to 90 degrees.

The data collected in the field tests was then used to create 195 real world simulations using Engineering Dynamics Corporation (EDC), Human Vehicle Environment (HVE) software with the Simulation Model Non-linear (SIMON) physics module. "SIMON is a dynamic simulation of the response of one or more vehicles to driver inputs, inter-vehicle collision(s) and factors related to the environment (e.g., terrain, atmosphere). SIMON is a newly developed simulation model, using a new, general purpose 3-D vehicle dynamics engine developed by Engineering Dynamics Corporation. The dynamics engine allows a sprung mass with six degrees of freedom and multiple axles with up to five degrees of freedom per axle" (Engineering Dynamics Corporation 2006). SIMON models vehicle and collision dynamics in a real world, validated process. SIMON is not an animation program and is accuracy dependent on the values and data entered by the user.

The environment used for SIMON is a completely three dimensional model. The data for this model was obtained from an actual portion of Interstate 10 in Arizona. The portion of the roadway was chosen as fairly representative of much of Arizona's interstate system; two traffic lanes in each direction of travel with a slightly depressed dirt median. Paved emergency lanes and slightly downward sloped shoulders border the roadway on each side. A value of 0.676 was used for the roadway unadjusted coefficient of friction. A value of 0.900 was used for the unadjusted dirt median and shoulder coefficient of friction. This value was intentionally chosen to be much higher than a normal dirt coefficient of friction. 0.900 was chosen to more accurately reflect the accumulation of dirt and debris under the target vehicle, which more accurately reflects what routinely occurs in collisions that travel into soft or "plowed" dirt. In other words, this value was chosen to simulate the "furrowing" effect of the target vehicle as it traveled sideways or with one hundred percent side-slip. This terrain and the subsequent simulations were not intended to model what occurs when a vehicle encounters a tripping mechanism, such as a curb or a drainage barrier.

Three types of vehicle were used in the SIMON based simulations. A 1989 through 1996 body style Mercury Cougar, a 2002 through 2006 body style Mini Cooper, and a 1992 through 1996 body style Lexus ES300. The vehicles were chosen due to their relative ability to represent different masses, different wheelbases, and different track widths. These vehicles also capture a variance of "rear overhang" lengths, which can affect damage severity to the pursuing vehicle.

The weights of the vehicles were left at published unladen values. The pursuing vehicle was 2010 body style Ford Crown Victoria. Simulations were completed with both left-side and right-side PITs to more representatively measure post-impact or post-PIT, lateral travel distance on the target vehicle.

Figure 3

Mercury Cougar						
#	Speed	Steer Angle	Peak Accel	Rollover	Damage	Lateral Dist
21	45	20	1.04	no	0.4	55.5
22	45	40	0.8	no	0.5	43.5
23	45	60	1.33	no	0.6	54.6
24	45	80	1.15	no	0.7	52.7
25	45	100	1.16	no	0.7	52.3
26	50	20	0.95	no	0.4	52.9
27	50	40	1.38	no	0.5	58.9
28	50	60	1.1	no	0.7	56.7
29	50	80	1.02	no	0.7	54.1
30	50	100	1.06	no	0.7	53.4
31	55	20	0.92	no	0.4	54.5
32	55	40	1.68	no	0.5	63.3
33	55	60	1.28	no	0.6	58
34	55	80	1.06	no	0.7	55
35	55	100	1.07	no	0.8	54.1

Each of the above described vehicles were PITed using SIMON sixty five times. Each vehicle was modeled for the speed range of 25 to 85 MPH, at 5 MPH increments. For each of the speed increments, five simulations were completed. The five simulations for each speed increment had varying steer angle inputs of 20 to 100 degrees. Figure 3 is a breakdown of the Mercury Cougar and some of the resulting data that was collected.

Example: For the speed of 45 MPH, five simulations were conducted at steer angles of 20 to 100 degrees. This resulted in no post-impact overturns, a maximum of 0.7 inches of damage intrusion into the body of the pursuing vehicle (lines 24 & 25), and a maximum of 1.33 g acceleration from impact to rest for the target vehicle (line 23).

As mentioned above, the two primary questions are one, is the propensity of the target vehicle to overturn directly related to speed at PIT and two, is the amount of damage related directly to the speed of a properly performed PIT. These two questions can now be addressed based on empirical and simulation based data analysis.

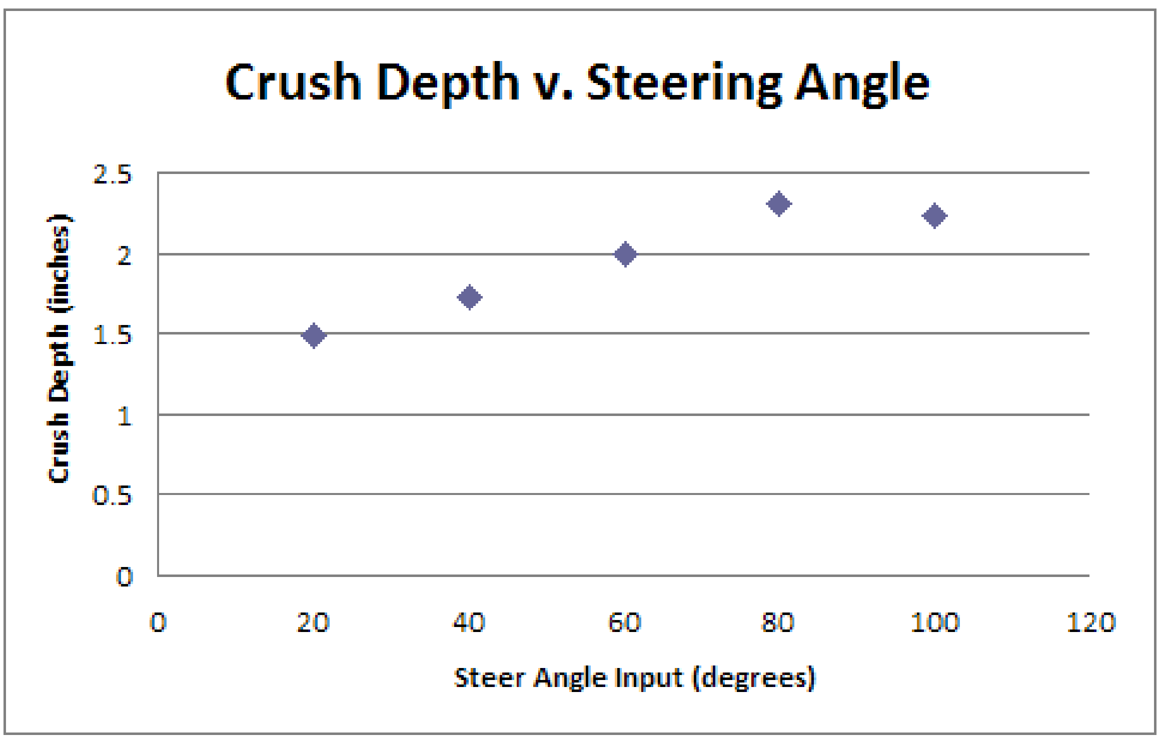
In all 195 simulations neither the target nor pursuing vehicle overturned. These simulations were conducted on a realistic and normally designed portion of freeway and as such, did not include tripping mechanisms that might normally be present in an intersection or city roadway.

To determine whether a relationship between the pursuing officer's steering angle input and the amount of damage to the patrol vehicle existed, the steering input value was taken from each simulation and directly correlated to the amount of damage, or crush in that same simulation. All crush depths for a particular angle of input were averaged and then plotted as a function of that angle. (Figure 4)

This data shows a clear relation between steering angle input of the pursuer and the amount of crush to the pursuer's vehicle. It is important to note that

Input θ	Crush (inches)
20	1.483784
40	1.725641
60	1.997436
80	2.310256
100	2.235897
(n = 190)	

Figure 4



these simulations did not account for the restitution of the patrol vehicle's body, specifically the respective quarter panel. Real-world vehicles performing these PITs with the exact same parameters would likely have less or no permanent deformation.

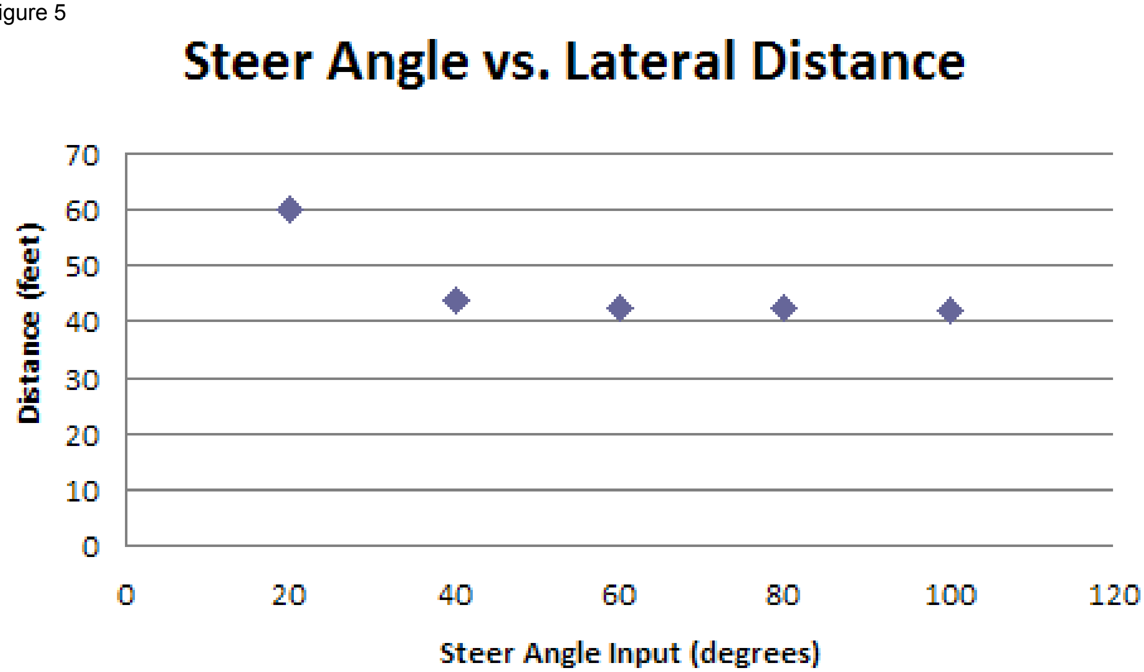
Although not a primary focus of this study, necessary data was obtained and recorded which show the relationships between steer angle input and the post-impact lateral travel distance of the target vehicle, as well as the speed at PIT and the post impact travel distance of the target vehicle.

To determine the relationship between steer angle input and the post-impact lateral travel distance of the target vehicle, this lateral distance was recorded for each iteration of angle inputs. The values for each simulation at a specific angle of steering input were then averaged.

At lower steer angle input values, based on the data above and also on the field test data, the vehicle travels a greater lateral, or side to side, distance from point of PIT. This makes sense as the vehicle is being accelerated into sideslip more slowly, taking more time and therefore a longer distance for the

Input θ	Lat. Distance (Feet)
20	60.14389
40	43.93333
60	42.55385
80	42.34462
100	41.79487
(n = 190)	

Figure 5



vehicle to reach one hundred percent side-slip and therefore one hundred percent of the roadway friction value. The sooner the target vehicle yaws into sideslip, the sooner the vehicle reaches the full friction value of the roadway, and lateral distance is decreased. (Figure 5)

To determine the relationship between speed at PIT and the post-impact lateral travel distance of the target vehicle, this lateral distance and the correlating speeds were recorded for each simulation. The average lateral travel distance for each simulation at the given speed was calculated.

This data plot (Figure 6) clearly shows the relationship between PIT speed and post-impact lateral travel distance of the target vehicle; the greater the speed, the greater the post-impact lateral travel distance of the target vehicle.

In the above described field tests and simulations, speed at PIT and input steer angles were controlled. The results of rollover occurrence, damage, and post impact target lateral travel distances were recorded and analyzed.

The relationship between target vehicle lateral travel distance after impact has been analyzed and relationships clearly exist between steer angle input, speed at PIT and the lateral travel distance. A more detailed analysis of this relationship will be addressed by the authors in a later study.

Conclusion

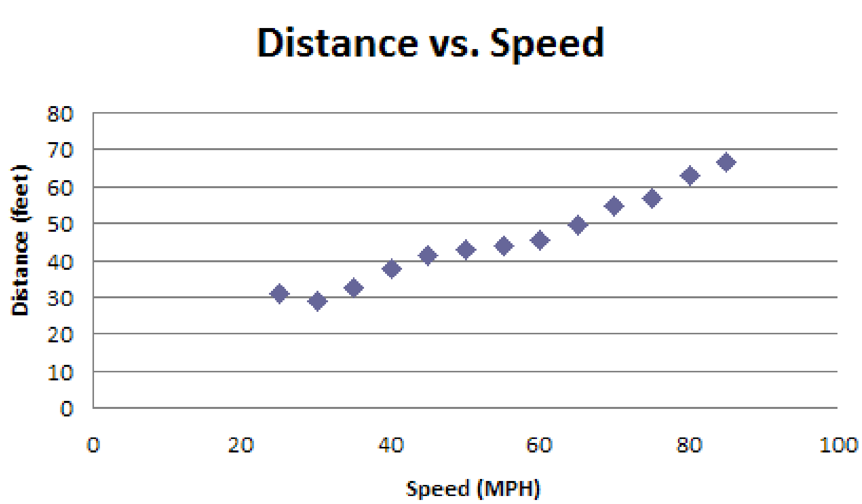
The questions posed at the beginning of this work are then answered. Even at speeds of 85 MPH, none of the PIT simulations resulted in the target vehicle overturning, even while traveling through a depressed dirt median with a compensated friction value. For a target vehicle to overturn, additional factors would be involved; tire pressure and condition, or a tripping mechanism such as a curb or secondary impact of a specific nature would be required for the speeds analyzed in this study.

There is an apparent relationship between the steer angle input and the amount of damage sustained by the pursuit vehicle. This was measured in damage depth in inches to the pursuit vehicle; this damage depth changed minimally for speeds up to 85 MPH. The simulations did not account for restitution in the damage area, and thus these damage values would likely be lower in a real-world crash.

The data examined and reported in this work highlight the importance of site selection on the part of the pursuing officer prior to initiating the PIT. If this is done, the PIT is a viable option to end pursuits at highway speeds, if done in accordance with state law and agency policy.

Speed (MPH)	Distance (feet)
25	30.88462
30	28.88571
35	32.54
40	37.54667
45	41.31333
50	42.69333
55	44.02933
60	45.50667
65	49.64667
70	54.88
75	56.84667
80	63.04533
85	66.8
(n = 190)	

Figure 6



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Synthetic Cannabinoids

Brandon Nabozny

Introduction

Over the past several years, and especially in 2010, officers from around the United States have seen an increase in the use of herbal marijuana alternatives such as “Spice” and “K2.” These herbal blends are marketed as incense and not for “human consumption.” However, in reality, these herbal blends contain synthetic chemicals designed to mimic the action of compounds found in marijuana.

The prevalence of these marijuana alternatives began in Europe around the mid 2000’s and naturally made their way into the United States thereafter. In May of 2010, The National Drug Intelligence Center issued a report saying “law enforcement officials in many areas of the country are reporting increasing use of synthetic cannabinoid products by teens and young adults as these products are widely available.” The report continues to state that the products are mainly produced internationally, but can be produced domestically. It also points out that synthetic cannabinoid products are widely available for purchase over the internet but many are available in “head shops” and similar stores. When asked, many patrol officers here in Arizona express that they have come in contact with this drug at one time or another.

History

Humans have been consuming marijuana for thousands of years. However, it was not until 1964 that Yachiel Gaoni and Raphael Mechoulam at Weizmann Institute of Science in Rehovot, Israel isolated the main psychoactive ingredient in marijuana named Δ9-tetrahydrocannabinol or Δ9-THC. With the discovery of Δ9-THC and other similar compounds came an increase in research into cannabis, its components, and its effects on the human body. Scientists began to focus their attention on what parts of the central nervous system THC affected and how these interaction correlated to the symptoms of marijuana use.

By the late 1980’s and early 1990’s, scientists had isolated two main receptors in the human body where Δ9-THC as well as other THC-like compounds bind and produce effects. In 1988, the CB_1 was isolated by a group of researchers at St. Louis University Medical School in conjunction with the Pfizer Research Group. Then, in 1993, two scientists at MRC Laboratory of Molecular Biology discovered CB_2. Although both receptors interact with the same class of chemicals found in marijuana, the two receptors are linked to very different functions in the human body. The CB_1 receptors, for example, are found in the brain and cause the characteristic effects of cannabis use. These effects include feelings of euphoria, relaxation, increased visual and auditory perception, and depression of motor activity. The CB_1 receptor is also found in the peripheral nervous system where it is responsible for stimulation of appetite, increased pulse, and vasodilatation (vasodilatation, or the widening of blood vessels, is most noticeable in the reddened conjunctiva of the eyes). The CB_2 receptor, on the other hand, is found outside of the central nervous system where binding to these receptors creates very different effects compared to the CB_1 receptor. This receptor is linked closely to the immune system and is involved in immunoresponse and pain relief.

Naturally, the discovery of these cannabinoid receptors has lead to numerous research initiatives. Many of these initiatives aim at investigating not only how these receptors operate, but also whether scientists can develop synthetic chemicals that bind and produce a desired effect. For quite some time, various research groups have been developing molecules that mimic some of the same effects ∆9-THC has on the CB_1 and CB_2 receptors. As with any scientific research, findings have to be published and shared with the rest of the scientific community. Once scientists such as John W. Huffman (JWH) or organizations like Hebrew University (HU) discovered molecules that would selectively bind to cannabinoid receptors they shared their findings with other scientists through scientific journal articles. These journal articles made information on synthetic cannabinoids very accessible. Since then, people have been able to recreate these designer drugs in underground laboratories, spray the drugs on plant material, and market them to the public. The challenge for law enforcement is that hundreds of synthetic cannabinoids have been discovered over the years. Many of these synthetic cannabinoids are structured in a way that allow for structural changes which produces a similar chemical called an analogue. Therefore, when law is passed controlling one chemical a change to the structure can make it legal again. In fact, in a U.S. patent issued for research compounds, scientists list not only 51 different synthetic cannabinoid analogs but also how each one is synthesized.

Effects on the Human Body

Both traditional cannabinoids found in marijuana and synthetic cannabinoids affect the same receptors in the human body. Therefore, it would not be surprising to find that they produce similar signs and symptoms. In an article published by the Journal of Mass Spectrometry, two researchers attempted to gain positive blood and urine samples by self-dosing with an herbal blend named “Spice Golden.” Both researchers noted symptoms similar to marijuana use. Effects included reddened conjunctiva, increased pulse rate, xerostomia (dry mouth) and an alteration in mood and perception. Their performance on psychomotor tests (not necessarily SFSTs) were normal, however both subjects noted they had the “impression of being moderately impaired.” Furthermore, at the 2010 DRE Conference in Pittsburgh, Dr. Barry Logan from NMS labs presented data from a DRE specific research study involving synthetic cannabinoids. In this study, six subjects were dosed with herbal blends containing the synthetic cannabinoids JWH-018, JWH-073, and CP47,497. The onset of effects began within 2-3 minutes post ingestion and included dry mouth, light headedness, blurred vision, agitation, and time dilation. During the SFST portion, researchers noted 3-4 inches of sway and leg tremors, loss of balance, and loss of coordination. DRE exams revealed an increase in pulse, an increase in blood pressure and lack of convergence. However, no HGN or VGN was noted, pupils remained normal, and muscle tone was normal.

While these drugs may cause some of the same signs and symptoms of cannabis use, it is important to keep in mind that some signs and symptoms may be diminished, some may be amplified, or they may be absent all together. The effects of synthetic cannabinoids can be very dangerous since some analogs are much more potent than cannabinoids found in marijuana. Many users have complained of severely high pulse rates, even to the point of tachycardia. Others have complained of severe agitation and hallucinations. More than likely, this is caused by the fact that some of the synthetic cannabinoids were designed to bind longer and more efficiently than ∆9-THC. This causes the effects to be amplified. This has public health officials and law enforcement concerned because there is no control over what type or what amount of synthetic cannabinoids are being added to these herbal blends.

Legislation

Since “Spice” and “K2” products first made their appearance in Europe, several countries there have attempted to outlaw many of the synthetic cannabinoid molecules. This has seen marginal success in controlling the drugs mainly because the molecular structures can be altered and made legal without losing their desired affect. In February 2010, Arizona Governor Jan Brewer signed into law Arizona House Bill 2167, making ten “Spice” compounds illegal under A.R.S. 13-3401. These include JWH-018, JWH-073, JWH-019, JWH-398, JWH-200, JWH-250, JWH-015, CP47,497, CP47,497 C8 homologue and any of their isomers. Also made illegal was the compound HU-210. Since there are many more synthetic cannabinoids than the ten that were scheduled, only time will tell whether producers will switch to using legal compounds or suspend production all together. A search of the internet suggests that many distributors are marketing what they claim to be legal herbal blends.

Laboratory capabilities

In March 2010, the Arizona Department of Public Safety Crime Laboratory issued an information bulletin detailing the lab's ability to analyze for synthetic cannabinoids. The Crime Lab suggests that officers submit all samples whether they are solid dose drug or a biological sample. Currently, the AZ DPS Controlled Substances Units are equipped to analyze solid dose items, such as plant material, for the newly controlled drugs. When a person is suspected of being under the influence of synthetic cannabinoids, the lab suggests submitting a biological sample as normal so the sample can be evaluated for all drugs. Since the analysis of synthetic cannabinoids in biological samples is new and complex, the lab is investigating the implementation of synthetic cannabinoid testing in blood and urine. However, the lab cannot currently test for these drugs in biological samples. If after complete analysis it is determined that synthetic cannabinoids may be the only drug on board, the sample may have to be sent to a private lab for testing.

NOTE: If you submit solid dose or biological samples to a lab besides DPS, please contact that lab for their capabilities concerning synthetic cannabinoid analysis.

***Notes on the author**: Brandon Nabozny is a Criminalist with the Toxicology Unit at the Arizona Department of Public Safety Central Regional Crime Laboratory in Phoenix. Brandon attended Arizona State University and received his Bachelor's of Science degree in biochemistry in 2006 and a Master's of Arts degree in criminal justice in 2010. He has successfully completed both HGN/SFST and DRE schools and in 2008 became a certified General Instructor. Brandon regularly instructs statewide on the field of toxicology and drug effects. Courses he has instructed include HGN/SFST School, DITEP, DRE School, and ARIDE. He has also been invited to instruct at HGN and DRE Instructor Schools. He has qualified as an expert witness in the field of toxicology in both superior and justice level courts.*

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Case Law and Legislative Updates

Beth Barnes

Case Law

DUI Jury Instructions

***State v. Miller,* 226 Ariz. 190, 245 P.3d 454 (App. 2011).** The Arizona Court of Appeals held the language of Revised Arizona Jury Instruction (RAJI) 28.1381(A)(1)-1 which states: "The crime of driving . . . while under the influence requires proof that . . . [t]he defendant's ability to drive a vehicle was impaired to the slightest degree by reason of being under the influence of intoxicating liquor" is improper because it could mislead a jury.

Facts:
Two defendants were charged with counts of aggravated DUI which required the state to prove they were "impaired to the slightest degree." In both cases, the trial judge indicated he would instruct the jury regarding the elements of aggravated DUI using RAJI 28.1383(A)(1)-1. The state filed special actions in the court of appeals challenging the ruling.

Holding and Analysis:
The state challenged the DUI jury instruction which was based on RAJI 28.1383(A)(1)-1 because the RAJI adds an additional element to § 28-1381(A)(1), requiring the state to prove a defendant's ability to drive was impaired instead of merely proving the defendant was impaired.

When granting relief, the court noted in A.R.S. § 28-1381(A)(1) the Arizona Legislature prohibited a person from driving or being in actual physical control of a vehicle while impaired to the slightest degree by intoxicating liquor. It did not require a finding that the person's ability to drive was impaired. The court held the additional language in RAJI 28.1381(A)(1)-1 could mislead a jury and is, accordingly, improper. "The jury could interpret it to require proof that the defendant's physical ability to drive was impaired as opposed to requiring only proof that the 'person' was impaired, for example, in judgment. The state need not offer evidence of bad driving to prove that a defendant is guilty of DUI. See § 28-1381(A)(1)." *Miller*, at 192 ¶10, 245 P.3d at 456.

The court cautioned the opinion did not examine or change substantive DUI law.

Officer Jury Duty/Selection

State v. Eddington, **226 Ariz. 72, 244 P.3d 76 (2011).** When a law enforcement officer is presently employed by the same department that conducted the investigation in a criminal case, the officer has "at a minimum, an indirect interest in the case and **must,** therefore be stricken for cause from a venire panel."

Facts: The defendant was charged with first degree murder based on an investigation conducted by the Pima County Sheriff's Department. During jury selection, a potential juror testified he was a Pima County sheriff's deputy and knew between one-third and one-half of the state's fourteen potential witnesses from the sheriff's department.

The defendant asked the trial court to strike the deputy for cause. The court denied the motion, noting the deputy repeatedly avowed he could be a fair and impartial juror and would not treat the testimony of law enforcement officers differently from that of any other witness. The defendant appealed.

Analysis and Holding: The court of appeals noted a peace officer is not automatically disqualified from serving as a juror. The court held, however, when a law enforcement officer is, at the time of jury service, employed by the same department that conducted the investigation in a criminal case, the officer has "at a minimum, an indirect interest in the case" and must be stricken for cause from the jury panel under A.R.S. § 21-211(2). That statute disqualifies a person from sitting on a jury if he or she is "interested directly or indirectly in the matter under investigation." [The court of appeals, affirmed the second degree murder conviction under harmless error review finding a fair and impartial jury was ultimately empanelled.]

REMINDER: A.R.S. § 21-202(B)(5) provides peace officers the right to be excused from jury service at their discretion upon application.

Right Turns From Private Drives

State v. Bouck, **225 Ariz. 527, 241 P.3d 524 (2010).** A right turn from a private driveway must be made into the lane closest to the curb. The failure to do so is a violation of A.R.S. § 28-751(1) and provides reasonable grounds for a stop.

Facts: The defendant was stopped in Gilbert for making an improper right turn from a private driveway into the middle lane of a three-lane public roadway in violation of A.R.S. § 28-751(1). As the officer approached the car, he noticed a faint odor of alcohol and the defendant's watery and bloodshot eyes. The defendant's blood test result was 0.198.

Defense counsel moved to suppress all evidence acquired as a result of the traffic stop arguing the defendant did not violate A.R.S. § 28-751(1) and the officer lacked reasonable suspicion for the stop. After the trial court denied the motion, the parties waived a jury trial and the defendant was found guilty of both counts of aggravated DUI.

Analysis and Holding: A.R.S. § 28-751(1) provides: "[b]oth the approach for a right turn and a right turn shall be made as close as practicable to the right-hand curb or edge of the roadway." The defendant asserted that because the statute specifies locations on a "roadway," it does not apply to vehicles turning from a private drive because a driveway is not a "roadway" (which A.R.S. § 28-601(21) defines to mean a "highway.") The court of appeals rejected this claim noting A.R.S. § 28-751(1) directs: "'[b]oth the approach for a right turn and a right turn' be 'made as close as practicable' to the right-hand side of the curb or roadway. Accordingly, when a driver turns from a driveway onto a roadway, the statute requires him/her to enter the roadway 'as close as practicable to the right-hand curb or edge of the roadway.'" *Bouck,* at 529 ¶8, 241 P.3d at 526.

The court of appeals also rejected the defense argument that A.R.S. § 28-856, which establishes stop-and-yield requirements for vehicles exiting alleys, driveways and buildings, controls cars turning from private driveways onto public roadways rather than § 28-751(1). The court acknowledged drivers must comply with both statutes. They must “yield the right-of-way to all closely approaching vehicles” as required by § 28-856(3) **and** turn into the lane closest to the right edge of the roadway as mandated by § 28-751(1).

NOTE: Though not the facts of *Bouck*, this case also supports the requirement that drivers turning into private drives make right turns from the curb lane. Right turns do not have to be at an intersection for A.R.S. § 28-751(1) to apply.

Crime Lab Testimony

***State v. Gomez,* 226 Ariz. 165, 244 P.3d 1163 (2010).** The Arizona Supreme Court held the Sixth Amendment Confrontation Clause is not violated when a testifying expert offers an opinion during trial on the similarity of DNA profiles prepared by criminalists who did not testify. This case should also have applicability to DUI blood and urine cases. For example, cases where: 1) the expert who conducted the analysis is not available and the state calls an expert who did not participate to provide his or her own opinion regarding the results, or 2) the state only calls one of several toxicologists who worked on the analysis.

FACTS: The lab used an “assembly line” method that employed seven steps for DNA testing. The state did not call all criminalists involved in the testing. Instead, a single witness testified. This included detailed testimony about the lab’s procedures, standards and safeguards. Although the testifying analyst had not observed each step in the process, she had checked the records for deviations from lab protocol. The analyst conducted the initial evidence screening and DNA extraction on most of the items and testified about the chain of custody for all items. For each sample, the analyst personally performed the final step in the process, interpretation and comparison. This was the only step involving human analysis.

The analyst gave her expert opinion that several profiles from evidence at the crime scene “matched” the profile from the defendant’s blood sample. The data from the testing process was not admitted into evidence as exhibits. The defense claimed that because the lab criminalists who generated DNA profiles did not testify, the analyst’s testimony violated the Confrontation Clause.

ANALYSIS AND HOLDING: The court recognized the analyst’s testimony about her role in the testing process, the lab’s procedures and the qualifications of the criminalists was not hearsay as it was based on the analyst’s personal knowledge.

Chain of custody

There were no chain of custody issues. The court observed the Confrontation Clause does not require every person in the chain be available for cross-examination. Only those who testify about the chain of custody must be available. Police officers testified the evidence was collected and sent to the lab. The analyst testified the evidence was received, processed, tested, and returned. The expert testified from her own knowledge not only about the lab’s general procedures, but also about the records kept by the lab in this specific case.

Defendant's inability to cross-examine the criminalists

The defendant claimed his inability to cross-examine the criminalists deprived him of his confrontation rights with respect to the expert’s testimony about the profiles. The court noted the DNA profiles "are in effect statements of the processing machine about the data contained in the samples." They contain neither the opinion nor the statement of the criminalists. The issue was whether the Confrontation Clause was satisfied when the analyst, rather than all criminalists, was available for cross-examination because the machine cannot be cross-examined.

The analyst reviewed the work of all the criminalists, testified from her own knowledge about the procedures and answered questions during cross-examination about the accuracy of the results. The analyst’s testimony, therefore, did not violate the Confrontation Clause.

The testifying analyst's expert opinion

The court relied on the line of cases holding the Confrontation Clause is not violated when an expert bases testimony on data prepared by analysts who are not subject to cross-examination as long as the testifying expert forms **his or her own opinion** based on the data. The expert cannot merely act as a "conduit" for the opinion of others. *See, State v. Snelling,* 225 Ariz. 182, 236 P.3d 409 (2010) and *State v. Smith,* 215 Ariz. 221, 159 P.3d 531(2007).

The defendant's confrontation right extends only to the testifying witness.

The testifying expert in this case was available and confronted through cross-examination about her independent conclusion that several of the DNA profiles were from the defendant. The analyst's reliance on data obtained from non-testifying criminalists in forming her opinion did not violate the Confrontation Clause.

Out of State Case of Interest

Law Enforcement Phlebotomy (Texas)

State v. Johnson, No. PD-1736-09 (TX 2011) is the first published opinion addressing Law Enforcement Phlebotomy that is not from Arizona. Like our courts in Arizona, the Texas court held the draw in this case was reasonable under the Fourth Amendment under both tests (reasonableness of the test chosen and reasonableness of the manner of performance.) The court rejected the defense argument that all police draws conducted in a non-medical environment are prohibited by the US Supreme Court's *Schmerber* opinion.

In support of the Texas blood draw, the court cited to both *Noceo* and *May*, the two Arizona phlebotomy opinions. The Texas opinion also mentions the Arizona Law Enforcement Phlebotomy Program. While this opinion is not precedent in Arizona, it is good to see Law Enforcement Phlebotomy gaining legal support and withstanding defense challenges in other portions of the country.

Legislative Updates

HB 2167: "Spice"/Synthetic Marijuana

House Bill 2167 addresses "Spice" a synthetic form of marijuana which is sold locally under the names Serenity Now, K2, Thai Dream, and Sky, among others. This bill added the ten most common versions of Spice to A.R.S. 13-3401. (There are more than 100 known versions.) The bill was signed with an emergency clause, making it effective on February 22, 2011.

The addition of these compounds to A.R.S. § 13-3401 will make it illegal for a person to drive with the substance in his/her system. The compounds are:

1-pentyl-3-(naphthoyl)indole (JWH-018 and isomers).

1-butyl-3-(naphthoyl)indole (JWH-073 and isomers).

1-hexyl-3-(naphthoyl)indole (JWH-019 and isomers).

1-pentyl-3-(4-chloro naphthoyl)indole (JWH-398 and isomers).

1-(2-(4-(morpholinyl)ethyl))-3-(naphthoyl)indole (JWH-200 and isomers).

1-pentyl-3-(methoxyphenylacetyl)indole (JWH-250 and isomers).

(2-methyl-1-propyl-1h-indol-3-yl)-1-naphthalenyl-methanone (JWH-015 and isomers).

(6ar,10ar)-9-(hydroxymethyl)-6,6-dimethyl-3-(2-methyloctan2-yl)-6a,7,10,10a-tetrahydrobenzo[c]chromen-1-ol) (hu-210).

5-(1,1-dimethylheptyl)-2-(3-hydroxycyclohexyl)-phenol (cp 47,497 and isomers).

5-(1,1-dimethyloctyl)-2-(3-hydroxycyclohexyl)-phenol (cannabicyclohexanol, cp-47,497 c8 homologue and isomers).

A copy of HB 2167 is available online at: http://www.azleg.gov/FormatDocument.asp?inDoc=/legtext/50leg/1r/bills/hb2167h.htm

Presently Arizona crime labs cannot test for these synthetic forms of marijuana in either blood or urine. Some labs, including DPS and the City of Phoenix, can test the actual packaged substance and verify it is Spice and specifically that the substance is one of the ten varieties of Spice listed in A.R.S. § 13-3401. Only two out of state labs have the current capability to test for synthetic marijuana in either blood or urine.

Because Arizona labs cannot test for Spice at the present time, please note: according to Chuck Hayes DEC Regional Coordinator for IACP, Spice is included in the cannabis DRE drug category. If a DRE officer suspects Spice/synthetic marijuana and calls cannabis, a negative tox result would not be inconsistent with this finding on the part of the officer, nor is it a miss. In fact, we would expect a negative tox result. According to Mr. Hayes, the officer should note in his/her log that the lab is incapable of testing for Spice rather than indicating the lab results verified or did not verify the opinion of the DRE officer.

The case would need to be reviewed for signs and symptoms of impairment and prosecuted under A.R.S. § 28-1381(A)(1) the DUI impairment statute. The officer may need to inform the prosecutor's office of the fact that the lab cannot test for spice and a negative results is not a "miss."

Medical Marijuana and DUI Cases

The medical marijuana provisions were effective as of December 15, 2010 and can be found in A.R.S. §§ 36-2801 thru 36-2819. The Arizona Department of Health Services has until April 16, 2011 to finalize the rules and regulations for implementing the statutes.

In general, the medical marijuana provisions permit: 1) physician approved use of marijuana by registered patients with debilitating medical conditions such as: cancer, glaucoma, HIV, AIDS, hepatitis C, MS; 2) registered individuals to grow limited amounts of marijuana in an enclosed, locked facility; 3) registered patients and primary caregivers to assert medical reasons for using marijuana as a defense to most prosecutions involving marijuana.

The following are specifically prohibited: 1) possessing or engaging in the medical use of marijuana on a school bus, on the grounds of any preschool, primary, or secondary school, in any correctional facility; 2) smoking marijuana in any public place, on any form of public transportation; 3) any use by a person who has no serious or debilitating medical condition.

Specific to DUI cases the medical marijuana provisions should not impede law enforcement's ability to cite those under the influence of marijuana under either A.R.S. §§ 28-1381(A)(1) or (A)(3).

A.R.S. § 36-2082 does not authorize and does not prevent any civil, criminal or other penalties for:

> D. Operating . . . or being in APC of any motor vehicle . . . while **under the influence of marijuana,** except that a registered qualifying patient shall not be considered to be under the influence of marijuana solely because of the presence of metabolites or components of marijuana that appear in **insufficient concentration to cause impairment**."

(Emphasis added.)

This provision is consistent with A.R.S. § 28-1381(A)(1) which makes it a violation to drive or be in APC of a vehicle while under the influence of any drug including marijuana while impaired to the slightest degree. Even though the medical marijuana provisions provide that a qualified person is not considered to be under the influence of marijuana solely due to the presence of metabolites that are in insufficient concentration to cause impairment, the Arizona DUI impairment statute already requires the state to prove impairment to the slightest degree. Unlike the .08 DUI statute, the medical marijuana statute A.R.S. § 36-2982(D) does not state a specific amount of the drug must be present. Additionally, A.R.S. § 28-1381 (B) provides: "It is not a defense to a charge of . . . [28-1381(A)(1)] that the person is or has been entitled to use the drug under the laws of this state."

Likewise, the medical marijuana provisions should not prevent prosecution under the A.R.S. § 28-1381(A)(3) DUI per se drug statute. That provision holds that a person cannot drive (operate) or be in actual physical control of a vehicle while there is any drug, including marijuana, defined in 13-3401 or its metabolite in the person's body.

It is true that A.R.S. § 28-1381(D) provides that a person using a drug as prescribed by a medical practitioner is not guilty of violating A.R.S. § 28-1381(A)(3), however, marijuana is a Schedule I drug. Physicians cannot prescribe Schedule I drugs. The medical marijuana statutes do not provide for patients to be given prescriptions for medical marijuana. They are given a written certification. Accordingly, A.R.S. § 28-1381(D) should not provide a defense.

This is a very brief description of the argument supporting the DUI statutes.

If you have further inquiries, please contact GOHS Arizona TSRP Beth Barnes.

Drug Use, Out of the Mouth of Babes

Jessica Smith

In a disturbing national trend of marijuana use among eighth, tenth, and twelfth graders, a new government survey found it to be the most widely-used illicit drug by teens today, beating out cigarette smoking.

According to statistics released from the 2010 Monitoring the Future Survey (MTF), which assesses drug and alcohol use among American youth, the rate of high school seniors who used marijuana rose by 10 percent or more over the last year.

Dr. Nora D. Volkow, director of the National Institute on Drug Abuse (NIDA), stated, "These high rates of marijuana use during the teen and pre-teen years, when the brain continues to develop, place our young people at particular risk. . . . "Not only does marijuana affect learning, judgment, and motor skills, but research tells us that about 1 in 6 people who start using it as adolescents become addicted."

With the recent passage of Proposition 203, we fully expect teen attitudes and perceptions of harmfulness concerning marijuana smoking to decrease. In youth education presentations, marijuana seems to be the only drug, alcohol included, that youth want to debate against the harmful effects. In most instances, we find that youth beliefs on marijuana use are based on false information, which is no surprise to those in prevention. Comments from youth on marijuana use include: “It’s medicine, the government just wants to keep it illegal so it does not replace big pharma.” “It does not have any harmful effects when smoked, unlike cigarettes.” “It’s better for you than alcohol.” “You cannot become physically addicted to marijuana.” “People who smoke marijuana are less of a risk on the roadways; they don’t speed, in fact, most of the time they don’t even want to get off the couch.” These are just a few of the comments that we repeatedly hear from youth, clearly showing that perceptions of harmfulness already are greatly diminished.

States that have already legalized marijuana for “medicinal” purposes are seeing the effects: they have among the highest addiction rates in the nation and rank at the bottom of the nation as far as the perception of harm by 12-17 year olds. According to experts, national interest in “medical” marijuana and its legalization may be responsible for its rise in teenage use.

It’s important to note that the Food and Drug Administration (FDA) and the National Institute on Drug Abuse (NIDA) agree that smoked marijuana has no currently accepted medical value. In fact, marijuana is a Schedule I drug under the Controlled Substances Act because it has no medical value, can be addictive and can’t be used safely even under a doctor’s supervision.

It has yet to be seen the effect passage of Prop 203 will have on youth drug trends in Arizona, but one thing is for certain – we as adults need to educate our children and expose the truth behind drug use.

Jessica Smith serves as the Arizona State Coordinator for Students Against Drunk Driving.

Law Enforcement Motorcycle Helmet Safety: Three Quarter Vs. Modular Full Face Helmets

Carrick Cook

For years, motor officers have been wearing a helmet that is referred to as a three-quarter open face helmet. This helmet provides protection to the rider's head and maintains the ability to contact citizens without interference from a chin bar or visor. The three-quarter open face helmet has been used for decades and has established itself as tradition. With new materials and technology there have been questions as to whether or not officers should be restricted to only wearing a three-quarter open face helmet, or is there sufficient safety data to suggest officers would benefit from a full face design. Is the modular full face helmet substantially safer than a three-quarter open face helmet?

This article will compare the safety benefits of the modular full face helmet as compared to the three-quarter open face helmet. This work will compare research data from two separate studies relating to motorcycle collisions, correlations between the research data and head injuries, as well as government compliance testing data. The government compliance testing data used is specific to the Shoei Multi-Tec modular helmet and the Arai Classic three-quarter face helmet. This work will evaluate, based on scientifically gathered data, the questions above.

A study and subsequent report entitled Motorcycle Accident Cause Factors and Identification of Countermeasures authored by Hurt, Ouellet and Thom was published in 1981. It examined the significant causation factors for motorcycle collisions. This work is commonly referred to as the "Hurt Study".

The study consisted of at-scene investigations of 900 motorcycle collisions and an additional review of 3600 motorcycle collisions, all in the Los Angeles, California area. The study attempted to measure all quantifiable causation factors, such as helmet use, vision impairment, use of alcohol, and many more. Parts of the study relevant to a comparison of three-quarter open face helmets and modular full face helmets are discussed in detail below.

One significant finding of the Hurt Study was, "The increased coverage of the full facial coverage helmet increased protection, and significantly reduces face injuries" (Hurt, 1981, p. 429). This finding indicates a potential safety benefit from the use of a full face modular helmet versus a three-quarters face open helmet design.

The Hurt Study also concluded, "Intersections are the most likely place for a motorcycle collision with the other vehicle violating the motorcycles right of way and often violating traffic controls" (Hurt, 1981, p. 426). The dynamics of an intersection are often complex with vehicles turning in many directions. The Hurt Study found the most likely type of motorcycle collision was a vehicle turning left in front of a motorcycle (Hurt, 1981, p. 426). This collision mechanism potentially leaves a rider's unprotected face vulnerable to an impact with another vehicle.

Hurt found, "The typical motorcycle pre-crash lines-of-sight to the traffic hazard portray no contribution of the limits of peripheral vision; more than three-fourths of all accident hazards are within 45 degrees of either side of straight ahead" (Hurt, 1981, p. 427). This conclusion showed the majority of motorcycle collisions occurred in front of the rider and peripheral vision was not a factor in most crashes. The Hurt Study determined that, "Seventy-three percent of the accident-involved motorcycle riders used no eye protection, and it is likely that the wind on the unprotected eyes contributed in impairment of vision which delayed hazard detection" (Hurt, 1981, p. 428). The three-quarter open face helmet offers little protection from wind and can lead to the wind impairing the vision of the rider. The modular full-face helmet offers full protection from the wind and other hazards such as debris.

The Hurt Study concluded, "The use of the safety helmet is the single critical factor in the prevention or reduction of head injury; the safety helmet which complies with Federal Motor Vehicle Safety Standards (FMVSS) 218 is a significantly effective injury countermeasure" (Hurt, 1981, p. 429). This finding is particularly important because it supports the U.S. Department of Transportation's (DOT) Standard, FMVSS 218. The FMVSS 218 standard includes testing in four different types of weather conditions and a total of 32 impacts on each tested helmet. Hurt further stated, "Safety helmet use caused no attenuation of critical traffic sounds, no limitation of pre-crash visual field, and no fatigue or loss of attention; no element of accident causation was related to helmet use" (Hurt, 1981, p. 429). During The Hurt Study, partial, three-quarter and full face helmets were involved during the study and the full face helmets showed no limitation of the rider's visual field or loss of hearing. A significant Hurt Study finding was, "The increased coverage of the full facial coverage helmet increased protection, and significantly reduces face injuries" (Hurt, 1981, p. 429).

In 2001 the European Co-operation in the Field of Science and Technical Research funded a research project better known as COST 327. Their objective was to determine the distribution and severity of injuries experienced by motorcycle riders during a collision, identify the most significant injury mechanisms, and determine the tolerance of the human head, brain, and neck. The results would be used to propose a specification for future testing of motorcycle helmets in Europe.

Cost 327 investigated 253 motorcycle related collisions; 35 in Finland, 166 in Germany, 52 in the United Kingdom. The investigation results showed a significant amount of impacts to the riders face, chin and head where the three-quarter face helmet offered no protection (Cost, 2001, p. 45). Cost 327 determined that 15.4 percent of the impacts were on the chin guard of the rider's helmet (Cost 327, 2001, p. 44). This finding is consistent with the Hurt Study in that it came to the same conclusion that the likelihood of an injury occurring to a rider's face in a collision is high.

An overview of the Abbreviated Injury Scale (AIS) is included in this work as it is needed and useful in relating test data for varying motorcycle helmets (discussed later) to injuries due to force during a collision. This grading system for injuries was established by The Association for Advancement of Automotive Medicine (AAAM) and is an internationally recognized scale of injuries. The AIS scale is graded as 1 being minor and 6 being untreatable by current technology (AAAM, 1990).

The following is the AIS as it relates to G forces allowed to the brain (Lippincott, Williams & Wilkins, 2006);

AIS 0 = <50 G's

AIS 1 = 50-100 G's

AIS 2 = 100-150 G's

AIS 3 = 150-200 G's

AIS 4 = 200-250 G's

AIS 5 = 250-300 G's

AIS 6 = >300 G's

The following comparison of the Shoei Multi-Tec Modular Full Face Helmet and the Arai Classic used the Safety Compliance Testing for FMVSS No. 218 reports completed by the Southwest Research Institute in San Antonio, Texas, and the SGS U.S. Testing Company Inc. in Fairfield, New Jersey. The Arai Classic Helmet was tested on October 4th, 2009, at the Southwest Research Institute (NHTSA 218-SRI-09-017); the Shoei Multi-Tec was tested on August 6th, 2007, at the SGS U.S. Testing Company Inc. (NHTSA 218-UST-07-013). The average amount of G forces to reach the rider's head during the DOT testing of the Arai Classic was 175.25 and was calculated by the report's author. This would potentially equate to an AIS 3. The average amount of G forces to reach the riders head during the DOT testing of the Shoei Multi-Tec was 133.25 and was calculated by the report's author. This would potentially equate to an AIS 2. This comparison demonstrates the ability of this particular full face helmet, the Shoei Multi-Tec, to better protect the rider's head.

The Hurt and Cost 327 Studies' findings and conclusions are consistent with the premise that a helmet providing more facial protection will result in lesser injuries to the rider.

The Arai Classic, and other helmets similar in design, have been used by law enforcement agencies for some time in the United States and would be considered a good representation of the traditional three-quarter face helmet. The Shoei Multi-Tec is also used by law enforcement, especially of late. Both the Hurt and Cost 327 studies show that injuries do occur in the areas of the head unprotected by the three-quarter face helmet. Also, the DOT compliance testing shows a significantly less amount of G forces transferred to the rider's head when a modular helmet was worn as opposed to the three-quarter helmet. This reduction in G forces potentially reduces the amount of injury sustained by the rider in a collision. The studies and conclusions cited in this work are clearly consistent with an increased level of safety for officers wearing full-faced modular helmets.

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Article Submission Requirements and Protocols

Editorial Staff

The Arizona Police Science Journal publishes peer-reviewed scientific papers and works significant and relevant to the law enforcement community. APSJ also publishes editorials and training articles that, while based on science or relevant to science, may not include new scientific research or theories. The goal of APSJ is to provide a combination of works written by well-renowned and credible authors, as well as prosecutors, criminalists, officers and engineers who may be new to the writing process, but have relevant and important information to share.

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The editorial staff is committed to providing quality training and information that is timely. Papers or work submitted to the editorial staff undergo a strict review process starting with the editors. Selected papers are then sent to experts or peers for a double blind, independent peer review process. If there are revisions, corrections or comments from the peer-reviewers, the editorial staff then coordinates between the author and the reviewers until a final work product is completed. The papers are then again peer-reviewed by experts and the APSJ Advisory Board for accuracy and quality. Only then will the articles be published.

Any submissions should be made electronically to facilitate the rigorous review process and level of quality a publication such as this demands. Authors should submit their work in Microsoft Word in a easy to read and standard format, accompanied by any images or photographs, also in a standard format. The submitted work should include a title page with the author's name, address, phone and email contact information. If the paper is of a highly specialized nature, the author may submit a list of at least three persons with the credentials and experience necessary to be qualified as peer-reviewers. The work must also include an abstract and a very short biography or "Author's Note".

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Arizona Police Science Journal

A publication of the Arizona Governor's Office of Highway Safety

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