**IN THE SUPREME COURT OF THE STATE OF NEVADA**

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| JAPONICA GLOVER-ARMONT,<br><br>APPELLANT,<br><br>VS.<br><br>JOHN CARGILE; CITY OF NORTH LAS VEGAS, A MUNICIPAL CORPORATION EXISTING UNDER THE LAWS OF THE STATE OF NEVADA IN THE COUNTY OF CLARK;<br>RESPONDENTS. | CASE NO.: 70988 |

APPEAL FROM ORDER GRANTING RECONSIDERATION OF DEFENDANTS' MOTION FOR SUMMARY JUDGMENT
AND
APPEAL FROM ORDER GRANTING SUMMARY JUDGMENT
EIGHTH JUDICIAL DISTRICT COURT, CLARK COUNTY, NEVADA
HONORABLE WILLIAM KEPHART, DISTRICT JUDGE

# APPELLANT'S APPENDIX


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Docket 70988 Document 2017-17163

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CLERK OF THE COURT

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**DISTRICT COURT**

**CLARK COUNTY, NEVADA**

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|---|---|
| JAPONICA GLOVER-ARMONT,<br><br>Plaintiff,<br><br>vs.<br><br>JOHN CARGILE; CITY OF NORTH LAS VEGAS, a Municipal Corporation existing under the laws of the State of Nevada in the County of Clark; DOES I through X, inclusive; and/or ROE CORPORATIONS I through X, inclusive,<br><br>Defendants. | Case No. A-13-683211-C<br><br>Dept. No. XIX<br><br>**DEFENDANTS' MOTION FOR SUMMARY JUDGMENT**<br><br>**Hearing date:**<br>**Hearing time:** |

Defendants City of North Las Vegas (the "City") and Sergeant John Cargile ("Sergeant Cargile") (collectively "City Defendants"), by and through their attorneys, hereby move for summary judgment on all claims against the City Defendants pursuant to Nev. R. Civ. P. 56(c). This Motion

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is made and based upon the following points and authorities, the papers and pleadings on file, and any argument the Court may entertain at any hearing of this matter.

DATED this 22nd day of December, 2015.

NORTH LAS VEGAS CITY ATTORNEY

*/s/ Christopher D. Craft*
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*John Cargile and City of North Las Vegas*

**NOTICE OF MOTION**

TO: ALL INTERESTED PARTIES:

PLEASE TAKE NOTICE that the undersigned will bring the above motion on for hearing in Department XIX of the above-entitled court on the 2 day of Feb., 2016, at the hour of 9:00am, or as soon thereafter as counsel may be heard.

DATED this 22nd day of December, 2015.

NORTH LAS VEGAS CITY ATTORNEY

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**POINTS AND AUTHORITIES**

**I.**

**INTRODUCTION**

Plaintiff has brought negligence claims against the City of North Las Vegas and one of its police officers based on an automobile accident. The substance of Plaintiff's Complaint is that the City's police officer was negligent by entering an intersection against a red light, causing a collision with Plaintiff's vehicle. However, the officer in question was in the act of responding to a call of shots fired and, using his judgment and discretion, decided to enter the intersection despite the red light. As the decision by the officer was his exercise or performance of a discretionary function or duty, in furtherance of a public policy, both the City and the officer are immune from liability pursuant to NRS 41.032(2). Summary judgment is appropriate.

## II.

## FACTUAL AND PROCEDURAL BACKGROUND

On November 5, 2012, at approximately 1:50 a.m., Plaintiff Japonica Glover-Armont ("Plaintiff") was driving eastbound on Cheyenne approaching the intersection of 5th Street in North Las Vegas. At the same time, Sergeant Cargile was driving northbound on 5th Street toward the same intersection. Sergeant Cargile was responding to a call of a fight and that shots had been fired at an apartment complex in North Las Vegas, and he was attempting to respond to the call.[1] His decision to take this particular route was based on it being the quickest from where he was located to the scene of the call, taking into account traffic conditions and levels of civilian traffic.[2] It is undisputed that when he approached the intersection, his emergency lights were activated.[3] Unfortunately, due to the lay of the land at the intersection (a large hill is built up at the southwest corner of the intersection), visibility of oncoming eastbound traffic on Cheyenne, from Sergeant Cargile's position, was very limited; essentially, it was impossible for Sergeant Cargile to determine whether any vehicles were approaching the intersection from the west without pulling "a couple of feet" into the intersection.[4] When Sergeant Cargile's vehicle entered the intersection, partially blocking Plaintiff's

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[1] Deposition of John Cargile, October 1, 2014 ("Cargile Deposition"), at 33:18 - 34:6. Excerpts of the deposition are attached hereto as Exhibit A.

[2] Cargile Deposition at 30:2 - 31:19.

[3] Deposition of Japonica Glover-Armont ("Glover-Armont Deposition"), August 7, 2014, at 22:8 - 16. Excerpts of the deposition are attached hereto as Exhibit B.

[4] As Plaintiff put it, "So I'm heading east, he's heading north, so I couldn't see him, and he couldn't see me. He couldn't have seen me because of the hill." Glover-Armont Deposition at 26:3 - 6.

lane, Plaintiff applied her brakes and skidded toward the intersection. A collision between the vehicles resulted.[5] Plaintiff filed her Complaint in this matter, asserting claims against Sergeant Cargile and the City, on June 10, 2013.

## III.

## ARGUMENT

### A. Legal Standard

In Wood v. Safeway, Inc., 121 Nev. 724, 731, 121 P.3d 1026, 1031 (2005), the Nevada Supreme Court ruled that "[s]ummary judgment is appropriate under NRCP 56 when the pleadings, depositions, answers to interrogatories, admissions, and affidavits, if any, that are properly before the court demonstrate that no genuine issue of material fact exists, and the moving party is entitled to judgment as a matter of law. The Court held that the "nonmoving party must, by affidavit or otherwise, set forth specific facts demonstrating the existence of a genuine issue for trial or have summary judgment entered against him." Id. The Court reasoned that "[w]hile the pleadings and other proof must be construed in a light most favorable to the nonmoving party, that party bears the burden to do more than simply show that there is some metaphysical doubt as to the operative facts in order to avoid summary judgment being entered in the moving party's favor." Id. "The nonmoving party is not entitled to build a case on the gossamer threads of whimsy, speculation, and conjecture." Id.

### B. Pursuant to NRS 41.032(2), Defendants are entitled to immunity because Sergeant Cargile's decision to enter the intersection was a discretionary act.

*1. Under Nevada law, discretionary immunity is broadly construed.*

City Defendants are entitled to discretionary immunity pursuant to 41.032(2). In Martinez v. Maruszczak, 168 P.3d 720, 726 (Nev. 2007), the Nevada Supreme Court held that NRS 41.032(2) "provides complete immunity from claims based on a state employee's exercise or performance of a discretionary function or duty. . . ." NRS 41.032(2) states that "no action may be brought under NRS 41.031" which is "[b]ased upon the exercise or performance or the failure to exercise or perform a discretionary function or duty on the part of the State or any of its agencies or political subdivisions

[5] Cargile Deposition at 40:8 - 41:10, 46:5 - 23.

or of any officer, employee or immune contractor of any of these, whether or not the discretion involved is abused." In interpreting this statute the Court in Martinez adopted the two-part Berkovitz-Gaubert test used under the Federal Tort Claims Act ("FTCA"). Id. at 728-29 (citing Berkovitz v. United States, 486 U.S. 531, 536-37 (1988) and United States v. Gaubert, U.S. 315, 322 (1991)). To qualify for discretionary immunity, "a decision must (1) involve an element of individual judgment or choice and (2) be based on considerations of social, economic, or political policy." Martinez v. Maruszczak, 123 Nev. 433, 439, 446–47, 168 P.3d 720, 724, 729 (2007)." The Court elaborated that "The focus on the second criterion's inquiry is not on the employee's subjective intent in exercising the discretion conferred by statute or regulation, but on the nature of the actions taken and on whether they are susceptible to policy analysis. Thus, the court need not determine that a government employee made a conscious decision regarding policy considerations in order to satisfy the test's second criterion." Id. "A discretionary act requires personal deliberation, decision, and judgment." Herrera v. Las Vegas Metropolitan Police Dept., 298 F.Supp.2d 1043, 1054 (D.Nev. 2004).

The Nevada Supreme Court has broadly applied the discretionary immunity test set forth in Martinez in cases involving police officers or other government officers deciding how to perform their duties. In Ransdell v. Clark County, 192 P.3d 756, 759-63 (Nev. 2008), the plaintiff challenged code enforcement efforts by Clark County, which had determined that plaintiff's residence, which had essentially become a junkyard, was in violation of several provisions of the Clark County Code. The Nevada Supreme Court, using the Martinez test, held that Clark County was entitled to discretionary immunity from state law claims involving the application for and execution of a "seizure warrant" because the county's officers were required "to use their own judgment and conduct individual assessment of the conditions on [a homeowner's] property to determine if abatement was required under the Clark County Code" and "strong public policy considerations related to public health safety, and welfare are associated with abatement procedures generally." Plaintiff's claims against the County were dismissed.

Similarly, in Bryan v. Las Vegas Metropolitan Police Dept., No. 08-15992, 2009 WL 3249742 at *2 (9th Cir. Oct. 7, 2009),[6] plaintiff brought a variety of claims, including state law claims, against LVMPD officers after they entered his apartment and shot him. The District Court found that the municipality and its officers were entitled to discretionary immunity under NRS 41.032 because "the scope and manner in which the agency conducts an investigation" involve discretionary decisions that "(1) [involve] an element of individual judgment or choice and (2) [are] based on considerations of social, economic, or political policy"). Specifically, the court stated that the actions of the individual officers were protected under Nev.Rev.Stat. § 41.032, "as their handling of the confrontation with Austin Bryan led to discretionary decisions that "were concerning the scope and manner in which [the agency] conducts an investigation," and were "based on the policies of the METRO police." Id. Furthermore, claims against the LVMPD for negligent hiring, training and supervision were also dismissed based on discretionary immunity. The court explained as follows:

> Our court has held that "decisions relating to the hiring, training, and supervision of employees usually involve policy judgments of the type Congress intended the discretionary function exception to shield." Vickers v. United States, 228 F.3d 944, 950 (9th Cir.2000). Because Nevada looks to federal case law to determine the scope of discretionary immunity, and because federal case law consistently holds that training and supervision are acts entitled to such immunity, METRO police is entitled to discretionary immunity on this claim.

Id. Again, where an officer uses his judgment for a course of action, and that action is related to a government policy, the officer is immune from negligence claims arising out of those actions.

Two recent cases, though unpublished, are demonstrative of the Nevada Supreme Court's application of discretionary immunity to police actions. In Gonzalez v. Las Vegas Metropolitan Police Department, 2013 WL 7158415 (2013), plaintiff brought suit for wrongful imprisonment when LVMPD officers mistook him for a suspect and arrested him. LVMPD was found to have discretionary immunity because "arresting Gonzalez pursuant to a facially valid warrant involved an element of individual judgment or choice regarding the scope of its treatment of Gonzalez," and the arrest was "part of a policy consideration that required analysis of multiple social, economic, efficiency, and planning concerns including public safety." Id. at 2-3. Similarly, in Seiffert v. City of Reno, 2014 WL 605863 (2014), plaintiff brought suit for negligence when police tape at a crime

[6] A copy of the decision is attached hereto as Exhibit C.

scene caused him to crash his bicycle. The Nevada Supreme Court found the city enjoyed discretionary immunity, because the placement of the tape required the officer to use his judgment, and was done in furtherance of public policy (specifically, policies of public safety and preserving evidence).[7]

Simply put, in Nevada, discretionary immunity will apply whenever (1) a government officer makes a decision or uses judgment, and (2) his action is related to any government policy. While discretionary immunity was once deemed to only apply at the operational level (i.e. legislative decisions on policy), the above cases show that it now is applied to ground level decisions. As long as the officer involved is making a choice or judgment, and the actions involved are related to a policy, the officer undertaking those actions will be immune from negligence claims.

### <u>2. *Discretionary immunity applies to police officers proceeding through a red light while responding to a call.*</u>

Numerous courts have applied discretionary immunity to instances of a police officer or other government personnel responding to an emergency. Though the immunity goes by different names (such as official immunity, sovereign immunity, etc.), the common thread to all such instances is that when an officer is responding to an emergency, and the officer is required to make decisions or use independent judgment, immunity is granted for any accidents which occur during the officer's response. Simply put, we do not want our emergency responders hesitating to act based on a fear that they may be held liable should anything go wrong.

In <u>Vassallo ex rel. Brown v. Majeski</u>, 842 N.W.2d 456 (Minn. 2014), a police officer proceeded through a red light while responding to an emergency call, and collided with plaintiff's vehicle. The trial court found, and the Minnesota Supreme Court affirmed, that the officer was engaged in a discretionary function and therefore was entitled to official immunity. <u>Id.</u> at 463. At issue in the case was whether the officer's compliance with Minn.Stat. § 169.03,[8] Minnesota's statute

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[7] Copies of the <u>Gonzalez</u> and <u>Seiffert</u> decisions are attached as Exhibits D and E. As unpublished decisions, <u>Gonzalez</u> and <u>Seiffert</u> do not have precedential bearing on this case.

[8] The parallel Nevada statute is NRS 484B.700, which permits emergency vehicles to "Proceed past a red or stop signal or stop sign, but only after slowing down as may be necessary for safe operation."

that requires an emergency vehicle to "slow down as necessary for safety" was discretionary or ministerial. As the court explained,

> The requirement that the driver of an authorized emergency vehicle shall slow down as necessary for safety, plainly does not impose an absolute duty upon the driver of an emergency vehicle to slow down in every situation upon approaching a red or 'Stop' signal or stop sign. Rather, the requirement is conditioned on the driver's, in this case Deputy Majeski's, determination of the level of speed appropriate for safety under the circumstances. **This is a textbook example of the exercise of discretion: the policy set out in the statute requires individual professional judgment that necessarily reflects the professional goal and factors of a situation, and is therefore discretionary.** Likewise, the duty to "proceed cautiously," as used in this statute, "means to go forward in the exercise of due care to avoid a collision." A requirement to use due care also calls for the exercise of independent judgment and is not absolute, certain, and imperative, involving merely the execution of a specific duty arising from fixed and designated facts.

Id. Because the officer exercised his judgment in what was appropriate "due care" while proceeding through the red light, his actions were discretionary, and both he and the city were immune from plaintiff's negligence claims.

In Colby v. Boyden, 400 S.E.2d 184 (Va. 1991), a Virginia Beach police officer was in pursuit of a driver who had run a red light. Attempting to flee the officer, the driver ran another red light, and the officer followed, running the red light as well, which resulted in a collision with plaintiff. The Virginia Supreme Court held that a police officer who was involved in an accident when he went through a red light while pursuing another vehicle was entitled to sovereign immunity:

> [A] police officer, engaged in the delicate, dangerous, and potentially deadly job of vehicular pursuit, must make prompt, original, and crucial decisions in a highly stressful situation. Unlike the driver in routine traffic, the officer must make difficult judgments about the best means of effectuating the governmental purpose by embracing special risks in an emergency situation. Such situations involve necessarily discretionary, split-second decisions balancing grave personal risks, public safety concerns, and the need to achieve the governmental objective. The exercise of discretion is involved even in the initial decision to undertake the pursuit[.]

Id. at 129-130. Because the response of the officer, in attempting to apprehend a dangerous driver, required decisions on the part of the officer, he was immune from liability.

In Terrell v. Larson, 2008 WL 2168348 (Minn. 2008) (unpublished decision),[9] a deputy responding to a domestic disturbance call ran a red light at between 30 and 45 miles per hour, and collided with another vehicle, resulting in the death of its driver. Under the doctrine of official

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[9] A copy of the decision is attached hereto as Exhibit F.

immunity, “a public official charged by law with duties which call for the exercise of his judgment or discretion is not personally liable to an individual for damages unless he is guilty of a willful or malicious wrong.” The doctrine parallels discretionary immunity in that it hinges on the individual officer’s “exercise of judgment or discretion.” The Terrell opinion discussed the deputy’s duty of care when proceeding through a red light, stating as follows:

> Terrell relies on a statute that provides, in part:
>
> > Stops. The driver of any authorized emergency vehicle, when responding to an emergency call, upon approaching a red or stop signal or any stop sign shall slow down as necessary for safety, but may proceed cautiously past such red or stop sign or signal after sounding siren and displaying red lights.
>
> Minn.Stat. § 169.03, subd. 2 (2000). Terrell argues that the words “shall slow down as necessary for safety” imposed a ministerial duty on Deputy Larson, leaving him no discretion to not slow down. Terrell emphasizes the statute's use of the word “shall,” but the phrase “as necessary for safety” is a significant qualifier. That phrase indicates that the degree to which an officer must slow down depends on conditions that the officer perceives at that time. This is a classic example of the use of discretion.

Id. at *5-6. Because the deputy had discretion as to how to proceed through the red light, including making the decision as to what he needed to do in order to comply with Minnesota’s “red light” statute, he was immune from liability.

Using this same reasoning, in Muse v. Schleiden, 349 F. Supp. 2d 990, 996-98 (E. D. Va. 2004), the court held that a deputy’s decision to enter an intersection against a red light without activating his lights and sirens was a discretionary function and therefore the deputy was immune from suit on a claim that the deputy negligently collided with another vehicle when responding to an assault in progress call. The court found that the deputy was required “to balance grave personal risks, public safety concerns, and the need to achieve the governmental objective.” Id. at 997. The court reasoned that “[s]overeign immunity protection is necessary in such circumstances to preserve the emergency responder's discretion to balance a variety of special risks in making the decision on how best to respond to an emergency call” because “activating emergency equipment might alert a criminal to a deputy's arrival or create a disturbance by drawing attention to the scene of the call.” Id. at 997-98. The court concluded that “a key purpose for extending sovereign immunity to a county's emergency responders [is] to eliminate public inconvenience and danger that might result from such responders being reluctant to act for fear of damaging lawsuits.” Id. at 998.

In Rivas v. City of Houston, 17 S.W.3d 23 (Tex.App. 2000), an ambulance driver transporting a patient ran a red light and collided with the plaintiff. The Court of Appeals of Texas found that the driver was immune from plaintiff's claims because he was engaged in a discretionary function. The court explained that Texas law defines a discretionary act as one which requires "personal deliberation, decision, and judgment," and that a paramedic or emergency medical technician's "decisions concerning how to transport a person to a medical facility will fundamentally involve his discretion." Id. at 29. Because the ambulance driver's duties at the time of the accident involved transporting a patient to the hospital on an emergency basis, the court held that the ambulance driver was performing a discretionary function as a matter of law at the time the accident occurred, and was therefore both he and the City were immune from liability.

In Pletan v. Gaines, 494 N.W.2d 38 (Minn.1992), a police officer's decision to engage in a high speed chase to pursue a fleeing criminal resulted in a fatal accident. Deciding whether the officer's actions were immune from suit, the Minnesota Supreme Court stated that when an official must make instantaneous decisions often on the basis of incomplete information, "[i]t is difficult to think of a situation where the exercise of significant, independent judgment and discretion would be more required." 494 N.W.2d at 41. As the court explained,

> Official immunity is provided because the community cannot expect its police officers to do their duty and then to second-guess them when they attempt conscientiously to do it. To expose police officers to civil liability whenever a third person might be injured would, we think, tend to exchange prudent caution for timidity in the already difficult job of responsible law enforcement.

Id. Because the officer responding to the situation was required to make quick decisions in order to fulfill his duty to uphold the law and protect the public, he was granted discretionary immunity.

*3. Sergeant Cargile and the City are entitled to discretionary immunity in this case.*

Because Sergeant Cargile was making decisions and judgments in how to best respond to an emergency, and his actions were in furtherance of public policy, he is entitled to discretionary immunity. The actions taken by Sergeant Cargile were in the course of his response to a call of a fight and shots fired. Sergeant Cargile's response required quick decisions and judgment, in particular a balancing of the choice to enter the intersection through the red light in order to arrive at the scene of the crime as quickly as possible against the risk of an accident. Indeed, consistent with the foregoing cases, his determination of what constituted slowing down as necessary for safe operation" as required by NRS 484B.700 itself constituted a discretionary act. Furthermore, his actions were in furtherance of public policy, specifically the policies of protecting the public, preventing crime, and enforcing the law. The public policy considerations of protecting public safety are all the more pressing when officers are investigating violent crime as the one present here, rather than investigating a public nuisance, which Ransdell found to be protected by discretionary immunity. Accordingly, Sergeant Cargile was engaged in a discretionary function in furtherance of a public policy, and therefore he is immune from suit on all claims alleged by Plaintiff.

The City is immune as well. As explained in Bryan, supra, decisions relating to the hiring, training, and supervision of employees usually involve policy judgments which are protected by discretionary immunity. Id. at *2. Plaintiff is without any evidence to support her claims against the City on these claims, but even if she did, the City would be immune. Plaintiff's claim for vicarious liability fares no better, because Sergeant Cargile's immunity from suit cuts off vicarious liability on the part of the City. See Village Development Company v. Filice, 90 Nev. 305, 310, 526 P.2d 83, 86 (1974) (overruled on other grounds) ("Where no basis exists to charge an employer, other than vicarious liability for the imputed negligence of its agent, courts have often held that a judgment on the merits in the agent's favor bars further action against the employer.") Because Cargile is immune, none of Plaintiff's claims against the City are viable.

## IV.

## CONCLUSION

Under Nevada law, police officers have discretionary immunity for their actions if (1) the actions involve an element of choice or judgment, and (2) the actions were based on policy considerations. Here, Sergeant Cargile exercised judgment in proceeding through a red light while responding to an emergency call, making decisions as to how and when to proceed. Also, his actions in responding to the emergency call were made based on policy considerations, including policies relating to public safety and enforcing the law. Accordingly, Sergeant Cargile's actions in proceeding through the red light are subject to discretionary immunity, and Sergeant Cargile and the City are immune from Plaintiff's claims arising from this accident. For the foregoing reasons, the City Defendants respectfully request that this Court grant their Motion for Summary Judgment.

DATED this 22nd day of December, 2015.

NORTH LAS VEGAS CITY ATTORNEY

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**CERTIFICATE OF SERVICE**

I HEREBY CERTIFY that service of a true and correct copy of the **DEFENDANTS' MOTION FOR SUMMARY JUDGMENT** was made on the 22nd day of December, 2015, as indicated below:

_√_ By electronic service, pursuant to N.E.F.C.R. 9

___ By first class mail, postage prepaid from Las Vegas, Nevada pursuant to N.R.C.P. 5(b) addressed as follows

___ By facsimile, pursuant to EDCR 7.26 (as amended)

___ By hand delivery

To the parties listed below:

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*Attorneys for Plaintiff*

*/s/ Michelle T. Harrell*
An Employee of North Las Vegas
City Attorney's Office

# EXHIBIT “A”

# EXHIBIT “A”

# Glover-Armont v. Cargile, et al.

Deposition of:
**Sergeant John Cargile**

**October 1, 2014**

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A. No. I spent one year on graveyard. This week, it happens to be that I'm back on graveyard, believe it or not. But my current assignment is administrative sergeant. I work day, swing, and grave. I work all shifts.
Q. November 2012, where did that fall within your year of working graveyard?
A. I was promoted in 2011. So it would have been that February of 2012 I would have gone to graveyard. So that would have been my graveyard shift.
Q. How many days a week did you work during that period of time?
A. I work four days a week. Yes.
Q. Was it a set four days that you normally worked?
A. Yes. I worked grave B, B squad, so, again, I came in Saturday night. I was working basically the Sunday morning, Monday morning, Tuesday, and Wednesday morning, for the most part.
Q. This wreck occurred about 1:53 in the morning is I believe when you called it in. So I assume it occurred maybe minutes before that.
A. Uh-huh.
Q. Is that a fair statement?

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A. Yes.
Q. Where were you coming from?
A. I was coming from the South Area Command, which is at Lake Mead and Bruce. And I was driving to -- I think the exact is 3260 Fountain Falls, which is basically Cheyenne and Simmons, is where I was heading to.
Q. How do you remember that address?
A. I remember that it's -- it's an apartment complex that's right there that we respond to quite often back then, especially when I was assigned to the south. It was one that you become frequent with.
Q. What's the name of the complex?
A. It's called Fountain Falls. And that might not be the current name of the apartment complex today. They tend to change from year to year by ownerships.
Q. It was your intended route to take -- take me through your intended path had this accident not -- had this not occurred.
A. The quickest way for us to get down there as we come on to the west side of town, which is on the west side of the I-15 freeway, the North Fifth Street off of Losee is our easiest way to come up, to only have to come up to the light that's at North Fifth and

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Cheyenne. So we're trying to get to the area that's used less by the civilian traffic. Then I was going to go westbound on Cheyenne from there. All straight up to Simmons.
Q. So it was your intent to make a left on north -- sorry, on Cheyenne and go westbound?
A. And go westbound, yes.
Q. Is there an alternative route from the -- you said we usually take that route. Is there an alternative route that can be taken from the Lake Mead and Bruce Southwest Area Command?
A. There's several different ways that you can go. But a lot of times it will depend upon current traffic. If we had other calls or accidents working, based on where you are at, you may take a different route based on that alone. But, yes, you could use Lake Mead or Carey or come across Civic Center and up Cheyenne that way. But several different ways to get there.
Q. It appears to me -- strike that.
Is there -- strike that.
Did you inspect your car prior to getting in the vehicle to head to this call?
A. Yes.
Q. What did you do to inspect your vehicle?

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A. Our normal inspection of our vehicle is to make sure that all of our required equipment is inside of the vehicle -- traffic vest, cones. As a supervisor, we have additional equipment that we carry inside the vehicles, which are shields, rams, extra protective equipment for the officers, so forth. So we verify that all of our required equipment is inside the vehicle. Then after that, then we do an inspection of the tires and an external of a vehicle. Then we turn on lights and sirens and make sure everything is operational.
Q. Was that done immediately prior to the call, or was that done at the beginning of your shift?
A. At the very beginning of the shift.
Q. You were kind of indicating a -- some kind of writing. Is there some kind of form that you fill out to do that?
A. No, we don't do a form. We have a vehicle log that is on -- an electronic vehicle log. Once you complete your inspection, you type in on the vehicle log that vehicle check was okay and that the gas card is in the vehicle. That's usually what's put inside the log.
Q. Is that something that is kept for a period of time?

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A. I believe -- it's kept for I believe for three months. Right after that you can see it and then electronically up for a year and then it's gone.
Q. Anything else that you did regarding your inspection?
A. No. Once inspection is complete, then that's it. We put ourselves in service.
Q. I understand that you said that you were at the southwest command. Were you at a desk at the time you received the call? What were you doing? Do you remember?
A. Don't specifically. I know I was down at the South Area Command. I believe I was talking with other officers when the call first started coming out. But just based on the information of the call as it starts to come out, I immediately jumped in my vehicle and started heading in that general direction.
Q. My understanding is that there was -- well, what is your memory of what kind of call was made?
A. The call that was in is that there was a fight that was going on inside the complex with several juveniles, that it was still active. And then there was shots fired at the complex which of course that generated people to start going, which at that point, the two primary officers and myself being the

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supervisor are now automatically dispatched to the call to have to respond. I believe shortly within the very first few seconds of that call coming out, then the dispatch claimed that they had a victim down to a gunshot wound and people were requesting medical to respond as well.
Q. Ultimately, you never made it to that call; is that correct?
A. Correct.
Q. Do you have an understanding of what exactly occurred that night, if there was any kind of convictions from that, anything like that?
A. No, not off the top of my head I don't remember. Basically once I was en route and involved in the accident, my job was just to notify them that I was involved so that another supervisor could get en route to the call to be able to get on scene.
Q. Who was the other supervisor at the time?
A. Tell you the truth, I'm not sure. I think there were a couple of supervisors that were on. I believe Sergeant Semper was on up north and I believe Sergeant Fay was still there. But I believe Sergeant Semper actually responded on scene. But I would have to go verify who actually got there.
Q. I was just curious.

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And you don't remember what ultimately occurred, whether or not the victim was found -- I'm sorry, the --
A. Victim was found. I know an arrest was made. I don't know like what the outcome was whether or not the suspect had received time or anything like that.
Q. Okay. You obviously didn't have anybody else in your vehicle at the time; correct?
A. Correct.
Q. Can you describe in detail how this wreck occurred?
A. Basically, I was running lights and sirens going which would be northbound on Fifth Street as I approached Cheyenne, the intersection with Cheyenne. I was preparing to make a left-hand turn and go westbound on Cheyenne. As I approached the intersection, there was nobody on my side of the street. I do remember that there was vehicles directly across because we did have a red light for east and westbound traffic. There was vehicles that were stopped on the other side that were traveling south. It would be south on North Fifth. And as I approached, I believe there was some cross traffic as in vehicles had passed through the intersection as I

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was approaching up to the intersection. At that point, then I came to a stop prior to the intersection as typically we do, because I know there was one or two vehicles -- I don't recall like make or models of vehicles on the other side of the intersection. That we then will do something where we will change. We have four different siren tones that are on our vehicle. What we do is we'll push from button to button to button. It changes the sound, the tone, how loud it goes, in order to make sure everybody that's in the intersection or nearby is gathering their attention to my patrol vehicle. Then I started to -- once I believed there was no oncoming traffic on either east or westbound on Cheyenne, I started to encroach into the intersection to get ready to make my left-hand turn. As soon as I started to encroach into the intersection, I heard the vehicle lock up its brakes. And it was to my left. So I noticed it was a small car now that was traveling eastbound on Cheyenne approaching the intersection. Two things occurred to me. I noticed it was a small dark-colored vehicle and it had no headlights or anything on the vehicle as it approached. At that point I stopped as that vehicle was locking up its brakes. There's that point in there where I realized I can't move or go anywhere,

but knowing that the vehicle mostly likely was going to end up striking the front of my vehicle. Once the collision occurred, then I called out on the radio to advise them that I was --
Q. Let's stop there.
MR. GANZ: Do you mind reading back his answer?
Q. (BY MR. GANZ) I'm going to have her read that back to you, make sure it's accurate and correct, and if there is something you need to change, let us know afterwards. Okay?
A. Okay.
(The reporter read the requested portion of the record)
Q. (BY MR. GANZ) You heard her read that back?
A. Nope.
Q. You didn't?
A. I heard her read it back. I have one clarification. I will say I know it was a red light to stop north and southbound traffic. I was traveling north. It was green lights that allowed east and westbound traffic through the intersection as I approached.
Q. Anything else?
A. Huh-uh.



Q. Is that no?
A. Yeah, that's a no. That's it.
Q. Was there anything else you want to add to that, something that you may have missed in your explanation of how the wreck occurred?
A. Nope. That's pretty much exactly how it happened.
Q. I have some questions for you. You had said that there was some cross traffic at one point in time.
A. Correct.
Q. Are you talking about cross traffic meaning east and -- eastbound and westbound Cheyenne?
A. East and westbound Cheyenne, correct. As I approached still a distance -- I'm going to say several hundred feet away from the intersection, but as I'm approaching, I can see the intersection. I could see cars that had gone through the intersection as I was approaching.
Q. You had then said that as you approached the intersection you stopped prior to the intersection.
A. Correct.
Q. And started changing the tones of your siren; correct?
A. Correct.



Q. First of all, how long had you stopped before you proceeded into the intersection?
A. I would -- probably five to six seconds. It's not a whole lot of time. Once I stopped, then it's just a matter of just visually clearing each intersection as I go.
Q. When you stopped prior to approaching the intersection, I want to make sure we have the same definition of an intersection just because it gets very confusing sometimes where the intersection begins and where it doesn't. At least from my perspective.
My take on where the intersection occurs is where the stop bar is for the vehicles traveling in that direction. Do you agree with that?
A. Correct. From any point from that stop sign into is included into the intersection, which is typically defined by the curbing that is along the road, the roadway.
Q. I'm talking about -- if you're looking at an aerial above, there is a stop bar that's before the light where you are supposed to stop waiting for a light.
A. Correct.
Q. Can we agree that at least for the discussion today even if that's not the technical



beginning of the intersection that we use that as a point of reference for now?
A. Correct. That's fine.
Q. When you say you stopped prior to the intersection and changed your tone, were you stopped behind that stop bar?
A. Yes. Stopped behind the line, yes.
Q. And I know from traveling that area -- not that often -- but recently in an inspection of the area, I noticed there's this -- for lack of better term there's this big hill that's on the southwest corner of Fifth Avenue just right before the intersection; correct?
A. Correct.
Q. It actually goes beyond the stop bar, doesn't it?
A. The hill?
Q. Yes.
A. The hill goes, yes, correct, all the way up.
Q. When I say it's a big hill, it's a hill -- I don't know, I haven't measured it, but it's probably at least 50 feet in the air; right?
A. I would put the hill probably a good 20, 25 feet up. I believe that mound that is there is the Las Vegas -- or the North Las Vegas Golf Course. It's

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a built up tee box that is for the golf course.
Q. When you are at that stop bar with that hill on your left, are you able to see -- and I'm talking about stopped right before the stop bar. Are you able to see the eastbound traffic on Cheyenne?
A. Yes, for only a certain distance. There's two limiting factors I see on that one. One is the obstruction, the large hill that's on that southwest corner, and two is the limited lighting at night to be able -- how far up the hill you can see.
Q. In addition to the hill, there's also trees and stuff there too, isn't there?
A. That is inside the fence up on the hill. Lower down, all the way up -- down around by the fencing I don't think there's any trees down there.
Q. Forgetting about lighting issues because of being dark, even if it was during the middle of the day with that hill there at the stop bar can you estimate for me how far you could see into the eastbound travel lanes if you're at that stop bar in that one lane?
A. That's a tough question, a tough question. There's no lighting there. Typical lighting is 150 feet up. It's a good judge for us to be able to see a streetlight -- the next streetlight up from a

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corner because it's not exact but it's roughly about 150 feet for the placement. That gives us usually a good judgment of how far up we can see. In this case, there is no street lighting that is right there. Not until you're much further up the road to the entrance to the little park that sits right there by that golf course.
Q. Just so you understand, I'm looking for an estimate. I recognize you haven't maybe have done -- doesn't sound like you've done this analysis.
A. Right.
Q. My question is as you sit here today, what would you estimate how far you could see if you're looking to the left in clear conditions in daylight?
A. It's rough being stopped behind the line looking up the street. I'm -- most likely I'm going to say the angle to see eastbound traffic or probably less -- maybe around 150 feet to 200 feet that you could probably see up the roadway.
Q. What about specifically for the third travel lane closest to the curb?
A. Close to the curb? That's going to be the shortest distance that you're going to be able to see going up the hill. Again, 150 feet. But I'm making a rough guess.

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Q. Surely you've gone -- traveled eastbound on Cheyenne on that road as well; correct?
A. Correct.
Q. Can you give me an estimate of how far you believe in a Number 3 travel lane that somebody could see somebody sitting at that stop bar facing northbound on Fifth Avenue if you're traveling eastbound on Cheyenne?
A. Eastbound on Cheyenne? It's a little easier to see eastbound than west. And, again, I would have to -- it's like anything else. I'll refer it to such as building clearing and cutting corners. Where I'm sitting to make a left-hand turn, the closer that I sit to that side, it's harder for me to see an angle to get cleared up. Otherwise, somebody who is coming down from the other direction, the distance off between where the travel lanes are -- and I don't know exactly how it is, but, obviously, the further out you go the easier it is for you to see back one way. I don't know the exact term for it, but it's a thing that we use to where one direction you can actually see somebody. But someone looking the other direction actually can't, when you cut off those corners. But it's fairly close. It's not like a huge advantage, if that makes sense.

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Q. So still in that 150 to 200 feet range?
A. Correct. Where you could be -- again, it's tough to say with being exactly there. But sitting where I'm at, somebody could be -- if they are 150 feet up this way, they could see this vehicle where this vehicle couldn't see them.
Q. Regardless of that, it's still about 150 --
A. About 150 feet. Roughly, I would say, in that third lane. As you go further out, you'd be able to see -- I could see a little bit further and then they could also see me.
Q. Sure. Would you agree with me that that hill, the fence, and the foliage on that corner obstructs the view of somebody who is sitting in the northbound Fifth Avenue -- obstructs the view of anybody coming eastbound on Cheyenne? Would you agree with that general concept?
A. Yeah. All that goes into play. I'd say almost anywhere that that's going to go on there, what you can see, what you can't see. It all makes -- we have -- there's a new state law in reference to I want to say campaign signs because they put them out there and when they are sitting on corners, it obstructs people's views to be able to see clearly in any directions on the roadways.

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Q. I'm just asking very specifically on this intersection, that hill, foliage, fencing, and trees obstructs the view of somebody who is traveling northbound -- the view of the eastbound travel on Cheyenne is obstructed?
A. Yes. That corner does. Whether you are traveling eastbound Cheyenne or northbound on North Fifth, it's going to limit your view.
Q. I'm not just talking about a little bit; right? I mean, that's a really big obstruction. I mean, I drove by it. I was fairly impressed with how large that hill was and the amount of obstruction it caused on that area. I mean, it's a tough spot to see around, isn't it?
A. It is a tough spot to see around, correct.
Q. Because of that, you testified that you had stopped, did your tone change, and then started -- you described yourself as creeping forward a little bit; is that correct?
A. Yes.
Q. Then you said that you heard a vehicle lock up and then at that point you stopped and realized that there was nowhere that you could go; is that correct?
A. Correct.

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Q. At the point that you heard the vehicle, you were already in the third travel lane for eastbound Cheyenne; correct?
A. Correct.
Q. How far were you in the travel lane when you first heard the sound?
A. As I began to encroach, I'm only a couple of feet. My vehicle is starting to roll forward because I'm getting ready. My anticipation, even though I'm not going to go fast, is that I've started because I'm going to go out and make my left-hand turn across the intersection. Specifically where I was at, I don't know. I know that I had a stop prior to the intersection. There's several feet. Again, without going out there and measuring it -- because of that and because of that spot, it's three to five feet or so behind. So as I was rolling out -- my best example is always to use the curbing that is on the sidewalk that is on the Cheyenne side for the east and west travel. I was fairly close to that or I would say even starting to pass that when I heard the brakes lock up, which immediately drew my attention to my left. Then I stopped.
Q. And it's your testimony that you were stopped at the time of impact; correct?

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A. Correct.
Q. So when you heard the vehicle, you immediately applied your brakes?
A. Correct.
Q. And didn't move any further?
A. Correct.
Q. So whatever position that the impact occurred, is it fair to say that that's the location that you first heard the vehicle?
A. Yeah. Fairly close. I could only probably travel two to three -- I mean, a small amount of feet. My vehicle is in motion when I heard it. I got to stop. At that speed, I'm only going to go a couple feet at most before I get stopped.
Q. How fast were you traveling from your point of stopping before the stop bar and the time that you heard the vehicle to the left?
A. Couple miles per hour. It was -- basically it was just getting this vehicle into motion and then hearing it and then applying the brakes and stopping.
Q. You used the word encroaching into the Cheyenne travel; correct?
A. Correct.
Q. Is that a term that you used?
A. Yes.

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Q. What you meant by that was that you were already within that Cheyenne travel when you heard the vehicle to the left?
A. Encroaching. I was entering the intersection.
Q. But you were already in it?
A. Yes.
Q. When you do your little change in sounds, do you then have to hit another button to be able to have the sound continuous to a specific sound or is it just change it and then it rotates?
A. It just changes. It will continue to change. Whatever I leave it on -- our main siren on our vehicles is called wail, W-A-I-L. Once I start hitting buttons to change, if I leave it on -- if it's the constant or yelp, if I start to drive, it will stay there for say roughly 10 seconds and then it automatically changes back to the main wail without me having to push anything. All I'm doing by pushing the button, again, is just changing the tone or the type of sound that's coming off.
Q. Do you know what decibel level the wail is?
A. No, I don't. It varies in how loud and the pitch to be able to -- and how frequently it goes. It changes to get people's attention.

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Q. I know this sounds obvious, but clearly you were working within the course and scope of your employment at the time this incident occurred; correct?
A. Correct.
Q. Had plaintiff had her lights on -- I understand your testimony that she didn't -- had she had her lights on, would she have done anything wrong?
A. Would she have done anything wrong?
Q. Yes.
A. I believe that if she would have had her lights on, I would have been able to see her and that I would not have encroached into the intersection prior to her arriving into the intersection.
Q. So my question is had she had her lights on, did she do anything wrong?
A. If she would have had her lights on, I wouldn't have encroached in. She probably would have went right through the intersection and then I would have went behind her.
Q. Never made aware of any other person who witnessed it and stuck around and gave you a name or number or anything like that?
A. No.
Q. The instrumentation in your vehicle you have

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at the time was radios. I assume you had your cell phone. Computer that's there as well and accessible; correct?
A. Correct.
Q. Were you distracted at all prior to entering the intersection by looking at any of those devices?
A. No.
Q. It's your testimony that you were not on your phone or texting or on the radio or your computer within the few minutes before the impact?
A. Correct. Yeah, I was not using anything. In this case, I knew the exact address and where I needed to go. So I didn't need the use of all that. Listening to the radio, but I was actually not using it.
Q. Last question. You know you are under oath. Do you really like the Dodgers? I mean, really? Just kidding.
MR. GANZ: I have nothing further.
MR. CRAFT: No questions.
(The deposition was concluded at 5:19 p.m.)
* * * * *

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CERTIFICATE OF DEPONENT

I, SERGEANT JOHN CARGILE, deponent herein, do hereby certify and declare the within and foregoing transcription to be my deposition in said action, subject to any corrections I have heretofore submitted; and that I have read, corrected, and do hereby affix my signature to said deposition.

____________________________
SERGEANT JOHN CARGILE, Deponent

Subscribed and sworn to before me this _____ day of _____________, _____.

STATE OF NEVADA )
ss:
COUNTY OF CLARK )

____________________
Notary Public

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CERTIFICATE OF REPORTER

I, Marnita J. Goddard, CCR No. 344, a Certified Court Reporter licensed by the State of Nevada, do hereby certify:

That I reported the deposition of the witness, SERGEANT JOHN CARGILE, commencing on Wednesday, October 1, 2014, at the hour of 3:49 p.m.;

That prior to being examined, the witness was by me first duly sworn to testify to the truth, the whole truth, and nothing but the truth; that I thereafter transcribed my related shorthand notes into typewriting and that the typewritten transcript of said deposition is a complete, true, and accurate record of testimony provided by the witness at said time.

I further certify (1) that I am not a relative or employee of an attorney or counsel of any of the parties, nor a relative or employee of any attorney or counsel involved in said action, nor a person financially interested in the action, and (2) that pursuant to NRCP 30(e), transcript review by the witness was not requested.

IN WITNESS WHEREOF, I have hereunto set my hand in my office in the County of Clark, State of Nevada, this _____ day of _____________, 2014.

____________________________
Marnita J. Goddard, RPR, CCR No. 344

# EXHIBIT "B"


# EXHIBIT "B"

DISTRICT COURT
CLARK COUNTY, NEVADA

| | |
|---|---|
| JAPONICA GLOVER-ARMONT, Plaintiff, vs. JOHN CARGILE; CITY OF NORTH LAS VEGAS, a Municipal Corporation existing under the laws of the State of Nevada in the County of Clark; DOES I through X, inclusive; and/or ROE CORPORATIONS I through X, inclusive, Defendants. | Case No. A-13-683211-C |

DEPOSITION OF JAPONICA FELISHA GLOVER-ARMONT
Taken on Thursday, August 7, 2014
At 2:08 p.m.
At 2250 Las Vegas Boulevard North
Suite 810
North Las Vegas, Nevada 89030

Reported by: Susan Lee Naylor, RPR, RMR, CCR #513

down from the top, the report says -- and I am reading from this -- "V No. 1's operator stated that she saw V No. 2's emergency lights activated as she approached the intersection but did not hear the vehicle's siren."
First of all, is that correct that's what it says?
A Yes.
Q Do you agree with that statement? Let me rephrase that. Did you state to the officer that was making this report that you saw Vehicle No. 2, the police car's, emergency lights activated as you approached the intersection?
A I saw him as I entered the intersection.
Q Okay. And you saw his emergency lights activated?
A Yes.
Q So this is an accurate statement of what you had told the officer?
MR. GANZ: That's not what she said, so be careful there. She says as she entered. This says "approached." That's why she didn't agree with that.
MR. CRAFT: She didn't say she didn't agree with that.
BY MR. CRAFT:
Q Now we're just debating over what you said,



so let's start over and leave the attorneys out of it for a moment.
MR. GANZ: Leave the what out?
MR. CRAFT: The attorneys.
BY MR. CRAFT:
Q Is this an accurate statement?
A No.
Q Why not?
A Because I was already in the intersection when I saw him -- or let me rephrase that. I was -- as I was coming into the intersection, I looked to my right, and that's when I saw him. So I'm coming --
Q And as you said -- sorry. Go ahead.
A I'm coming into the intersection, and he's coming northbound. And when I looked, that's when I saw him to my -- when I looked to my right, that's when I saw him.
Q Okay. When you first saw the police vehicle on Fifth Street, what was your immediate reaction? What did you do?
A Slam on my brakes.
Q Can you estimate how much time it took between when you first saw the vehicle there and when you were able to apply the brakes?
A Maybe a couple of seconds, maybe.



Q Going back to page 2, same page, third paragraph on the bottom says, "Vehicle No. 1 left approximately 110 feet of four-wheel skid marks in an attempt to avoid a collision with Vehicle No. 2."
Do you have any reason to doubt the report as far as saying how long the skid marks were?
A I don't know.
(Exhibit D was marked.)
BY MR. CRAFT:
Q Marking Exhibit D, have you seen that document before?
MR. GANZ: Or a copy of it?
THE WITNESS: A copy of it, I guess. Yes.
BY MR. CRAFT:
Q And what is this?
A It's the questions, I think.
Q Is it your responses to defendants' first set of interrogatories?
A Is it what?
Q Plaintiff's response to defendants' first set of interrogatories, just reading the title of it on the first page.
A Oh, yeah.
Q Looking forward to your answer to Interrogatory No. 2, "Please describe in detail the



incident that is the subject of the lawsuit," basically a summary of your side of the story. In your answer to Interrogatory No. 2 on page 3, the last sentence, you say, "The officer did not have his sirens on, and plaintiff could not see his lights flashing due to the hill obstructing her view."
As you sit here today, is that an accurate statement?
A Yes.
Q And explain how the hill obstructed your view of the officer's lights flashing.
A This hill was huge, so there was no vision, period, to the right of you as you're approaching this hill. And the hill starts -- I don't know how many feet back from the light, but it starts, and it inclines, and it goes to a peak, so there's no vision of anything to the right of you. You can't, even if you wanted to -- like people do a right-hand turn on a light, you would have to completely stop, ease up, ease up, and look around this hill. So it totally obstructs anything to the right of you, and that's what was to the right of me from the direction he was coming.
Q Okay. So you're not talking about the hill that Cheyenne is, like coming -- talking about the hill where you're coming down Cheyenne. You're talking

about something on the right?
A Yeah. The hill was to my right, so I'm heading east toward the 15, he's heading north. So I'm heading east, he's heading north, so I couldn't see him, and he couldn't see me. He couldn't have seen me because of the hill.
Q Okay. Thank you for clarifying that. And you said that he did not have his sirens on. Is it your understanding that he had some sort of duty to have his sirens on?
A I was told that all police officers had to have their sirens on when they're in a hurry, or I grew up being told that, so I don't know.
Q But you don't have any knowledge of any Nevada laws to the contrary?
A I don't know anything about Nevada laws.
Q So to paraphrase -- and not to put words in your mouth, but is it fair to say that your position is, you don't dispute that the police car had its lights activated, but because of the hill being there, you couldn't see them in time to react?
A I didn't see him or hear him.
Q Okay. Is that a fair summary of what you're saying?
A Yes.



Q Thank you. Was the road that you were driving on slick or wet or otherwise slippery, to your recollection?
A No.
Q So you've been working for the Review-Journal since June of 2010; is that correct?
A Yes.
Q That was about two and a half years prior to the accident?
A Yes.
Q Almost on a daily basis, you were driving with your car with varying amounts of newspapers?
A Yes.
Q On any occasion where your car was filled with newspapers -- let me rephrase that.
On any occasion where your car had the amount of newspapers roughly equal to or more than the amount the day of the accident, did you have any occasion to slam on your brakes for any reason?
A Not that I can recall, no.
Q In this case, did your car slow as you expected it to, or did it take longer to stop than you expected?
A I don't know. I just slammed on brakes.
Q Okay. I think I know where this is going,



but do you believe that the added weight of your newspapers made it harder for your car to stop in time to avoid the accident?
A No.
Q Following the accident, did you have any conversation with the police officer who was driving the police car that was involved in the collision?
A You said after?
Q Yes.
A Or during?
Q After the accident.
A The only police officer that I spoke to was the one that came to the hospital.
MR. GANZ: He means at the accident scene.
BY MR. CRAFT:
Q That's what I meant.
A Just the one that opened the door and said, "Are you okay?"
Q And he also instructed you to turn off your vehicle?
A Yes.
Q Do you recall any other conversation with that individual?
A No.
Q To your knowledge, were there any other



witnesses to the accident aside from you and the officer that was involved?
A No.
Q Were you issued a citation for this accident?
MR. GANZ: Again, you meant at the scene? She did mention the one at the hospital that I got her off on. You were talking about at the scene still, right?
MR. CRAFT: I was.
MR. GANZ: Okay. I didn't mean to cut you off earlier, but she did say she had a conversation with somebody at the hospital.
MR. CRAFT: No. I appreciate that.
BY MR. CRAFT:
Q Do you recall who the officer was that you spoke with at the hospital?
A No.
Q Do you recall the conversation that took place?
A Yes.
Q What was the conversation, basically?
A He came to the emergency room where I was laying down in the bed, and he informed me that I was being cited for the accident, failure to stop for an

on charges without knowing what those charges were.
MR. GANZ: I'm going to object. I believe it's argumentative.
THE WITNESS: I paid, you know -- yeah. I just paid what I was told to pay.
BY MR. CRAFT:
Q Going back to the interrogatories, your response to Interrogatory No. 3 asking about the complaint -- which was obviously drafted by an attorney -- you asserted that the defendant, John Cargile, the police officer, was negligent and failed to use due care. In response, you said that Cargile breached his duty when he failed to use due care by failing to use his sirens. Is that correct, your response?
A Yes.
Q Is that still your response to that interrogatory?
A Yes.
Q Okay. Just to clarify one response you gave earlier, I believe you indicated that -- and again, I'm paraphrasing. I'm not trying to put words in your mouth. You had indicated it's your understanding that there's no way Officer Cargile could have seen your car coming unless he pulled forward into the intersection.



Is that a fair statement?
A Yes.
MR. CRAFT: I have no further questions.
EXAMINATION
BY MR. GANZ:
Q Did you go to trial on that citation?
A No.
Q Was there a judge and a hearing and a trial that was taking place, and you were found guilty of anything?
A I wasn't there.
MR. GANZ: All right. Nothing further.
MR. CRAFT: Thank you.
(The deposition concluded at 2:54 p.m.)
* * * * *



CERTIFICATE OF REPORTER

STATE OF NEVADA )
) ss.
COUNTY OF CLARK )

I, Susan Lee Naylor, CCR #513, RMR, a Certified Court Reporter licensed in the State of Nevada, do hereby certify: That I reported the taking of the deposition of the witness, Japonica Felisha Glover-Armont, commencing on August 7, 2014 at 2:08 p.m.

That prior to being examined the witness was by me duly sworn to testify to the truth. That I thereafter transcribed my said shorthand notes into typewriting and that the typewritten transcript of said deposition is a complete, true and accurate record of the testimony provided by the witness at said time.

I further certify that (1) I am not a relative or employee of an attorney or counsel of any of the parties, nor a relative or employee of an attorney or counsel involved in said action, nor a person financially interested in the action, and (2) that transcript review pursuant to NRCP 30(e) was not requested.

IN WITNESS WHEREOF, I have hereunto set my hand in my office in the County of Clark, State of Nevada, this 20th day of August 2014.

Susan Lee Naylor, RPR, RMR, CCR #513

# EXHIBIT "C"

# EXHIBIT "C"

349 Fed.Appx. 132
This case was not selected for publication in the Federal Reporter.
Not for Publication in West's Federal Reporter See Fed. Rule of Appellate Procedure 32.1 generally governing citation of judicial decisions issued on or after Jan. 1, 2007. See also Ninth Circuit Rule 36-3. (Find CTA9 Rule 36-3)
United States Court of Appeals,
Ninth Circuit.

Austin BRYAN; et al., Plaintiffs—Appellants,
v.
LAS VEGAS METROPOLITAN POLICE DEPARTMENT; et al., Defendants—Appellees.

No. 08–15992. | Submitted July 14, 2009.* | Filed Oct. 7, 2009.

**Synopsis**
**Background:** Plaintiff brought § 1983 action against police department and officers, alleging that they used excessive force when plaintiff was shot in his apartment. The United States District Court for the District of Nevada, Kent J. Dawson, J., granted motion of department and officers for summary judgment. Plaintiff appealed.

**Holdings:** The Court of Appeals for the Ninth Circuit held that:

[1] those police officers who did not fire at plaintiff could not be held liable;

[2] department could not be held liable under theory of municipal liability;

[3] police department was entitled to discretionary immunity and could not be held liable for negligent training or supervision; and

[4] defendants could not be held liable for punitive damages arising out of claim of negligent training or supervision.

Affirmed in part; reversed and remanded in part.

Smith, J., filed opinion concurring in part and dissenting in part.

West Headnotes (7)

[1] **Civil Rights**
Criminal law enforcement; prisons

Those police officers who did not fire at plaintiff when police entered his home could not be held liable in his § 1983 action for use of excessive force, as those officers were merely present when plaintiff was shot, and there was no indication that those officers integrally participated or had personal involvement in any behavior that caused deprivation of any right of plaintiff. 42 U.S.C.A. § 1983.

2 Cases that cite this headnote

[2] **Civil Rights**
Criminal law enforcement; prisons
**Civil Rights**
Criminal law enforcement; prisons

Police department could not be held liable under theory of municipal liability in plaintiff's § 1983 action against police department for use of excessive force when plaintiff was shot by police, as plaintiff did not demonstrate that department had policy or practice that showed deliberate disregard for plaintiff's constitutional rights, or that department policy or practice was moving force behind any constitutional violation. 42 U.S.C.A. § 1983.

Cases that cite this headnote

[3] **Municipal Corporations**
Police and fire

Police department was entitled to discretionary immunity and thus could not be held liable under Nevada law for negligent training or supervision, in action arising from plaintiff being shot by police in his apartment, since officers' handling of confrontation with plaintiff led to discretionary decisions concerning scope and manner in which investigation was conducted based on department policies, and did not violate mandatory directive. West's NRSA 41.032.

2 Cases that cite this headnote

[4] **Civil Rights**
Government liability

Plaintiff could not recover punitive damages on his § 1983 claim against municipality or police department arising from being shot in his apartment. 42 U.S.C.A. § 1983.

1 Cases that cite this headnote

[5] **Municipal Corporations**
Damages

Nevada statute, providing that award for damages in action sounding in tort against officer or employee of State or any political subdivision could not include punitive damages, barred punitive damages arising out of the state claims against individual officers and police department, arising from incident in which plaintiff was shot in his apartment. West's NRSA 41.035(1).

2 Cases that cite this headnote

[6] **Civil Rights**
Exemplary or Punitive Damages

Individual police officers could not be held liable for punitive damages in plaintiff's § 1983 action for use of excessive force arising from being shot by police in his apartment, as officers' conduct did not involve reckless or callous indifference to federally protected rights of others. 42 U.S.C.A. § 1983.

1 Cases that cite this headnote

[7] **Federal Civil Procedure**
Civil rights cases in general

Genuine issue of material fact existed as to whether police officer identified himself as officer prior to ordering plaintiff to drop his gun before shooting him in his apartment, precluding summary judgment on issue of qualified immunity for officer in plaintiff's § 1983 action against officer for use of excessive force. 42 U.S.C.A. § 1983.

Cases that cite this headnote

**Attorneys and Law Firms**

*133 Frank J. Cremen, Esquire, Law Offices of Frank J. Cremen, Las Vegas, NV, for Plaintiffs–Appellants.

Thomas D. Dillard, Jr., Esquire, Olson, Cannon, Gormley & Desruisseaux, Las Vegas, NV, for Defendants–Appellees.

Appeal from the United States District Court for the District of Nevada, Kent J. Dawson, District Judge, Presiding. D.C. No. 2:06–cv–01103–KJD–PAL.

Before: SILVERMAN, CLIFTON and M. SMITH, Circuit Judges.

**MEMORANDUM****

**1 Austin Bryan and the Estate of Glenna Bryan appeal from the district court's summary judgment in their 42 U.S.C. § 1983 excessive force action against the Las Vegas Metropolitan Police Department (METRO police) and four of its officers. We have jurisdiction to hear this appeal under 28 U.S.C. § 1291. Because the parties are familiar with the facts, we do not recount them here except as necessary to explain our decision.

[1] First, the district court did not err by finding that the

three defendants who did not fire at Austin Bryan were entitled to summary judgment because Appellants failed to show that the officers participated in any behavior that caused the deprivation of any right. Officers who are merely present at the time of an unlawful search cannot be held liable under § 1983 without evidence of "either integral participation or personal involvement." *Jones v. Williams,* 297 F.3d 930, 936 (9th Cir.2002). Appellants do not allege that these three officers fired shots or engaged in any other activities that might be construed as excessive force. *See Duran v. City of Maywood,* 221 F.3d 1127, 1131 (9th Cir.2000) (concluding ***134** that uniformed officers did not act unreasonably in walking up a driveway with their guns drawn without announcing their presence when responding to a report that shots had been fired); *see also Billington v. Smith,* 292 F.3d 1177, 1190 (9th Cir.2002) (noting a plaintiff may not "establish a Fourth Amendment violation based merely on bad tactics that result in a deadly confrontation that could have been avoided").

[2] Second, the district court did not err in dismissing Appellants' municipal liability claims after finding that Appellants failed to meet their burden of proving a policy allowing unreasonable use of deadly force. The Appellants do not offer any proof that the METRO police had a policy or practice that showed deliberate disregard for Appellants' constitutional rights, or any proof that a METRO policy or practice was the moving force behind any constitutional violations. *See Gibson v. County of Washoe,* 290 F.3d 1175, 1185 (9th Cir.2002). Thus, the district court was correct in determining that the Appellants' claims against METRO police cannot stand.

[3] Third, the district court did not err in granting summary judgment on Appellants' state law causes of action. The district court, pursuant to Nev.Rev.Stat. § 41.032, granted summary judgment as to the state law claims on the basis of state law discretionary-act immunity, citing *University of Nevada, Reno v. Stacey,* 116 Nev. 428, 997 P.2d 812, 816 (2000). Although this is the correct result, the Nevada Supreme Court has modified its state law discretionary-act immunity doctrine since *Stacey. See Martinez v. Maruszczak,* 123 Nev. 433, 168 P.3d 720 (2007). *Martinez* adopted the general principles of federal jurisprudence as to discretionary-function immunity, *id.* at 727, holding that the actions of state actors are entitled to discretionary-act immunity if their decision (1) involves an element of individual judgment or choice and (2) is based on considerations of social, economic, or political policy, *id.* at 729. The Nevada Supreme Court clarified that "decisions at all levels of government, including frequent or routine decisions, may be protected by discretionary-act immunity, if the decisions require analysis of government policy concerns." *Id.*

****2** Appellees bring state law claims against the METRO police for negligent training and/or supervision. As noted, Nevada looks to federal decisional law for guidance on what type of conduct discretionary immunity protects. *See id.* at 727–28. Our court has held that "decisions relating to the hiring, training, and supervision of employees usually involve policy judgments of the type Congress intended the discretionary function exception to shield." *Vickers v. United States,* 228 F.3d 944, 950 (9th Cir.2000). Because Nevada looks to federal case law to determine the scope of discretionary immunity, and because federal case law consistently holds that training and supervision are acts entitled to such immunity, METRO police is entitled to discretionary immunity on this claim. The actions of the individual officers are also protected under Nev.Rev.Stat. § 41.032, as their handling of the confrontation with Austin Bryan led to discretionary decisions that "were concerning the scope and manner in which [the agency] conducts an investigation," based on the policies of the METRO police, and did not "violate a mandatory directive." *Vickers,* 228 F.3d at 951 (citations omitted).

[4] [5] [6] Fourth, the district court did not err by finding that defendants could not be liable for punitive damages arising out of the state law claims. *City of Newport v. Fact Concerts, Inc.,* 453 U.S. 247, 101 S.Ct. 2748, 69 L.Ed.2d 616 (1981), bars Appellants ***135** for recovering punitive damages in their § 1983 claim against the municipality or the METRO police, and Nev.Rev.Stat. § 41.035(1) bars punitive damages arising out of the state claims for both the individual officers and for the METRO police. Appellants' punitive damages claim against individual officers in their § 1983 claim fail as well, because the officers' conduct did not involve reckless or callous indifference to the federally protected rights of others. *Smith v. Wade,* 461 U.S. 30, 103 S.Ct. 1625, 75 L.Ed.2d 632 (1983).

[7] However, the district court erred in granting summary judgment to Officer Rubio on qualified immunity grounds because a key fact is disputed. The factual dispute is over whether Rubio identified himself as a police officer prior to ordering Bryan to drop his gun and before shooting him. Had Rubio failed to identify himself as a police officer before telling Bryan to drop his gun—as Bryan and his mother claim—Bryan would have had no duty to drop his gun (or else be shot) at the insistence of an unidentified intruder. The existence of this factual dispute was explicitly recognized by the district court but thought not to preclude summary judgment. However, on summary judgment all justifiable inferences must be

viewed in the light most favorable to the nonmoving party. *See Matsushita Elec. Indus. Co. v. Zenith Radio Corp.*, 475 U.S. 574, 587, 106 S.Ct. 1348, 89 L.Ed.2d 538 (1986).

This case is thus similar to *Sledd v. Lindsay*, 102 F.3d 282, 288 (7th Cir.1996), where the Seventh Circuit held the officers were not entitled to qualified immunity under the plaintiff's version of events. There, the plaintiff alleged that the officers broke into his home without announcing themselves and without wearing any police insignia. *Id.* at 285–86. The plaintiff, believing the officers to be unlawful intruders, grabbed his gun and was then shot by the police. *Id.* at 286. The court identified two "crucial" factual questions precluding summary judgment: whether the officers announced their presence and whether they were justified in shooting the plaintiff under the circumstances. *Id.* at 288. The court's holding is readily applicable here: "Given the significance of the disputed issues of fact here, qualified immunity from suit is effectively unavailable, even though after a full trial the officers may yet prevail on the merits." *Id.*

****3** Each party shall bear its own costs on appeal.

**AFFIRMED IN PART, REVERSED AND REMANDED IN PART.**

M. SMITH, Circuit Judge, concurring in part and dissenting in part:

I would uphold the district court's grant of summary judgment as to all defendants, including Officer Rubio. I acknowledge that the district court concluded that "[w]hether the officers actually announced their presence is in dispute." However, the district court also recognized that there were other important, uncontested facts at issue in this case, and understood that we are to analyze such cases with an eye towards "the totality of the facts and circumstances in the particular case." *Blanford v. Sacramento County*, 406 F.3d 1110, 1115 (9th Cir.2005). Specifically, the district court noted that it was undisputed that the officers had a firsthand report that Bryan had threatened an individual with a gun, that Bryan answered the door with his gun pointing out the door, and that Bryan failed to immediately drop his gun to the ground when the officers ordered him to do so. Additionally, Bryan lived in a neighborhood that was so dangerous that his mother slept each night with a gun under her pillow for protection.

***136** I respectfully disagree with the majority's view that the decision in *Sledd v. Lindsay*, 102 F.3d 282 (7th Cir.1996), is similar to this case. In *Sledd*, officers broke into the plaintiff's home while the plaintiff was upstairs preparing to shower. *Id.* at 286. The plaintiff was unaware of the officers' presence until he went downstairs and saw them rushing into his home, armed, and not wearing full uniforms. *Id.* The plaintiff had just run back to his bedroom to tell his fiancee what was happening when he saw a man with a gun standing at his bedroom door, wearing blue jeans, a blue jacket, and white tennis shoes. *Id.* Under those facts, the plaintiff understandably feared that the would-be officers were unlawful intruders and thought to grab his gun to protect himself and his fiancee. *Id.* Moreover, the officers had the opportunity to possibly avoid a conflict by announcing their presence after they entered the home or by not pursuing the plaintiff upstairs.

Officer Rubio did not have the same luxury. The officers rang the doorbell and knocked on Bryan's door, waited outside Bryan's apartment while he answered, and were in uniform. Bryan responded immediately by pointing his gun out the door. Therefore, unlike the officers in *Sledd*, Officer Rubio had a significant reason to question Bryan's motives in brandishing a gun, and to use force in response, in order to possibly save his life, and the lives of his fellow officers.

To evaluate the reasonableness of the force used, we must view the totality of circumstances "from the perspective of a reasonable officer on the scene, rather than with the 20/20 vision of hindsight." *Graham v. Connor*, 490 U.S. 386, 396, 109 S.Ct. 1865, 104 L.Ed.2d 443 (1989). The standard is not one of certainty, but of reasonableness. *See Price v. Sery*, 513 F.3d 962, 971 (9th Cir.2008) (stating that the "touchstone of the inquiry is reasonableness" (internal quotation marks omitted)). Officer Rubio was not required to wait until he was absolutely certain that Bryan was going to shoot him, or his fellow officers. Officer Rubio faced a dangerous situation and had to make a split-second decision. Even if the police did not announce their presence, given the totality of circumstances recited above, I believe that Officer Rubio could have reasonably believed that Bryan "pose[d] a significant threat of death or serious physical injury" to himself and his fellow officers, and that deadly force was justified. *Scott v. Henrich*, 39 F.3d 912, 914 (9th Cir.1994) (internal quotation marks omitted). Accordingly, I am unwilling to second-guess his actions from the comfort of my chambers years after the fact, and I respectfully dissent.

**All Citations**

349 Fed.Appx. 132, 2009 WL 3249742

## Footnotes

* The panel unanimously finds this case suitable for decision without oral argument. *See*Fed. R.App. P. 34(a)(2).

** This disposition is not appropriate for publication and is not precedent except as provided by 9th Cir. R. 36-3.

**End of Document**

# EXHIBIT “D”

# EXHIBIT “D”

2013 WL 7158415
Unpublished Disposition
Only the Westlaw citation is currently available.
An unpublished order shall not be regarded as precedent and shall not be cited as legal authority.
SCR 123.
Supreme Court of Nevada.

Francisco GONZALEZ, an Individual, Appellant,
v.
LAS VEGAS METROPOLITAN POLICE DEPARTMENT, a Political Subdivision of Clark County, Nevada, Respondent.

No. 61120. | Nov. 21, 2013.

**Synopsis**
**Background:** City resident with same name, birthday, height, and eye color as suspect for whom arrest warrant, which was issued by neighboring police department, was outstanding, and who had been arrested 11 times based on warrant, brought action against metropolitan police department asserting claims for negligence, false imprisonment, and seeking injunctive relief. The Eighth Judicial District Court, Clark County, Timothy C. Williams, J., granted summary judgment in favor of police department. Resident appealed.

**Holdings:** The Supreme Court held that:

[1] police officers' actions in detaining and/or arresting city resident with same name, birthday, height, and eye color as suspect for whom facially valid arrest warrant involved individual judgment or choice, as required to establish police department's discretionary-function immunity from suit, and

[2] police officers' actions in detaining and/or arresting city resident with same name, birthday, height, and eye color as suspect for whom facially valid arrest warrant was outstanding was part of course of conduct that involved public policy considerations, as required to establish police department's discretionary-function immunity from suit.

Affirmed.

West Headnotes (2)

[1] **Municipal Corporations**
Police and Fire

Actions of police officers employed by metropolitan police department in detaining and/or arresting city resident with same name, birthday, height, and eye color as suspect for whom facially valid arrest warrant was outstanding a total of eleven times in two year period involved individual judgment or choice, as required to establish police department's discretionary-function immunity from suit; officers were required to make their best educated guess within course of their duties to determine whether city resident was the person named in warrant. West's NRSA 41.032.

1 Cases that cite this headnote

[2] **Municipal Corporations**
Police and Fire

Actions of metropolitan police department officers in detaining and/or arresting city resident with same name, birthday, height, and eye color as suspect for whom facially valid arrest warrant was outstanding a total of eleven times in two year period was part of course of conduct that involved policy considerations, requiring analysis of multiple social, economic, efficiency, and planning concerns including public safety, as required to establish police department's discretionary-function immunity from suit; stops were in furtherance of public policy goals, including apprehension and arrest of wanted criminals. West's NRSA 41.032.

1 Cases that cite this headnote

**Attorneys and Law Firms**

Parker Scheer Lagomarsino

Marquis Aurbach Coffing

### *ORDER OF AFFIRMANCE*

*1 This is an appeal from a district court summary judgment granting immunity in a tort action. Eighth Judicial District Court, Clark County; Timothy C. Williams, Judge.

In November 2007, the North Las Vegas Police Department (NLV) entered a warrant (the NLV warrant) for the arrest of one "Francisco Garcia–Gonzalez" (the wanted man) into the Nevada Criminal Justice Information System for drug trafficking-related charges. Appellant Francisco Gonzalez is a lifelong resident of Las Vegas who has the same name, birthdate, height, and eye color as the information listed for the wanted man in the NLV warrant. Between June 2008, and August 2010, respondent Las Vegas Metropolitan Police Department (LVMPD) detained or arrested Gonzalez at least 11 times based on the NLV warrant. Each incident involved a different LVMPD officer. Only NLV had the ability to modify or edit the NLV warrant. NLV ultimately modified the NLV warrant and since then, Gonzalez has not had any additional incidents with the LVMPD.

As a result of the stops and arrests, Gonzalez filed a complaint against LVMPD and NLV that alleged negligence, false imprisonment, and asserted a claim for injunctive relief. Gonzalez then voluntarily dismissed NLV from the lawsuit for unknown reasons. LVMPD filed a motion for summary judgment on Gonzalez's claims. The district court granted LVMPD summary judgment on three independent grounds: (1) discretionary immunity under NRS 41.032, (2) the existence of probable cause, and (3) the lack of an expert to establish the standard of care for LVMPD's alleged negligence. Gonzalez now appeals.

***The district court properly granted LVMPD's motion for summary judgment based upon discretionary immunity under NRS 41.032***

We review a district court's grant of summary judgment de novo. *Wood v. Safeway, Inc.*, 121 Nev. 724, 729, 121 P.3d 1026, 1029 (2005). Summary judgment is appropriate if the pleadings and other evidence on file, viewed in the light most favorable to the nonmoving party, demonstrate that no genuine issue of material fact remains in dispute and that the moving party is entitled to judgment as a matter of law. *Id.* To withstand summary judgment, the nonmoving party cannot rely solely on general allegations and conclusions set forth in the pleadings, but must instead present specific facts demonstrating the existence of a genuine factual issue supporting his claims. NRCP 56(e); *see also Wood*, 121 Nev. at 731, 121 P.3d at 1030–31. "The substantive law controls which factual disputes are material and will preclude summary judgment; other factual disputes are irrelevant." *Wood*, 121 Nev. at 731, 121 P.3d at 1031.

[1] Gonzalez argues that LVMPD officers should not receive discretionary immunity protection under NRS 41.032 because (1) officers do not use personal judgment or discretion when they stop persons pursuant to arrest warrants because they are only acting under orders, and (2) the officers are not policy makers and the decision to arrest is a routine, day-to-day, operational act entrusted to the LVMPD. Gonzalez relies on *Martinez v. Maruszczak*, 123 Nev. 433, 435–36, 168 P.3d 720, 722 (2007), where this court concluded that a state medical doctor's practice of medicine did not fall within the scope of immunity protections. We disagree.

*2 NRS 41.031 contains Nevada's general waiver of sovereign immunity from civil suits arising from the wrongful acts of state employees. NRS 41.032 sets forth exceptions to Nevada's general waiver of sovereign immunity and provides that no action may be brought against a state officer or employee or any state agency or political subdivision that is:

> Based upon the exercise or performance or the failure to exercise or perform *a discretionary function* or duty on the part of the State or any of its agencies or political subdivisions or of any officer, employee or immune contractor of any of these, whether or not the discretion involved is abused.

NRS 41.032(2) (emphasis added). NRS 41.0336(2) also states that LVMPD is not responsible for "negligent acts" of its officers unless an officer affirmatively causes the harm. Our "application of sovereign immunity under NRS Chapter 41 presents mixed questions of law and fact." *Martinez*, 123 Nev. at 438, 168 P.3d at 724. We review de novo conclusions of law, including statutory construction. *Id.* We "will not disturb a [district] court's findings of fact if supported by substantial evidence." *Id.* at 438–39, 168

P.3d at 724.

In 2007, we adopted the United States Supreme Court's *Berkovitz–Gaubert* two-part test regarding discretionary immunity. *Martinez,* 123 Nev. at 435–36, 445–47, 168 P.3d at 722, 728–29. Thus, a decision is entitled to discretionary immunity under NRS 41 .032 if the decision "(1) involve[s] an element of individual judgment or choice and (2)[is] based on considerations of social, economic, or political policy." *Id.* at 446–47, 168 P.3d at 729. In applying this test, we assess cases on their facts, keeping in mind Congress' purpose "to prevent judicial 'second-guessing' of legislative and administrative decisions grounded in social, economic, and political policy through the medium of an action in tort." *Id.* at 446, 168 P.3d at 729 (quoting *United States v. Varig Airlines,* 467 U.S. 797, 814, 104 S.Ct. 2755, 81 L.Ed.2d 660 (1984)).

We conclude that LVMPD meets the first prong of the *Berkovitz–Gaubert* test because an officer must make his/her best educated guess within the course of their duties to determine whether someone was the right person sought in a warrant. Therefore, LVMPD's actions in detaining and/or arresting Gonzalez pursuant to a facially valid warrant involved an element of individual judgment or choice regarding the scope of its treatment of Gonzalez. *Martinez,* 123 Nev. at 446–47, 168 P.3d at 729.

[2] Immunity attaches under the second criterion "if the injury-producing conduct is an integral part of governmental policy-making or planning, if the imposition of liability might jeopardize the quality of the governmental process, or if the legislative or executive branch's power or responsibility would be usurped." *Martinez,* 123 Nev. at 446, 168 P.3d at 729.[1] NRS 41.032 protects even "frequent or routine decisions ... if [they] require analysis of government policy concerns." *Id.* at 447, 168 P.3d at 729. The district court does not determine a police officer's "subjective intent in exercising the discretion conferred by statute or regulation, but [rather focuses] on the nature of the actions taken and on whether they are susceptible to policy analysis." *Id.* at 445, 168 P.3d at 728 (quoting *United States v. Gaubert,* 499 U.S. 315, 325, 111 S.Ct. 1267, 113 L.Ed.2d 335 (1991)). Therefore, to satisfy the second criterion, we need not consider whether an LVMPD officer "made a conscious decision regarding policy considerations."[2] *Id.* at 446, 168 P.3d 720, 168 P.3d at 728.

*3 We conclude that LVMPD's decision to arrest or detain Gonzalez based on the NLV warrant was part of a policy consideration that required analysis of multiple social, economic, efficiency, and planning concerns including public safety. *See Martinez,* 123 Nev. at 446–47, 168 P.3d at 729; *see also Santiago v. Mass. Dep't of State Police,* No. 11–30248–KPN, 2013 WL 680685, at *9 (D.Mass. Feb.22, 2013) (officers' decisions regarding investigation and when to seek warrants for arrests are based on considerations of public policy). LVMPD's stops were in furtherance of public policy goals, including the apprehension and arrest of wanted criminals pursuant to a facially valid warrant. *See United States v. Gaubert,* 499 U.S. 315, 334, 111 S.Ct. 1267, 113 L.Ed.2d 335 (1991). We further note that Gonzalez does not challenge the facial validity of the NLV warrant.

We also observe that the imposition of liability against LVMPD in this case may jeopardize the quality of the governmental process. *Martinez,* 123 Nev. at 446, 168 P.3d at 729. For example, LVMPD could be faced with the difficult choice between releasing a potential criminal closely matching the description of a valid warrant, or running the risk of potential civil liability in those close cases. Officers must be able to make this decision confidently. Thus, although we are sympathetic to Gonzalez's plight, we conclude that the decision to detain or arrest a person closely matching a warrant's description is the type of decision that discretionary immunity should protect.[3] Therefore, the district court properly granted LVMPD summary judgment because no genuine issue of material fact remained regarding whether LVMPD was entitled to discretionary immunity under NRS 41.032.

Accordingly, we ORDER the judgment of the district court AFFIRMED .[4]

**All Citations**

Slip Copy, 2013 WL 7158415 (Table)

## Footnotes

1 In *Martinez,* we concluded that a state physician was not entitled to immunity for his diagnostic and treatment decisions because they did not include policy considerations. 123 Nev. at 447, 168 P.3d at 729. To hold otherwise would have left many clients and patients with no form of recourse against doctors who fail to act according to their profession's reasonable standard of care. *Id.* at 448, 168 P.3d at 730. It would have also discriminated against indigent patients who make up a greater portion of those seeking treatment from state providers. *Id.* We conclude that this case is not

subject to the same policy concerns as in *Martinez* because injured parties may bring federal suit for violations of 42 U.S.C. § 1983 against officers, including false arrest, malicious prosecution, failure to intervene, discrimination, excessive force, etc. *See generally Sandoval v. Las Vegas Metro. Police Dep't*, 854 F.Supp.2d 860, 871 (D.Nev.2012) ("To sustain an action under § 1983, a plaintiff must prove: (1) that a defendant acted under color of state law; and (2) the conduct deprived the plaintiff of a right secured by the Constitution or laws of the United States.").

2 Acts that involve negligence unrelated to policy objectives do not fall within discretionary immunity. *Martinez*, 123 Nev. at 446, 168 P.3d at 728. "For example, a government employee who falls asleep while driving her car on official duty is not protected by the exception because her negligent judgment in falling asleep cannot be said to be based on the purposes that the regulatory regime seeks to accomplish." *Id.* at 446, 168 P.3d at 729 (internal quotations omitted). In contrast, we conclude that the decision whether to arrest or detain relates to policy objectives and falls within the purpose of Nevada's regulatory scheme, which seeks to apprehend criminals.

3 We accept respondent's representation to this court that measures have been taken to avoid recurrence of the situation which gives rise to this appeal.

4 Because we affirm the district court's order granting summary judgment based on discretionary immunity grounds under NRS 41.032, we decline to consider Gonzalez's remaining arguments.

**End of Document**

# EXHIBIT "E"

# EXHIBIT "E"

2014 WL 605863
Unpublished Disposition
Only the Westlaw citation is currently available.
An unpublished order shall not be regarded as precedent and shall not be cited as legal authority. SCR 123.
Supreme Court of Nevada.

Brad SEIFFERT, Appellant,
v.
CITY OF RENO, Respondent.

No. 60046. | Feb. 13, 2014.

**Attorneys and Law Firms**

Jeffrey Friedman

Reno City Attorney

***ORDER OF AFFIRMANCE***

*1 This is an appeal from a district court summary judgment in a tort action. Second Judicial District Court, Washoe County; Brent T. Adams, Judge.

Appellant brought a negligence action against respondent City of Reno after being injured by crashing his bicycle. Appellant argued that a Reno Police Department (RPD) officer negligently placed police caution tape across a bicycle path without providing adequate warning of the hazard. The City moved for summary judgment based on discretionary immunity, and the district court granted the motion.

This court reviews a district court's summary judgment order de novo. *Wood v. Safeway, Inc.,* 121 Nev. 724, 729, 121 P.3d 1026, 1029 (2005). To receive discretionary-act immunity under NRS 41.032(2), a public employee's decision "must (1) involve an element of individual judgment or choice and (2) be based on considerations of social, economic, or political policy." *Martinez v. Maruszczak,* 123 Nev. 433, 446–47, 168 P.3d 720, 729 (2007). "[D]ecisions at all levels of government, including frequent or routine decisions, may be protected by discretionary-act immunity...." *Id.* at 447, 168 P.3d at 729. A police officer's discretionary decisions concerning the scope and manner of conducting an investigation are immune under NRS 41.032, so long as they are based on police policy and do not violate a mandatory directive. *Sandoval v. Las Vegas Metro. Police Dep't,* 854 F.Supp.2d 860, 880–81 (D.Nev.2012) (concluding that law enforcement officers were entitled to discretionary-act immunity from tort liability under NRS 41.032 because their decision to investigate a possible crime involved judgment based on policy considerations and there was no evidence that the officers violated any mandatory directives during the investigation).

Here, RPD Officer Browett's decision in directing a fire department employee to hang caution tape across a bicycle path to secure pedestrian traffic in the area surrounding where a dead body was found required the officer's individual judgment in assessing the scene. Such a decision involves consideration of policy factors, including protecting public safety by guiding pedestrian and bicycle traffic away from the scene and preserving evidence in the event that the body or other evidence suggested the commission of a crime. In following the RPD's general order, Officer Browett's conduct was based on police policy and did not violate a mandatory directive. This conduct satisfies the elements for discretionary-act immunity and, accordingly, respondent may not be sued on the basis of the officer's actions. *Martinez,* 123 Nev. at 446–47, 168 P.3d at 729. Appellant's argument that hanging the tape was operational, and thus, not within the scope of discretionary-act immunity fails to observe that *Martinez* expressly replaced the planning-versus-operational test with the two-step federal analysis. *Id.* at 443–47, 168 P.3d at 726–29. Appellant has not set forth specific facts demonstrating a genuine dispute with respect to whether respondent's conduct was entitled to immunity under the *Martinez* test. *Wood,* 121 Nev. at 729, 121 P.3d at 1029.

*2 Additionally, appellant's contention that respondent's motion for summary judgment was untimely does not warrant reversal. Where a matter has been submitted for arbitration, dispositive motions must be brought at least 45 days before the arbitration date or the district court "may" foreclose the motion or impose sanctions. NAR 4(E). The rule provides the district court with discretion to impose a remedy for late-filed dispositive motions, but does not require the district court to reject the motion. *See State v. Am. Bankers Ins. Co.,* 106 Nev. 880, 882, 802 P.2d 1276, 1278 (1990) (construing "may" as permissive and "shall" as mandatory, absent contrary legislative intent). In this case, the district court declined to sanction respondent or foreclose respondent's motion for summary judgment. Appellant has provided no legal authority supporting his assertion that this exercise of discretion mandates reversal. *See Edwards v. Emperor's Garden Rest,* 122 Nev. 317, 330 n. 38, 130 P.3d 1280, 1288 n. 38 (2006) (declining to consider claims that are not cogently argued or supported by relevant authority). Accordingly, we

ORDER the judgment of the district court AFFIRMED.[1]

**All Citations**

Slip Copy, 2014 WL 605863 (Table)

## Footnotes

1 In response to respondent's motion to strike, appellant has requested that this court take judicial notice of the disposition of a summary judgment motion in Second Judicial District Court Case No. CV–11–00328. We deny the request for judicial notice. *Mack v. Estate of Mack,* 125 Nev. 80, 91, 206 P.3d 98, 106 (2009) (recognizing the rule that this court generally will not take judicial notice of records in another case); *see also Carson Ready Mix, Inc. v. First Nat'l Bank of Nev.,* 97 Nev. 474, 476, 635 P.2d 276, 277 (1981).

**End of Document**

# EXHIBIT "F"

# EXHIBIT "F"

2008 WL 2168348
Only the Westlaw citation is currently available.

NOTICE: THIS OPINION IS DESIGNATED AS UNPUBLISHED AND MAY NOT BE CITED EXCEPT AS PROVIDED BY MINN. ST. SEC. 480A.08(3).

Court of Appeals of Minnesota.

James TERRELL, as trustee for the heirs and next-of-kin of Talena Terrell, deceased, Appellant,
v.
Brek Andrew LARSON, individually and in his capacity as an Anoka County Sheriff's Deputy, Respondent.

No. A07-870. | May 27, 2008. | Review Denied Aug. 19, 2008.

Anoka County District Court, File No. 02-C4-01-009200.

**Attorneys and Law Firms**

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James T. Martin, Gislason, Martin, Varpness & Janes, P.A., Edina, MN, for respondent.

Considered and decided by ROSS, Presiding Judge; LANSING, Judge; and JOHNSON, Judge.

## UNPUBLISHED OPINION

JOHNSON, Judge.

*1 Talena Terrell died as the result of a collision at the intersection of Highway 65 and County Road 18 in Anoka County when the car she was driving was struck by a pickup truck driven at high speeds by a deputy sheriff in response to a report of a potentially violent domestic dispute. Five years later, Terrell's husband, James Terrell, commenced this lawsuit against Deputy Sheriff Brek Andrew Larson, the driver of the pickup truck. The district court denied Deputy Larson's motion for judgment on the pleadings based on the statute of limitations, but the district court later granted Deputy Larson's motion for summary judgment based on official immunity.

We conclude that Terrell's claim is not time-barred because the applicable statute of limitations was tolled by a federal statute. We further conclude that summary judgment was proper because neither a state statute nor Anoka County policies required Deputy Larson to refrain from responding to the domestic disturbance report or to drive through the intersection at slower speeds. Therefore, we affirm the entry of summary judgment in favor of Deputy Larson.

## FACTS

On the evening of December 29, 2000, at approximately 10:00 p.m., the Anoka County Sherriff's Office (ACSO) received a report of a domestic disturbance in East Bethel. The caller reported that his wife had locked herself and their small child in a room at their residence and had threatened to harm the child. The report was categorized as "level three," which means "very high priority."

Deputy Larson and a trainee, Deputy Shawn Longen, were at the Ham Lake substation when they heard the report. The East Bethel residence was in an area for which Deputy Larson had back-up responsibility. Deputy Larson radioed to the dispatcher to say that he and Deputy Longen would back up the responding squad. A second squad that was closer to the residence notified the dispatcher that it would provide back-up. The dispatcher then radioed to Deputy Larson's squad, saying, "You can cancel." Deputy Larson replied by saying to the second squad and the dispatcher, "We'll continue." The dispatcher reiterated the information by saying, "I covered you." Deputy Larson repeated his earlier statement, "We'll continue."

Deputy Larson rushed toward East Bethel in a sheriff's department pickup truck at speeds as high as 90 to 95 m.p.h. as he drove north on Highway 65, with flashing lights and sirens activated. There was slush on the road that evening. As he approached the intersection with County Road 18 (also known as Crosstown Boulevard), he observed flashing yellow lights, which are located approximately two-tenths of a mile before the intersection, indicating that the stoplight soon would turn red. According to Deputy Larson, he slowed down so that by the time he was halfway between the flashing lights and the intersection, he had reduced his speed to between

30 and 45 m.p.h., but he then accelerated after ascertaining that it was safe to do so. According to certain evidence offered by Terrell (which is discussed in more detail below), Deputy Larson did not slow down as he approached the intersection. In any event, it is undisputed that Deputy Larson proceeded through the intersection after the light had turned red.

***2** At the intersection, Talena Terrell pulled forward into the intersection from east to west after her stoplight turned green. Deputy Larson's pickup truck struck the Terrell car on the driver-side door at an estimated speed of 60 to 65 m.p.h. Tragically, Terrell soon died of injuries sustained in the collision. *See Terrell v. Larson,* 396 F.3d 975, 977 (8th Cir.2005) (en banc).

In July 2001, Talena Terrell's husband, James Terrell, sued Deputy Larson in the United States District Court for the District of Minnesota pursuant to 42 U.S.C. § 1983. The federal district court denied Deputy Larson's motion for summary judgment based on qualified immunity. On February 4, 2005, on interlocutory appeal, the United States Court of Appeals for the Eighth Circuit reversed the district court, holding that Deputy Larson was entitled to qualified immunity. *Terrell,* 396 F.3d at 980-81.On remand, the federal district court dismissed the federal claims in an order dated May 19, 2005, and the state-law claims in a second order, dated August 24, 2005.

On February 1, 2006, approximately five months after the federal district court's dismissal of the state-law claims, Terrell commenced this action against Deputy Larson in the Anoka County District Court. In July 2006, the district court denied Deputy Larson's motion seeking dismissal based on the statute of limitations. But in March 2007, the district court granted Deputy Larson's motion for summary judgment, holding that Deputy Larson's actions were protected under the doctrine of official immunity.

Terrell appeals from the grant of summary judgment in favor of Deputy Larson. By notice of review, Deputy Larson appeals from the district court's denial of his earlier motion for judgment on the pleadings.

## DECISION

### I. Official Immunity

The district court granted Deputy Larson's motion for summary judgment on the ground that his actions were protected by the doctrine of official immunity. Generally, when law enforcement officers respond to emergencies, their conduct is shielded by the doctrine of official immunity because "emergency conditions" offer "little time for reflection" and often involve "incomplete and confusing information" so that the situation requires "the exercise of significant, independent judgment and discretion."*Pletan v. Gaines,* 494 N.W.2d 38, 41 (Minn.1992). But Terrell argues that summary judgment was improper because a state statute and ACSO department policies imposed ministerial duties on Deputy Larson in two ways: first, to discontinue his response to the report upon learning that other squads would respond before him and, second, to slow down and remain at a slow speed while driving through the intersection.

Summary judgment is appropriate where "the pleadings, depositions, answers to interrogatories, and admissions on file, together with the affidavits, if any, show that there is no genuine issue of material fact."*Fabio v. Bellomo,* 504 N.W.2d 758, 761 (Minn.1993)."On appeal, [we] must view the evidence in the light most favorable to the party against whom judgment was granted."*Id.* If there are genuine issues of material fact, such as predicate facts material to the qualified immunity issue, summary judgment will be reversed. *See Thompson v. City of Minneapolis,* 707 N.W.2d 669, 675 (Minn.2006). Furthermore, the applicability of official immunity is a question of law that we review de novo. *Sletten v. Ramsey County,* 675 N.W.2d 291, 299 (Minn.2004).

***3** Under the doctrine of official immunity, "a public official charged by law with duties which call for the exercise of his judgment or discretion is not personally liable to an individual for damages unless he is guilty of a willful or malicious wrong."*Elwood v. Rice County,* 423 N.W.2d 671, 677 (Minn.1988) (quotations omitted). An official may be held liable, however, for injuries resulting from the execution of ministerial duties, which are duties that are "absolute, certain and imperative, involving merely the execution of a specific duty arising from fixed and designated facts."*Id.* (quotations omitted). A ministerial duty may arise from either written policies or unwritten protocols. *See Wiederholt v. City of Minneapolis,* 581 N.W.2d 312, 316 (Minn.1998) (holding that city ordinance imposed ministerial duty on sidewalk inspector to immediately repair broken sidewalk slabs); *Anderson v. Anoka Hennepin Indep. Sch. Dist. 11,* 678 N.W.2d 651, 657-59 (Minn.2004) (holding that unwritten protocol imposed ministerial duty on high school teacher concerning safe operation of table saw). The purpose of the official immunity doctrine is to free officials from the fear of personal liability that might "deter independent action and impair effective performance of their duties."*Elwood,* 423 N.W.2d at 678.

The supreme court recently considered the doctrine of official immunity in two cases arising from accidents caused by law-enforcement vehicles driving at high speeds. In *Thompson v. City of Minneapolis,* a police department policy provided that "officers shall use red lights and siren in a continuous manner for any emergency driving or vehicular pursuit."707 N.W.2d at 674 n. 2. Police officers conducted a high-speed chase without continuously operating their siren and emergency lights, and the driver of the vehicle being chased ran a red light and hit a pedestrian. *Id.* at 671.The supreme court held that the written policy imposed a ministerial duty on officers such that they were not entitled to official immunity from suit for injuries resulting from a failure to comply with the policy. *Id.* at 675.The court reasoned that the police department's policy was "absolute, certain, and imperative" because it left officers no discretion as to whether to operate emergency lights and siren during pursuit of a suspect. *Id.* at 674-75.

Similarly, in *Mumm v. Mornson,* 708 N.W.2d 475 (Minn.2006), the policy at issue provided that officers "shall not initiate a pursuit or shall discontinue a pursuit in progress whenever ... the officer can establish the identification of the offender so that an apprehension can be made at another time unless the crime is" a violent one. *Id.* at 491.The officers confronted a suicidal woman in her therapist's parking lot and pursued her after she drove away.*Id.* at 479.The officers conceded that they knew the driver's identity and did not suspect her of any violent crimes. *Id.* at 491.The supreme court held that the department policy imposed a narrow, definite, and mandatory duty to refrain from, or to discontinue, pursuit. *Id.* at 491-92.Thus, the court held that police officers were not entitled to official immunity when they pursued an identified suspect because a policy prohibited pursuit of the car of a suspect whose identity is known. *Id.* at 492.

*4 The first analytical step when applying the doctrine of official immunity is to determine the governmental conduct at issue. *Id.* at 490.Terrell alleges that Deputy Larson violated ministerial duties on the night of the accident in two ways: first, continuing his response to the report of a domestic disturbance even though other squads were responding and, second, not slowing down but re-accelerating before driving through the intersection. We will discuss each argument in turn.

**A. Deputy Larson's Decision to Respond to Report**

The district court held that Deputy Larson's decision to continue to respond to the domestic-disturbance report was within his discretion and, thus, protected by official immunity. On appeal, Terrell does not challenge Deputy Larson's initial decision to respond to the report. It appears unassailable that Deputy Larson reasonably determined that the report of a domestic disturbance is within the ACSO's definition of "an emergency." But Terrell argues that a written policy of the sheriff department imposed a ministerial duty on Deputy Larson to discontinue his response after he learned that other squads were responding and would arrive at the scene before him.

The ACSO policy manual, in a section entitled "Reasons to Cancel," states as follows:

a. Supervisor advises to cancel

1. Too many squads responding to call

2. Squad responding is leaving an assigned area when a squad for that area is free

b. Central Communications

1. Receives information you are not needed from the complainant, fire, rescue, ambulance, or alarm [ ]

c. Other squads

1. After evaluating scene, the squad on scene may determine no other squads are needed

d. Self

1. Squad problems

2. After checking status of deputies on scene, find out you are not needed

3. The need to respond to another priority call

4. Find higher priority incident while en route

Terrell appears to rely primarily on part (b) by arguing that the dispatcher "cancelled" Deputy Larson's response and that Deputy Larson then had a ministerial duty to discontinue.

This policy did not impose a ministerial duty on Deputy Larson to discontinue his response to the report of a domestic disturbance. As an initial matter, the language used in the policy does not support Terrell's argument that Deputy Larson's response was cancelled by someone else. Rather, the title of the policy-"reasons to cancel"-indicates that the policy merely provides reasons why an officer may decide to cancel his or her own response. This meaning is confirmed by the words used by the dispatcher to Deputy Larson: "you can cancel." Generally, the policy does not contain mandatory language, such as "shall," but, rather, uses language strongly suggesting that an officer may use his or her discretion in deciding whether to cancel his or her own response to an emergency. *Cf. Mumm,* 708 N.W.2d at 491 (holding that ministerial duty applied because policy provided that officers "shall not initiate a pursuit or shall discontinue a pursuit in progress whenever" the offender can be identified); *Thompson,* 707 N.W.2d at 673 (holding that ministerial duty applied because policy provided that "officers shall use red lights and siren in a continuous manner" during pursuit). Thus, the language used in part (b) does not support Terrell's argument that Deputy Larson was required to discontinue his response upon learning from the dispatcher that other squads were responding and would arrive sooner than Deputy Larson. Furthermore, Deputy Larson testified that the call from the dispatcher was not an order to cancel but merely an offer to cancel that he could have accepted. Both Deputy Larson and Deputy Longen testified that only a supervisor on duty could order the squad to cancel. Part (a) of the policy reflects that type of directive.

***5** Terrell relies on an affidavit of an expert witness, Lou Reiter, a former Los Angeles Police Department officer, which was executed in January 2002 for purposes of the federal action. The district court did not mention Reiter's affidavit in its order, and there is no indication that the district court ruled on the admissibility of Reiter's testimony. To the extent that the district court's silence on the matter indicates that it deemed the evidence inadmissible, we would affirm that ruling. Reiter offered the opinion that a "dispatcher's directions to a deputy are binding" because the dispatcher "acts as a 'quarterback.' " He recited an "axiom in law enforcement ... that the directions from the dispatcher are equivalent to a command from the Chief of Police." For these statements, Reiter relied on his "experience as a law enforcement officer and knowledge of standard law enforcement procedures." Reiter's experience with other law-enforcement departments is an insufficient basis for an opinion concerning ACSO protocols that are not stated in its written policies. *See Goeb v. Tharaldson,* 615 N.W.2d 800, 814 (Minn.2000) (stating that, to be admissible, expert testimony must be relevant and helpful to the trier of fact); *Larson v. Anderson, Taunton & Walsh, Inc.,* 379 N.W.2d 615, 620 (Minn.App.1985) (stating that expert testimony "must be based on facts sufficient to form an adequate foundation for an opinion"), *review denied* (Minn. Mar. 14, 1986). Although we do not question Reiter's experience in law enforcement, he did not have a basis to give opinion testimony concerning ACSO policies, especially where that testimony is inconsistent with ACSO written policies, which may be understood by jurors without expert testimony. Thus, we would affirm the district court's implicit conclusion that Reiter's expert testimony is inadmissible. *See*Minn. R. Evid. 702. Furthermore, the district court would have been entitled to conclude that the evidence simply has "no probative value." *DLH, Inc. v. Russ,* 566 N.W.2d 60, 70 (Minn.1997).

We therefore conclude that the applicable ACSO policy did not require Deputy Larson to discontinue his response to the report of a domestic disturbance.

**B. Deputy Larson's Speed**

The district court held that Deputy Larson did not have a ministerial duty to approach the intersection in a particular manner. Terrell contends that Minnesota law and ACSO policies imposed such a ministerial duty on Deputy Larson.

***1. Minn.Stat. § 169.03***

Terrell relies on a statute that provides, in part:

> **Stops.**The driver of any authorized emergency vehicle, when responding to an emergency call, upon approaching a red or stop signal or any stop sign shall slow down as necessary for safety, but may proceed cautiously past such red or stop sign or signal after sounding siren and displaying red lights.

Minn.Stat. § 169.03, subd. 2 (2000). Terrell argues that the words "shall slow down as necessary for safety" imposed a ministerial duty on Deputy Larson, leaving him no discretion to not slow down.

***6** Terrell emphasizes the statute's use of the word "shall," but the phrase "as necessary for safety" is a significant qualifier. That phrase indicates that the degree to which an officer must slow down depends on conditions that the officer perceives at that time. This is a classic example of the use of discretion. The statute further indicates that it may not be "necessary" to slow down at all if "safety" does not require it. Thus, the statute does not create an "absolute, certain, and imperative" duty to slow down, *Elwood,* 426 N.W.2d at 677, which means that Terrell cannot rely on the statute to show that Deputy Larson violated a ministerial duty. *See Travis v. Collett,* 218 Minn. 592, 595, 17 N.W.2d 68, 71 (1944) (interpreting "as necessary" language in section 169.03 to be "an elastic standard" that "plainly does not impose an absolute duty upon the driver of an emergency vehicle to slow down in every situation" upon approaching stop signal). Furthermore, the statute permits an officer to "proceed cautiously," which further indicates that an officer retains discretion as to the speed of his or her vehicle.

Terrell relies on an investigative report prepared by ACSO personnel, which concluded that Deputy Larson "did not slow down when approaching [the] intersection."Deputy Larson argued to the district court, and argues again on appeal, that this statement is inadmissible hearsay and, furthermore, not capable of creating a genuine fact dispute because it is not factually supported by another investigative report or by four witness statements on which the conclusion purportedly is based. The district court did not make a ruling concerning the admissibility of the report. Rather, the district court concluded that it was unworthy of any weight because the materials on which the report is based do "not indicate that any of the witnesses ever told investigators that Larson failed to slow down when he approached the intersection."In any event, to resolve Terrell's argument based on section 169.03, subdivision 2, it is unnecessary to determine whether Deputy Larson actually slowed down before reaching the intersection. What is significant is that the statute afforded him the discretion to decide whether to slow down, and if so, how much.

***2. ACSO Department Policies***

Terrell also contends that Deputy Larson had a ministerial duty to slow down at the intersection because of department policies. On appeal, Terrell cites both written and unwritten policies.

***a. Written Policies***

Section 4100:213 of the ACSO Policy Manual provides, "Pursuant to Minnesota Statutes 169.03, when a member is responding to an emergency, he/she shall slow down when approaching a controlled intersection where the deputy will be disregarding traffic controls and proceed cautiously."The language of the independent clause of this sentence is similar to Minn.Stat. § 169.03, subd. 2, though not identical. The introductory phrase ("Pursuant to Minnesota Statutes 169.03, ...") indicates that the policy is intended merely to incorporate the terms of the statute, which, as stated above, require an officer to "slow down *as necessary for safety.*" Minn.Stat. § 169.03, subd. 2 (emphasis added); *see also Travis,* 218 Minn. at 595, 17 N.W.2d at 71.We believe that the most reasonable interpretation of this policy is that it simply reiterates the requirements of the state statute.

*7 In addition to the textual reasons for this interpretation, a contrary interpretation would tend to eviscerate the general purpose of the official immunity doctrine. A governmental entity's internal policy does not necessarily create a ministerial duty; such a policy merely "can influence whether a duty is classified as ministerial or discretionary."*Mumm,* 708 N.W.2d at 491.Furthermore, the supreme court has suggested that the official immunity doctrine should not hinge on a literal parsing of statutes when applied to "public employees driving on emergency missions."*Kari v. City of Maplewood,* 582 N.W.2d 921, 925 (Minn.1998) (asking "whether the [allegedly] wrongful act" of a paramedic who struck a pedestrian while responding to an emergency "so unreasonably put at risk the safety and welfare of others that as a matter of law it could not be excused or justified"). The supreme court noted that to deny official immunity "would have a chilling effect on the discretion to be exercised by emergency vehicle drivers en-route to medical emergencies, and would conflict with our well-established law respecting the independent judgment that must be exercised by public servants in emergency situations."*Id.* at 925.In this case, an overly literal interpretation of section 4100:213 of the ACSO Policy Manual would penalize officers of law-enforcement agencies that take care to adopt policies to promote safety and thereby discourage such written policies, which generally assist officers in the exercise of their discretion and enhance public safety.

If Terrell were correct that the written policy imposed a ministerial duty by stating that an officer "shall slow down," without qualification, such an interpretation would beg the question whether Deputy Larson did slow down as he approached the intersection. The district court record contains excerpts from the transcripts of the depositions of both Deputy Larson and Deputy Longen. When asked about his speed approaching the intersection, Deputy Larson testified that he "started slowing down as soon as the yellow indicator lights came on."Deputy Longen testified that after the indicator light turned yellow, "We started to decelerate as we approached the intersection."

Terrell relies on the ACSO internal investigative report, which concluded that Deputy Larson violated section 4100:213 because he did not "slow down" and did not "proceed cautiously." This conclusion is based on a prior report prepared by a state trooper, who conducted an accident reconstruction. According to the ACSO internal report, the state trooper concluded that Deputy Larson's vehicle "did not appear to be 'slowing' on approach."Based on that conclusion, but apparently without reviewing the four witness statements on which the trooper's conclusion was purportedly based, the ACSO investigative report reached the same conclusion, that Deputy Larson "did not slow down when approaching [the] intersection."The ACSO report also concluded that Deputy Larson violated a written policy concerning "judgment" because he "did not use good judgment in carrying out his duties and responsibilities" and did not "properly weigh [ ] the consequences of his actions."

*8 In his reply papers filed in the district court, Deputy Larson challenged both the admissibility and the evidentiary weight of the investigative report. Deputy Larson submitted copies of the four witness statements on which the investigative report purportedly was based to show that the four witnesses did not say that Deputy Larson did not slow down. Deputy Larson's inadmissibility argument implicates Minn. R. Evid. 803(8), which governs "public records and reports." The rule no doubt applies and makes the report presumptively admissible. *See*Minn. R. Evid. 803. But the rule makes an exception when "sources of information or other circumstances indicate lack of trustworthiness."Minn. R. Evid. 803(8). Although Deputy Larson brought this exception to the attention of the district court, the district court did not exclude the report, either in whole or in part, nor did the district court make any ruling concerning admissibility. Because we review evidentiary rulings for an abuse of discretion, *see Kroning v. State Farm Auto. Ins. Co.,* 567 N.W.2d 42, 45-46 (Minn.1997), we will not overturn the district court's implicit ruling by holding that this part of the report is inadmissible.

Accepting, for purposes of our analysis, that the report is admissible to the extent that the investigator stated that Deputy Larson did not slow down (and this part of our analysis assumes a very strict interpretation of section 4100:213), the district court was not required to credit all statements contained in the ACSO report. In reasoning that the report did not create a genuine issue of material fact, the district court quoted from one of our prior cases, which stated that a party opposing summary judgment must offer more than "evidence which merely creates a metaphysical doubt as to a factual issue and which is not sufficiently probative with respect to an essential element of [the] case to permit reasonable persons to draw different conclusions."*Gunderson v. Harrington,* 632 N.W.2d 695, 703 (Minn.2001) (quotation omitted). We believe that the district court properly analyzed the evidence. The investigative materials in the evidentiary record were internally inconsistent. The district court properly concluded that it would be unreasonable for a factfinder to rely on the conclusory statements in the ACSO investigative report while rejecting the underlying materials on which it is purportedly based where the underlying materials do not in fact provide factual support for the report. *See DLH,* 566 N.W.2d at 73 n. 9 (stating that reliance on "internally inconsistent" evidence would be "misplaced"); *Oreck v. Harvey Homes, Inc.,* 602 N.W.2d 424, 429 (Minn.App.1999) (holding that affidavit that contradicted deposition testimony did not create material fact issue), *review denied* (Minn. Jan. 25, 2000).

Thus, even if section 4100:213 were interpreted to require an officer to slow down for every intersection when responding to an emergency, without regard for whether slowing down is "necessary for safety," Terrell's evidence nonetheless is insufficient to defeat official immunity. As a matter of law, the investigatory report does not create a genuine issue of material fact as to whether Deputy Larson slowed down as he approached the intersection. Rather, based on the deposition testimony of Deputy Larson and Deputy Longen, the evidentiary record supports only one conclusion on the issue-that Deputy Larson *did* slow down as he approached the intersection. Thus, Deputy Larson did not violate the ministerial duty that arguably was imposed on Deputy Larson by section 4100:213 of the ACSO Field Manual.

***b. Unwritten Protocols***

*9 Terrell refers to several other portions of the internal investigative report in an attempt to show that Deputy Larson did not adhere to certain unwritten standards concerning how slowly an officer should drive when approaching an intersection. Specifically, Terrell relies on a portion of the investigative report that recites the unsworn statement of Deputy Robert Elmer, who was the ACSO field training officer who trained Deputy Larson and other ACSO deputies. Deputy Elmer informed the ACSO investigator that Deputy Larson was trained to slow "to almost a stop ... and then crawl through the intersection at a speed of approximately 10 to 20 mph." Terrell also relies on a portion of the investigative report that recites the unsworn statement of Dave Schultz, the director of the Minnesota Highway Safety Center. Schultz apparently provided training to Deputy Larson at the Alexandria Technical College in 1995, approximately three years before Deputy Larson joined the ACSO. Schultz stated that he trained Deputy Larson and others to slow down enough so that one "can stop immediately." In Mr. Schultz's opinion, "that is a maximum speed of 15 mph."

On appeal, Terrell argues that this training regime evidences an unwritten protocol of the ACSO that imposed a ministerial duty on Deputy Larson that he breached. *See Anderson,* 678 N.W.2d at 657-58 (holding that staff practice created unwritten, established "protocol" regarding the use of a table saw, which imposed a ministerial duty on shop teacher). But Terrell did not present *any* argument to the district court concerning *unwritten* protocols. In his memorandum opposing Deputy Larson's motion for summary judgment, Terrell relied solely on *written* policies of the ACSO. In neither the statement of facts nor in the argument of his responsive memorandum did Terrell even mention these portions of the investigative report. The responsive memorandum did contain a brief statement that "Plaintiff refers the [District] Court to its submissions that comprise the record ..., which are incorporated as if fully set forth herein."But this statement is not a substitute for argument based on the applicable facts and the applicable law. It is a well-established general rule that this court does not consider arguments that were not made in the district court. *Thiele v. Stich,* 425 N.W.2d 580, 582 (Minn.1988).

Nonetheless, even if we were to address Terrell's argument based on alleged unwritten protocols, we would reject it. In the absence of an evidentiary ruling by the district court with respect to Deputy Larson's training, this court would need to determine in the first instance the admissibility of that evidence. Although the investigator's statements in his report may be admissible hearsay, *see*Minn. R. Evid. 803(8), the statements of Deputy Elmer and Schultz constitute a second level of hearsay. No exception to the hearsay rule is apparent for the second level.

***10** Even if the statements of Deputy Elmer and Schultz were admissible, the evidence would be insufficient to establish that the information communicated during Deputy Elmer's training was an unwritten protocol that had been adopted by the decisionmaking structure of the ACSO or was well accepted throughout the department, as opposed to merely reflecting Deputy Elmer's personal views. The statement of Schultz is even more tenuous a basis for such a conclusion because he apparently is not a member of the ACSO and because he stated that it was his own "opinion." It also is unclear whether Deputy Elmer and Schultz sought to induce conduct in strict conformance with their instructions or whether, in an abundance of caution, they encouraged their pupils to engage in conduct that went further than what was required by law, or whether they suggested impractical standards in the hope that their pupils would attain partial compliance. All in all, Terrell's evidence of an unwritten protocol is far weaker than the evidence in *Anderson,* where the record contained consistent testimony by the defendant's direct supervisor, another co-employee, and the defendant's own admission that "this is the way that it is done" and "[i]t's the way it's done throughout the [school] district."678 N.W.2d at 657-58.Thus, the statements of Deputy Elmer and Schultz, even if admissible, would not establish an unwritten protocol of the ACSO that imposed a ministerial duty on Deputy Larson to slow down to "almost to a stop," "approximately 10 to 20 mph," or "a maximum speed of 15 mph" as he approached the intersection. Moreover, a ministerial duty based on the alleged unwritten protocol would be inconsistent with *Kari,* where the supreme court focused on "whether the [allegedly] wrongful act so unreasonably put at risk the safety and welfare of others that as a matter of law it could not be excused or justified."582 N.W.2d at 925.

In sum, Terrell's evidence is insufficient to prove that Deputy Larson was required to comply with a ministerial duty. Thus, he was exercising his discretion when he engaged in the conduct for which Terrell seeks to hold him liable.

**C. Willful and Malicious Exception**

In two sentences, Terrell briefly argues that Deputy Larson's conduct was willful and malicious because he did not discontinue his response to the report and because he accelerated as he approached the intersection. Such a finding would remove the protection of the official immunity doctrine. *Rico v. State,* 472 N.W.2d 100, 107 (Minn.1991). Terrell, however, does not develop the argument with legal analysis or citations to case law. The district court made a brief, conclusory statement that "the evidence is insufficient to support a claim that the manner in which Larson approached the intersection makes him guilty of a 'willful' or 'malicious' wrong."But this statement was gratuitous because Terrell did not even make any argument to the district court concerning willfulness or malice. Because Terrell did not make the argument in the district court, and because he has not made a complete argument on appeal, we decline to consider the issue. *See Thiele,* 425 N.W.2d at 582; *Schoepke v. Alexander Smith & Sons Carpet Co.,* 290 Minn. 518, 519-20, 187 N.W.2d 133, 135 (1971) ("An assignment of error based on mere assertion and not supported by any argument or authorities in appellant's brief is waived and will not be considered on appeal unless prejudicial error is obvious on mere inspection."). In any event, the evidence plainly is insufficient to prove that Deputy Larson acted willfully and maliciously when he collided with Ms. Terrell.

### II. Limitations and Tolling

*11 Deputy Larson argues that the district court erred by denying his motion for judgment on the pleadings, which argued that Terrell's action is untimely. We review a denial of a motion to dismiss on the pleadings de novo.*Larson v. Wasemiller,* 738 N.W.2d 300, 303 (Minn.2007). The construction and applicability of a statute of limitations is a question of law that we review de novo. *Benigni v. County of St. Louis,* 585 N.W.2d 51, 54 (Minn.1998).

A three-year limitations period applies to Terrell's action. Minn.Stat. § 573.02, subd. 1 (2000). Larson argues that Terrell did not satisfy the three-year limitations period because he commenced his state-court action more than five years after the accident. But Terrell cites a federal statute that provides:

> The period of limitations for any claim asserted under [supplemental jurisdiction], and for any other claim in the same action that is voluntarily dismissed at the same time as or after the dismissal of the claim under [supplemental jurisdiction], shall be tolled *while the claim is pending and for a period of 30 days after it is dismissed* unless State law provides for a longer tolling period.

28 U.S.C. § 1367(d) (emphasis added). This federal statute applies because the federal courts had supplemental jurisdiction over Terrell's state-law claims before declining to exercise that jurisdiction and dismissing those claims. In *Rothmeier v. Investment Advisers, Inc.,* 556 N.W.2d 590 (Minn.App.1996), *review denied* (Minn. Feb. 26, 1997). this court held that because the plaintiff had asserted a state-law whistleblower claim in federal court along with a federal age-discrimination claim, section 1367(d)"tolled [the] whistleblower claim while the age discrimination claim was pending in federal court."*Id.* at 593.

Here, the accident occurred in December 2000. Terrell asserted his state-law negligence claim no later than February 2002, when his third amended complaint was filed. That filing occurred approximately 14 months after the accident. Under section 1367(d), the limitations period on Terrell's state-law claim was tolled until the federal district court dismissed that claim in August 2005. Terrell commenced the present action in the Anoka County District Court approximately five months later, in January 2006. Thus, no more than approximately 19 months elapsed between the accident and the commencement of Terrell's state-court action, not counting the three-and-one-half years in which the state-law claims were pending in federal court. Because Terrell commenced his state-court action well within the three-year limitations period in Minn.Stat. § 573.02, his claim is not time-barred.

**Affirmed.**

**All Citations**

Not Reported in N.W.2d, 2008 WL 2168348

**End of Document**

**IN THE SUPREME COURT OF THE STATE OF NEVADA**

* * * *

| | |
|---|---|
| JAPONICA GLOVER-ARMONT,<br><br>APPELLANT,<br><br>VS.<br><br>JOHN CARGILE; CITY OF NORTH LAS VEGAS, A MUNICIPAL CORPORATION EXISTING UNDER THE LAWS OF THE STATE OF NEVADA IN THE COUNTY OF CLARK;<br><br>RESPONDENTS. | CASE NO.: 70988 |

Electronically Filed
May 23 2017 08:42 a.m.
Elizabeth A. Brown
Clerk of Supreme Court

APPEAL FROM ORDER GRANTING RECONSIDERATION OF DEFENDANTS' MOTION FOR SUMMARY JUDGMENT
AND
APPEAL FROM ORDER GRANTING SUMMARY JUDGMENT
EIGHTH JUDICIAL DISTRICT COURT, CLARK COUNTY, NEVADA
HONORABLE WILLIAM KEPHART, DISTRICT JUDGE

# **APPELLANT'S APPENDIX**

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MARJORIE HAUF, ESQ.
Nevada Bar No. 8111
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*Attorneys for Appellant*

## CHRONOLOGICAL INDEX TO APPENDIX




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| No. | Document | Date | Vol. | Page Nos. |
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| 14. | Plaintiff's Fourth Supplemental Early Case Conference Report | October 22, 2015 | 2 | 0406-0426 |
| 15. | Defendants' Motion for Summary Judgment | December 22, 2015 | 2 | 0427-0475 |
| 16. | Plaintiff's Opposition to Defendants' Motion for Summary Judgment | January 11, 2016 | 3 | 0476-0664 |
| 17. | Defendants' Reply in Support of Motion for Summary Judgment | January 26, 2016 | 4 | 0665-0671 |
| 18. | Transcript of Hearing Motion for Summary Judgment February 2, 2016 | February 2, 2016 | 4 | 0672-0702 |
| 19. | Defendants' Supplemental Brief In Support of Motion for Summary Judgment | February 23 2016 | 4 | 0703-0707 |
| 20. | Plaintiff's Supplemental Opposition to Motion for Summary Judgment | February 23 2016 | 4 | 0708-0860 |
| 21. | Transcript of Hearing Motion for Summary Judgment March 1, 2016 | March 1, 2016 | 4 | 0861-0884 |
| 22. | Defendants' Motion to Reconsider | April 7, 2016 | 4 | 0885-0890 |
| 23. | Plaintiff's Opposition to Motion to Reconsider | April 27, 2016 | 4 | 0891-0897 |
| 24. | Defendants' Reply in Support of Motion to Reconsider | May 24, 2016 | 5 | 0898-0903 |

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| 25. | Transcript Hearing- Defendants' Motion to Reconsider, Plaintiff's Motion in Limine Nos. 1 through 8, Defendants' Omnibus Motion in Limine | May 31, 2016 | 5 | 0904-0926 |
| 26. | Order granting Defendants' Motion to Reconsider and Motion for Summary Judgment | July 5, 2016 | 5 | 0927-0929 |
| 27. | Memorandum of Costs and Disbursements | July 6, 2016 | 5 | 0930-0955 |
| 28. | Notice of Entry of Order Motion for Reconsideration and Summary Judgment | July 6, 2016 | 5 | 0956-0959 |
| 29. | Plaintiff's Motion to Retax Costs | July 11, 2016 | 5 | 0961-0968 |
| 30. | Defendants' Opposition to Plaintiff's Motion to Retax Costs | July 20, 2016 | 5 | 0969-0972 |
| 31. | Plaintiff's Notice of Appeal | August 3, 2016 | 5 | 0973-1005 |
| 32. | Order and Judgment- Motion to Retax Costs | October 6, 2016 | 5 | 1006-1007 |
| 33. | Stipulation and Order to Stay Execution of the Judgment Pending the Appeal | October 27, 2016 | 5 | 1008-1009 |

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**DISTRICT COURT**

**CLARK COUNTY, NEVADA**

JAPONICA GLOVER-ARMONT,

Plaintiff,

vs.

JOHN CARGILE; CITY OF NORTH LAS VEGAS, a Municipal Corporation existing under the laws of the State of Nevada in the County of Clark; DOES I through X, inclusive; and/or ROE CORPORATIONS I through X, inclusive,

Defendants.

CASE NO.: A-13-683211-C
DEPT NO.: XIX

**PLAINTIFF'S REBUTTAL EXPERT DISCLOSURE**

Plaintiff, JAPONICA GLOVER-ARMONT, by and through her attorney, MARJORIE HAUF, ESQ., of the law firm of GANZ & HAUF, hereby produces her List of Expert Witnesses pursuant to Rule 16.1 of the Nevada Rules of Civil Procedure as follows (said witnesses are expected to testify in person at the time of trial of this matter, however, Plaintiff reserves the right to use each of the below-listed experts as well as those previously listed experts' respective deposition(s) in place of their live testimony, if the circumstances warrant said use):

///

## I. EXPERT WITNESSES

1. Raimundo Leon, M.D.
   Advanced Pain Consultants
   2650 Crimson Canyon Drive
   Las Vegas, Nevada 89128

Raimundo Leon, M.D. is a Nevada licensed doctor, Board-certified and Fellowship-trained in pain medicine and anesthesiology, who will provide testimony regarding causation and damages issues. He is expected to testify as to the nature, extent and cause of the injuries suffered by Japonica Glover-Armont; the past medical treatment provided for her; the future medical treatment needed; the amount, necessity, and reasonableness of the charges for the past and future medical treatment; and that the charges for the past and future medical treatment are within the usual and customary charges in the community. Dr. Leon's testimony may also include expert opinions as to whether Ms. Glover-Armont has any restrictions of activities, including work activities, and Ms. Glover-Armont's life expectancy. Dr. Leon's opinions are expected to be consistent with his reports. Dr. Leon will also rebut the opinions of Defendants' experts, if any.

Dr. Leon has authored medical records which have been produced in Plaintiff's Production of Documents and Witness List Pursuant to NRCP 16.1 and any supplements thereto. The exhibits to be used as a summary of support for Dr. Leon's opinions are Ms. Glover-Armont's medical records, billing, all deposition testimony in this case, Ms. Glover-Armont's radiographic studies, films, and reports, all expert reports, his evaluation of Ms. Glover-Armont, as well as the report produced in Plaintiff's Second Supplemental Production of Documents and Witness List Pursuant to NRCP 16.1., as Exhibit 13 served concurrently herewith.

Dr. Leon was provided with the following records:

- Complaint;
- Answer;
- Traffic Accident report with photographs;
- Advanced Care Emergency Services;
- North Vista Hospital;
- Medic West Ambulance Services;

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- Matt Smith Physical Therapy;
- Las Vegas Radiology;
- Sams Club Pharmacy;
- Estimate & photos of Defendant's Truck; and
- Photographs of Plaintiff's Car;
- North View Hospital Medical Records;
- Defendants' Answer to Request for Production of Documents;
- Defendant City of North Las Vegas Answers to Request for Admissions;
- Defendant City of North Las Vegas Answers to Interrogatories
- Defendant John Cargiles' Answers to Request for Admissions;
- Defendant John Cargiles' Answers to Interrogatories;
- Plaintiff's responses to Defendants' Interrogatories;
- Plaintiff's response to Request for Production of Documents; and
- Deposition of Japonica Glover-Armont.

Dr. Leon's fee schedule is as follows: $1,500 per hour for deposition testimony; $5,000 per half day, plus travel expenses, for trial testimony; and $10,000, plus travel expenses, for an entire day of trial testimony. A copy of Dr. Leon's curriculum vitae, prior testimony list, and fee schedule produced in Plaintiff's Second Supplemental Production of Documents and Witness List Pursuant to NRCP 16.1., as Exhibit 14. **Dr. Leon may also offer rebuttal opinions to any of Defendants' experts.**

2. Sam Terry
Exhibit-A
PO Box 53011
Henderson, NV 89053

Mr. Terry is an engineer specializing in automobile collision analysis, reconstruction and vehicle dynamics. Mr. Terry will testify regarding the accident at issue and his testimony will be consistent with his report. Mr. Terry's report is attached as Exhibit 15 in Plaintiff's Second Supplemental Early Case Conference Report. His fee schedule, testimony list and curriculum vitae attached as Exhibit 16 in Plaintiff's Second Supplemental Early Case Conference Report, served concurrently herewith.

Mr. Terry was provided the following records:

- Complaint;
- Answer;

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- Traffic Accident report with photographs;
- Defendant's Estimate;
- Photos of Defendant's Truck;
- Notice of Claim to City;
- Maintenance records for Defendant's truck;
- Pictures of site;
- Defendants' Answer to Request for Production of Documents;
- Defendant City of North Las Vegas Answers to Request for Admissions;
- Defendant City of North Las Vegas Answers to Interrogatories
- Defendant John Cargiles' Answers to Request for Admissions;
- Defendant John Cargiles' Answers to Interrogatories;
- Plaintiff's responses to Defendants' Interrogatories;
- Plaintiff's response to Request for Production of Documents;
- Photographs of Plaintiff's Car;
- Advanced Pain Consultants Medical Records;
- Dr. Leon's Medical Record Review;
- North Vista Hospital Medical Records; and
- Deposition of Japoinca Glover-Armont.

Mr. Terry's fee schedule is as follows: $365.00 per hour for deposition testimony and $365.00 per hour for trial testimony. **Sam Terry may also offer rebuttal opinions to any of Defendants' experts.**

3. Officer Jim Byrne, ID # 956
c/o North Las Vegas Police Department
2332 Las Vegas Blvd. North, Ste. 200
North Las Vegas, NV 89030

This non-retained witness is expected to give expert and rebuttal testimony and opinions regarding the nature, causation and investigation of the subject incident and testimony regarding the conditions, weights, speeds, distances, measurements, parties' perceptions and times as they relate to this accident. He is expected to also review documents outside his report for the purpose of providing and defending those opinions. The qualifications of this witness are that he is a trained police officer in accident investigation with the North Las Vegas Police Department. This witness' fee is as proscribed in NRCP 45(b)(1).

...

...

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## III. NON-RETAINED PHYSICIANS AND WITNESSES

The following non-retained physicians and witnesses are expected to give opinions regarding the treatment of Plaintiff at their respective facilities, the authenticity of the records for said treatment, the necessity of treatment rendered, and the causation of the necessity for the medical treatment rendered. Their opinions shall include the cost of past medical care, diagnostic testing, surgery and medication; the cost of future medical care, diagnostic testing, surgery and medication; and whether those past and future medical costs fall within the ordinary and customary charges in the community for similar medical care and treatment:

1. Patrick Flores M.D.
   The Person Most Knowledgeable and/or
   The Custodian of Records for
   Advanced Care Emergency Services
   P.O. Box 30102 Dept. 300
   Salt Lake City, UT 84130-0102

2. Patrick Flores, M.D.
   The Person Most Knowledgeable and/or
   The Custodian of Records for
   North Vista Hospital
   1409 E. Lake Mead Blvd.
   N. Las Vegas, NV 89030

3. The Person Most Knowledgeable and/or
   The Custodian of Records for
   Medicwest Ambulance Service
   9 W. Delhi Ave
   North Las Vegas, NV 89030

4. Michael McKay, DPT,
   Mark Mateja, PT
   The Person Most Knowledgeable and/or
   The Custodian of Records for
   Matt Smith Physical Therapy
   3155 W. Craig Rd., Ste 140
   N. Las Vegas, NV 89132

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Las Vegas, NV 89147
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5. Bhuvana Kittusamy, M.D.
The Person Most Knowledgeable and/or
The Custodian of Records for
Las Vegas Radiology
7500 Smoke Ranch Rd. Ste 1
Las Vegas, NV 89128

6. Raimundo Leon, M.D.
The Person Most Knowledgeable and/or
The Custodian of Records for
Advanced Pain Consultants
2650 Crimson Canyon Dr.
Las Vegas, NV 89128

7. The Person Most Knowledgeable and/or
The Custodian of Records for
Sam's Club Pharmacy
2650 E. Craig Rd
Las Vegas, NV 89081

8. Patrick Flores, D.O.
The Person Most Knowledgeable and/or
The Custodian of Records for
Advanced Care Emergency Services

Dated this 20th day of March, 2015.

GANZ & HAUF

Ida Ybarra

MARJORIE HAUF, ESQ.
Nevada Bar No. 8111
IDA M. YBARRA, ESQ.
Nevada Bar No. 11327
8950 W. Tropicana Ave., Suite 1
Las Vegas, Nevada 89147
Attorney for Plaintiff

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## CERTIFICATE OF E-SERVICE

Pursuant to NRCP 5(b) and EDCR 7.26, I certify that on this date, I served the foregoing **PLAINTIFF'S REBUTTAL EXPERT DISCLOSURE** on all parties via wiznet:

Christopher Craft, Esq.
Deputy City Attorney
2250 Las Vegas Blvd Ste 810
North Las Vegas, NV 89030

Dated this 20th day of March, 2015.

An employee of the law firm of GANZ & HAUF

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Las Vegas, NV 89147
Phone: (702) 598-4529
Fax: (702) 598-3626

DOEW
NORTH LAS VEGAS CITY ATTORNEY
Sandra Douglass Morgan, Nev. Bar No. 8582
City Attorney
Christopher D. Craft, Nev. Bar No. 7314
Deputy City Attorney
2250 Las Vegas Blvd. North, Suite 810
North Las Vegas, Nevada 89030
Telephone: (702) 633-1050
Facsimile: (702) 649-8879
*Attorneys for Defendants*
*John Cargile and City of North Las Vegas*

**DISTRICT COURT**

**CLARK COUNTY, NEVADA**

JAPONICA GLOVER-ARMONT,

Plaintiff,

vs.

JOHN CARGILE; CITY OF NORTH LAS VEGAS, a Municipal Corporation existing under the laws of the State of Nevada in the County of Clark; DOES I through X, inclusive; and/or ROE CORPORATIONS I through X, inclusive,

Defendants.

Case No. A-13-683211-C

Dept. No. XIX

**CITY OF NORTH LAS VEGAS'S DESIGNATION OF REBUTTAL EXPERT WITNESSES PURSUANT TO N.R.C.P. 16.1(a)(2)**

Defendants JOHN CARGILE and CITY OF NORTH LAS VEGAS (collectively "City"), by and through its counsel, Christopher D. Craft of the North Las Vegas City Attorney's Office, and hereby designates the following rebuttal expert witness pursuant to N.R.C.P. 16.1(a)(2):

**REBUTTAL EXPERT WITNESSES**

1. David M. Ingebretsen
COLLISION FORENSICS AND ENGINEERING, INC.
2469 E. Fort Union Blvd., Suite 114
Salt Lake City, UT 84121
Phone: (801) 733-5458
Email: CFANDE.com

Mr. Ingebretsen is an expert in accident reconstruction and biomechanical engineering. Mr. Ingebretsen will testify regarding his report and the attached documents.

## DOCUMENTS

1. Expert Report, Curriculum Vitae, Rate Sheet, Rule 26 Case Deposition Record, (4) MPEG Animation Clips (see attached DVD).

The City reserves its right to supplement this designation as needed.

DATED this 1st day of April, 2015.

NORTH LAS VEGAS CITY ATTORNEY

*/s/ Christopher D. Craft*

Sandra Douglass Morgan, Nev. Bar No. 8582
Christopher D. Craft, Nev. Bar No. 7314
2250 Las Vegas Blvd. North, Suite 810
North Las Vegas, Nevada 89030
Telephone: (702) 633-1050
*Attorneys for Defendant City of North Las Vegas*

## CERTIFICATE OF SERVICE

I HEREBY CERTIFY that service of a true and correct copy of the **CITY OF NORTH LAS VEGAS'S DESIGNATION OF REBUTTAL EXPERT WITNESSES PURSUANT TO N.R.C.P. 16.1(a)(2)** was made on the 1st day of April, 2015, as indicated below:

_√_ By electronic service, pursuant to N.E.F.C.R. 9

_√_ By first class mail, postage prepaid from Las Vegas, Nevada pursuant to N.R.C.P. 5(b) addressed as follows

___ By facsimile, pursuant to EDCR 7.26 (as amended)

___ By hand delivery

To the parties listed below:

Marjorie Hauf, Esq.
Ida M. Ybarra, Esq.
GANZ & HAUF
8950 W. Tropicana Avenue, Ste. 1
Las Vegas, Nevada 89147
Facsimile (702) 598-3626

*Attorneys for Plaintiff*

/s/ Michelle Harrell
An Employee of North Las Vegas
City Attorney's Office

David M. Ingebretsen
Ronald L. Probert
Michael S. Anderson

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Salt Lake City, UT 84121
(801) 733-5458 – FAX: (801) 733-5491
www.CFandE.com

Collision Forensics and Engineering, Inc.

March 26, 2015

Sandra Douglass Morgan, Esq.
Christopher D. Craft, Esq.
North Las Vegas City Attorney
2250 Las Vegas Blvd. North, Suite 810
North Las Vegas, NV 89030

RE: ***Glover v. Cargile, City of North Las Vegas***

Dear Ms. Morgan and Mr. Craft:

I completed my initial analysis of this incident and submit this report for your consideration. I used standard methods and techniques of investigation as well as applying fundamental principles of engineering, physics, and biomechanics. In brief, I have a bachelor's degree in mechanical engineering, a master's of science degree in physics, and a master's of engineering degree in bioengineering. This education affords me a unique perspective regarding how people interact with and are affected by our surrounding environment. The course work and my experience in mechanical engineering covered concepts of statics, dynamics, solid mechanics, material science, etc. This education and experiences was augmented by my graduate work in physics and bioengineering. My education and experience in physics extended the foundations of mechanical engineering into advanced dynamics, measurement and instrumentation, and other typical courses in physics. My experience and education in bioengineering, with an emphasis in biomechanics, included anatomy with a cadaver dissection lab, physiology, micro cellular biology, biomaterials, biomechanics, and other graduate level medical and engineering courses addressing the human body from an engineering perspective. My engineering education required acquiring and applying a working knowledge of higher mathematics, inorganic, organic, and biochemistry, biology and other allied fields.

During my work experience, and specifically at Evans & Sutherland, I studied the details of the human vestibular, proprioceptive, visual, and hearing systems and how we interact with our environment as I designed and implemented mathematical models for incorporation into the control systems for a multi-degree of freedom motion system for the vehicle/driving simulator I helped design and implement. I was specifically the principle engineer designing and coding these models for use in controlling the motion system as well as developing various parts of the vehicle dynamics model, force feedback, and data acquisition systems. I also had the opportunity to work in a department developing head and eye tracking systems for our military and commercial flight simulators. In this job, I was tasked with developing the control system software including the feedback models for controlling the target and detail projectors.

I spent the past 20 years acquiring and applying this education[1] and experience in a forensic setting. This education and work background affords me the ability to combine and apply this education and experience in physics, mechanical engineering, and biomechanical engineering to the various aspects of a dynamic event in reconstructing and analyzing dynamic events such as the subject incident. I drew on this education in mechanical engineering, bioengineering, and physics, as well as my additional education and studies specifically in accident reconstruction and the biomechanics of trauma, and my experience in order to understand and interpret the evidence, facts, and results of this analysis and investigation. All opinions expressed herein are to a reasonable degree of scientific probability.

I examined the following material in addition to my own research:

- Two photographs of the vehicles at rest and the interior of Ms. Glover's vehicle;
- Ms. Cargile's answers to requests for admissions and interrogatories;
- Depositions of:
  - Officer Byrne;
  - Sergeant Cargile;
  - Ms. Glover;
- Report by Mr. Sam Terry;
- Property damage report and photographs of Officer Cargile's vehicle;
- Traffic accident report (TAR);

I considered the facts and best evidence contained in the provided documentation as well as my own research in the context of my education and experience modeling and analyzing vehicle dynamics and handling. I then performed calculations and analysis to determine the most likely collision speeds, changes in speeds, and accelerations for the vehicles. The analysis I performed relied on calculations made with PC-Crash software by DSD Engineering. This software is based on Newton's Impulse–Momentum method and has been verified against staged collisions and has been used by myself to support my testimony in courts in Utah, California, and Nevada. PC-Crash has been accepted in courts world-wide as a scientific tool for analyzing vehicle accidents (see attached for a partial list of courts and cases in which PC-Crash was admitted).

Newton's Impulse-Momentum formulation does not require an input of crush damage or energy, therefore, a hands on inspection or photographs are not scientifically required to effectively use the simulation engine of PC-Crash to accurately determine collision speeds, times, distances, and changes in speeds despite the misrepresentations of some not properly trained in physics and engineering. Other time, distance, and speed calculations if needed were performed based on other standard kinematic and kinetic relationships. Some publications by the Society of Automotive Engineers are given here for reference,

- *"Reconstruction of Twenty Staged Collisions With PC-Crash's Optimizer,"* Cliff, Moser, SAE 2001-01-0507
- *"Validation of the Coupled PC-Crash-Madymo Occupant Simulation Model,"* Steffan, 2000-01-0471
- *"Data From Five Staged Car-To-Car Collisions and Comparison With Simulations,"* Bailey, SAE 2000-01-0849
- *"The Collision and Trajectory Models of PC-Crash,"* Steffan, Moser, SAE 960886

1 I earned my degree in Bioengineering in 2001.

- *"The Measured Rolling Resistance of Vehicles for Accident Reconstruction"* Cliff, Bowler, SAE 980368

PC-Crash was used for simulation, testing, and investigation in lieu of physical testing in this case which afforded repeatable, verifiable, and safe testing using the validated vehicle dynamics and crash model of PC-Crash. Using the validated PC-Crash simulation model allowed me to investigate the effect of various parameters effectively, while constrained to physical laws and relationships in a way which can be repeated and analyzed by any other qualified reconstructionist using PC-Crash, other validated computer models, or physically with vehicles.

**PC-Crash:**
PC-Crash is a validated well known, widely used and accepted simulation program tailored for vehicle collision reconstruction. The foundation derives from Newton's laws, primarily the equation "Force = Mass * Acceleration", rewritten as "Force * Change in Time = Mass * Change in Velocity" or "Impulse = Change in Momentum." It is used in an iterative manner adjusting input parameters, such as velocity, orientation, and so on, while comparing the results to the available physical evidence bound by the constraints of the particular geometry of the area of the collision and other facts and evidence as recorded by the investigating officer and where physically possible and not in conflict with the evidence or physical law, testimony of the parties and witnesses. In many instances, the PC-Crash program has a built in optimizer which can be employed. The optimizer automates the solution process and minimizes the output error. This process has been shown to yield results within a few percent of actual crash data used for comparison.

One of many available outputs of PC-Crash is typically the change in velocity of the vehicles. Because PC-Crash performs thousands of individual calculations during the solution (PC-Crash preserves these data for analysis by several means), it is not usually practical to print or provide the individual data points, however these data can be displayed in graphs or in 2 dimensional or 3 dimensional animated computer graphic output using 3D vehicle shapes and objects where appropriate from within the PC-Crash environment. The data are also available for output to a spreadsheet if further data processing is warranted, but this feature is not commonly employed due to the difficulty in interpreting or examining these data.

PC-Crash is also uniquely suited for side-swipe type collisions where a common velocity is not achieved between the colliding vehicles. From the user manual,

> "The default impact model in PC-Crash is a momentum-based 2 or 3 dimensional model that relies on restitution rather than vehicle crush or stiffness coefficients. This model assumes an exchange of the impact forces within an infinitely small time step at a single point, herein called 'impulse point'. Instead of resolving the impact forces over time, only the integral of the force-time curve (the impulse) is considered. This model, which was described first by Kudlich [Kudlich, H., *"Beitrag zur Mechanik des Kraftfahreug-Verkehrsunfalls,"* Dissertation TU-Wien, 1966] and Slibar [Slibar, A., *"Die mechanischen Grundsätze des Stoßvorganges freier und geführter Körper und ihre Anwendungauf den Stoßvorgang von Fahrzeugen,"* Archiv für Unfallforschung, 2. Jg., H. 1, 1966, 31ff], contains the means to calculate 'full impacts' (impacts in which a common velocity is reached by the impact areas of the two vehicles) and 'sliding impacts' (impacts where no common velocity is reached, commonly called sideswipe impacts)."

PC-Crash has approximately 3000 users worldwide and approximately 300 in the United States. It has been accepted on numerous occasions as support to my testimony in district courts in Nevada, California, and Utah.

Testing performed has shown that the actual transfer of impulse (or momentum) during a typical collision occurs over a time frame of between 0.1 and 0.2 seconds. Because of this short time period, the forces can be considered of short duration and impact dynamics methods may be accurately used to study the interaction. PC-Crash implements such a method using Newton's impulse momentum form of his equations.

My assignment was to analyze this collision in the context of the report authored by Mr. Terry.

**General circumstances:**
The general circumstances of this collision are:

- DOL 11/5/2012, 0153 hours.
- Intersection of Cheyenne Avenue and 5th Street, North Las Vegas, NV.
- Two vehicles each one with only one occupant.
- Ms. Glover was eastbound on Cheyenne in the #3 of 3 travel lanes driving a 1995 Chevrolet Cavalier;
- Sergeant Cargile was northbound on 5th Street running lights and siren in a marked 2008 Ford Expedition.
- The collision occurred when the Ford was partially into the intersection and the Chevrolet skidded into the intersection where the Ford and the Chevrolet collided.

**TAR:**
Officer Byrne investigated the accident and provided the following information:

- Sergeant Cargile was northbound on 5th Street with lights and siren activated responding to a shots fired call with a confirmed victim.
- The Chevrolet was eastbound on Cheyenne approaching 5th Street.
- The Chevrolet had a green light.
- Sergeant Cargile stated the Chevrolet did not have lights on.
- Sergeant Cargile stopped at the intersection and slowly began to move into the intersection.
- There was a visual obstruction to eastbound traffic for Sergeant Cargile.
- Sergeant Cargile had to partially move into the intersection.
- Ms. Glover stated she saw Sergeant Carglie's lights but did not hear a siren.
- The Chevrolet left approximately 110 feet of 4-wheel skid marks.
- The Ford was approximately 6.5 feet north of the curb line.
- The Chevrolet's right front "A" pillar struck the front of the Ford.
- The Chevrolet traveled approximately 5.5 feet after the initial contact.
- Officer Byrne found Ms. Glover was at fault for this collision and violated Nevada law as described in his report.

**Sam Terry:**
**Deposition summaries:**
Mr. Terry offered a brief review of the deposition testimony which testimony speaks for itself. When considering the sworn testimony or even the statement of a witness or party to an action such as this, I assume the individual is being honest, but not necessarily accurate. That is, testimony has to be considered if it is physically possible

and consistent with the other objective evidence. Even if a deponent in one part of the testimony is not accurate, if other parts are physically possible, those parts have to be considered. An accident reconstructionist is not in a position to determine the credibility or honesty of any witness or deponent. At most, the accident reconstructionist can demonstrate that testimony is correct or incorrect based on physical law or objective evidence.

**Scene:**
After his summary of the testimony, Mr. Terry described his site inspection. He found Cheyenne had a 3% down grade at this location. He described a daytime and nighttime inspection and other aspects of the scene.

**Vehicles:**
He next presented his interpretation of the evidence on the vehicles. He noted the damage to the right front fender, wheel, and passenger door of the Chevrolet. He noted there was no damage to the front bumper or the leading edge of the fender.

He noted contact damage to the front bumper, bumper cover, and grille of the Ford. He noted there was no damage to the left front fender. [Note the bumper cover on the Ford wraps around to the side of the Ford.]

**Reconstruction:**
Mr. Terry then presents his reconstruction. For my part I will quote and/or paraphrase the parts of Mr. Terry's analysis on which I want to comment and will then provide my commentary and opinions.

> "Neither the physical damage evidence sustained to the subject vehicles nor the physical roadway evidence is consistent with Sergeant Cargile's testimony that he was stopped at the moment of contact."

Mr. Terry explains that the damage to the vehicles "suggests" the impact first occurred at the right front wheel of the Chevrolet and can only occur if the Ford is moving into the Chevrolet.

Mr. Terry assumed there was zero rotation of the Chevrolet and that the Ford was pointed exactly at right angles to the Chevrolet. It is very unlikely that a vehicle with four tires skidding[2], down a slope, on a worn asphalt road, will not rotate at least slightly as it descends. Mr. Terry did not consider the reality of how vehicles behave and and therefore did not recognize other as likely if not more likely explanations of the damage pattern.

Mr, Terry was critical of Officer Byrne when Officer Byrne noted he did not find an "offset mark" for the Ford. Mr. Terry defined this as a shift in a skid mark, and I agree with that definition as a general proposition. However,iIt can also mean a lateral mark observed when vehicle's direction is shifted when the tires are not locked and leaving a skid mark. For example, when a stopped vehicle is struck such that the tires are forced to slide sideways, a mark can be left on the road. It is not necessarily limited to the narrow definition Mr. Terry imposed on Officer Byrne.

**Time/Distance:**
Mr. Terry offered his opinion as to how the collision occurred. He assumed Sergeant Cargile accelerated from a stop and was therefore traveling 6 to 8 mph at the moment of the collision. This means that Sergeant Cargile

2 Which means there is no longer any steering control of the vehicle.

accelerated up to the moment of the collision. This then also means Sergeant Cargile was not braking at the moment of contact. Therefore, there would be a short, but finite time where Sergeant Cargile would still be pressing the accelerator pedal after contact.

Using Mr. Terry's 6 mph speed at impact (0.18 Gs acceleration) it took Sergeant Cargile 1.5 seconds to arrive at the AIC. AT 8 mph (0.33 Gs), it took 1.1 seconds. Using Mr. Terry's $85^{th}$ percentile 2.0 second PRT, Even if Sergeant Cargile started his perception and response to Ms. Glover as he started to enter the intersection, Sergeant Cargile was likely still pressing the accelerator[3] post collision.

Under Mr. Terry's scenario, Ms. Glover likely started her PRT when Sergeant Cargile started to enter the intersection. Therefore, Sergeant Cargile would have been accelerating for at least 1.5 to 2.0 seconds before his PRT started. The bottom line is the timing for Mr. Terry's scenario and his estimated speeds are not self consistent nor are they consistent with the other facts and evidence.

Under Mr. Terry's scenario, given a 1.5 to 2.0 second PRT for Ms. Glover and at least a 2.5 second skidding time prior to the collision for Ms. Glover (see below), Ms. Glover had to have started her PRT before Sergeant Cargile even started to move.

**My analysis:**
With the Ford stopped and the Chevrolet rotated CCW by approximately 10 degrees, a speed of 14 mph on the Chevrolet causes the known interaction, matches the contact locations, and the post collision travel distance measured by Officer Byrne. It also is consistent with the minimal penetration of the Ford into the Chevrolet.

I used PC-Crash to investigate Mr. Terry's and Sergeant Cargile's version of events. Using the more likely urgent acceleration of 0.33 Gs and the corresponding collision speed of 8 mph for the Ford and the 14 mph speed for the Chevrolet I calculated above, I determined the point of contact between the vehicles as described by Mr. Terry could be matched, but the post collision motion and interaction even with a short, 0.25 second, continuation of acceleration on the part of Sergeant Cargile produced a motion inconsistent with the physical evidence. I therefore conclude the most likely scenario is where the Chevrolet (with no ABS system) had rotated CCW with respect to its velocity vector and collided with the stationary Ford.

Mr. Terry concludes Ms. Glover's PRT was reasonable. He did not fully explain how he determined this. He assumed in his previous analysis, Sergeant Cargile had been stopped at the curb line, 6.5 feet of acceleration to the AIC. Because it will take several seconds, 2.5 seconds or more depending on the drag[4] and starting/ending speeds, for Ms. Glover to skid and then adding on 1.5 to 2 seconds for PRT, Ms. Glover had to have seen

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3 Given the urgency of the situation and in Mr. Terry's hypothetical, it is unlikely Sergeant Cargile was using a "normal" acceleration rate.

4 Mr. Terry did not offer the drag factor he used, only that he thought the starting speed for Ms. Glover was 42 to 48 mph. Assuming a 0 mph collision speed will maximize the drag factor Mr. Terry used. With 110 feet of skidding, ending at 0 mph, starting at an average 44 mph, the drag factor Mr. Terry used was -0.59 G. With a collision speed of 5 mph, -0.58 G, collision speed of 10 mph, -0.56 G. Even with a grade of 3%, the reduction in drag would be approximately 0.03G. Asphalt typically has a coefficient of friction between 0.65 and 0.75 so that the effective drag with four locked wheels would be 0.62 to 0.72. Mr. Terry chose a low drag for reasons unexplained. At an average drag of 0.67 and a collision speed of 14 mph, Ms. Glover was traveling at 49 mph consistent with Mr. Terry's highest estimate and consistent with Officer Byrne's speed analysis.

Sergeant Cargile while he was stopped at the curb line.

Ms. Glover saw Sergeant Cargile's light bar. Sergeant Cargile testified he stopped and then slowly entered the intersection saw Ms. Glover after hearing her brakes and stopped. The PC-Crash simulations, expected behavior of a vehicle skidding with four locked tires descending a hill, the damage pattern and post collision motion and evidence and lack thereof are completely consistent with Sergeant Cargile's version of events. Mr. Terry's conclusions did not consider the full post collision motion of the vehicles nor did they consider that the assumption Sergeant Cargile was accelerating up to impact means there has to be some post contact continuation of that acceleration and the effect that would have on the collision dynamics.

**Headlight status:**
Mr. Terry was critical of Officer Byrne for not conducting an headlight analysis. Hot shock is a useful tool in helping to determine the direction of the impulse and/or whether or not a light was illuminated at the time of the collision. The Northwestern University Traffic Accident Investigation text has a length chapter on lamp analysis and investigation. It is sufficient to say that given the location, direction, and magnitude of the impulse in this collision, it is possible, even probable, the lights would not have shown evidence of illumination. While I agree Officer Byrne could have performed a check, the results would not have necessarily been useful and would not alter the result of his investigation. Ms. Glover was not cited for non-use of headlights. I also note that Ms. Glover's testimony was that her dash lights were on, therefore her headlights were on. She did not have an affirmative recollection of her headlights. It is possible for the marker lights and dash light to be illuminated but not the headlights.

Mr. Terry made a very curious statement at the end, “Sergeant Cargile's account of Ms. Glover's headlights cannot be taken as direct evidence since he is obviously incorrect about other facts of the subject incident.” Mr. Terry has chosen to ignore Sergeant Cargile *not* because his testimony is physically impossible or at odds with objective evidence, but because Mr. Terry doesn't believe certain other aspects of Sergeant Cargile's testimony. I already demonstrated that it is most likely Sergeant Cargile was stopped at the moment of contact. There is no reason to discount this testimony because it is physically possible and even Ms. Glover didn't offer specific affirmative testimony her headlights were, in fact, on. She was only able to say her dash lights were on.

**Audible warning:**
This section is not applicable because Ms. Glover responded to the flashing lights.

**Visibility analysis:**
I have extensive experience and education in photography and videography. Nighttime video is extremely difficult to match with regard to contrast, illumination, and other factors. The detectors used in modern video cameras simply do not match the sensitivity and other characteristics of the eye and great care and effort must be expended to adjust the exposure of any visual acquired at night [see the following for more information on nighttime video and photography: SAE 921575, 890730, 960895, 2012-01-0078, 2003-01-0294, Ayres, T.: *“Psychophysical Validation of Photographic Representations,”* Safety Engineering and Risk Analysis 1996, SERA-Vol. 6, ASME, Phillips, E, et al.: *“Faithful presentation of luminance contrast: Evaluation of photographs and computational display methods,”* SPIE 01 EI03-5007-44].

Mr. Terry did not have a full light bar which presented a very different visible cue due to the difference in colors as well as the light's motion and simply more light being emitted. Taken in all, Mr. Terry's criticism's of the lack of visibility for Sergeant Cargile's flashing lights was based on an observation using a single amber flashing light which is far different that the multiple lights in a police light bar. Mr. Terry constructed a straw man argument in an attempt to excuse Ms. Glover from seeing the conspicuous lights which she testified she in fact saw and responded to.

He concluded this section with an opinion Ms. Glover responded appropriately and "normally". However, he does not address how long Sergeant Cargile was present at the intersection. He also doesn't address the fact that by his calculations, Sergeant Cargile had to have been stopped for several seconds. It took at least 1.1 seconds for him to arrive at the AIC. Ms. Glover was skidding for at least 2.5 seconds (47 to 14 mph, -0.67 Gs, 110 feet) and then add 1.5 to 2 seconds for PRT. Sergeant Cargile was stopped for at least 2.9 to 3.4 seconds. This means Ms. Glover started to skid with the accompanying sound of skidding tires, before Sergeant Cargile started to move.

**Opticon device:**
I have no comment here.

**Conclusions:**

- Speed of 42 to 48 mph. I think the speed was closer to 48 mph, but I don't think Ms. Glover was speeding.
- The Ford was traveling 6 to 8 mph. I disagree. The damage pattern is easily explained by a slight CCW rotation of the Chevrolet which would be expected on a vehicle, four tires locked descending a hill. The damage pattern would be different, post impact motion would be different, and physical evidence on the road would be different than what was recorded. The notion that one car hit another is not a principle of physics or engineering. Forces are by definition equal and opposite during a collision. The specific assignment of one vehicle hitting another "not vice versa" only confused the trier of fact by suggesting the vehicle which "hits" another is the vehicle at fault. Two colliding objects "hit" each other.
- It is not relevant whether or not Ms. Glover heard the siren.
- The evidence:
  - Does indicate Ms. Glover attempted to slow. The charge of failure to decrease speed does not mean the driver did not apply their brakes, only that they failed to stop before the collision.
  - Does not eliminate the clear possibility did not used due care by slowing as she approached 5$^{th}$ Street with Sergeant Cargile stopped with flashing lights.
  - Mr. Terry does not define what every attempt means. We only know Ms. Glover applied her brakes too late to avoid the collision.
  - Ms. Glover took the action which at the time seemed reasonable.
- Mr. Terry's opinion that Sergeant Cargile had "the best ability to avoid this collision" is based on his analysis of Sergeant' Cargile's pre-collision actions and Mr. Terry had to essentially discard all of Sergeant Cargile's testimony and the investigation of Officer Byrne to arrive at this conclusion. I disagree with much of Mr. Terry's analysis for reasons described above. It is my opinion an equally reasonable solution is that:
  - Ms. Glover's headlights were off.
  - Ms. Glover did not slow as Sergeant Cargile was stopped at Cheyenne clearing traffic before

proceeding.
   - Sergeant Cargile stopped and slowly entered the intersection not seeing Ms. Glover's approaching vehicle.
   - Ms. Glover then perceived and responded to Sergeant Cargile's entrance and applied her brakes.
   - Sergeant Cargile heard the brakes, stopped his vehicle and the collision occurred.
- Mr. Terry implied that Sergeant Cargile should have taken a different route knowing there was a view obstruction at this intersection. This implication was done admitting he did not know the circumstances or reasons for Sergeant Cargile's choices. At best this comment is a red herring.

**Summary:**
With due respect to Mr. Terry, I disagree with his conclusions in general and specifically as detailed above. Mr. Terry made assumptions that ignored real physical behavior, did not fully consider the implications of his opinion of collision speeds for the Ford, did not present other reasonable solutions, and constructed straw man arguments and offered red herrings which confuse and distract from the real issues. It is my opinion that the testimony of Sergeant Cargile is consistent with the evidence, physical law, and an analysis of the collision. Officer Byrne's investigation was not flawed and covered the aspects of the collision needed to form his opinions. That he didn't do something Mr. Terry wanted is not relevant. It is also my opinion Sergeant Cargile did not act inappropriately and the evidence and my analysis also supports his version of events.

I reserve the right to amend and/or modify this report should further information, facts, or evidence be provided/discovered or additional analysis performed which warrants such action.

Sincerely,

David M. Ingebretsen, M.S., M.E.
Mechanical-Biomechanical Engineer / Physicist

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- Regina v. Judge, BC Provincial Court #58114-1, Godfrey, J., April 30 - May 2, 2001.
- Regina v. Lunman, Brockville, Ontario, Sulthorpe J., October 22, 2001.
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- Regina v. Summers, Brockville, Ontario, Quigley J., May 17, 2006.
- Regina v. Van Gisteren, Provincial Court, Calgary, Alberta, 1998.
- St-Pierre v. Doiron, NB Court of Queen's Bench, B/C/282/02, June 15, 2006.
- Cavezza v. Siefreid, Supreme Court, Vancouver, BC, October 2008.
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- Dechev v. Maerkov et al, Brampton, Ontario, June 2007.
- Myers v. Walters, Sarnia, Ontario, January 2008.

UNITED STATES

- Agudo v. Peterson, Federal Court, Hawaii, July 1996.
- American Standard v. Johnson, Adams County Court, CO 03CV2955, February 2006
- Andrus v. Standard Plumbing, 3rd District Court - Salt Lake City, UT, April 2007
- Applewhite v. Hyundai, Coahoma County, MS, March 2008
- Bailey v. Carter, 3rd District Court - Salt Lake City, UT, February 2008
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- Butler Bus Service v. ?, heard in Vermont District Court, 1997.
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- Douglas B. Carl v. Rachel N. Orndorff, Division II, Vigo Superior Court, Vigo County, Indiana, February 6, 2008.
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- Robinson v. Nissan, Marengo County, Alabama, September, 2009
- RTD v. Denver Health and Hospital Authority, District Court, City and County of Denver, State of CO 05CV8173, November 2007
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- Swegles v. UHaul, Cincinatti, Ohio, January 2007
- Tannich v. City of Bremerton, Cause # 02-2-02169-9, Kitsap County Superior Court, Port Orchard, Washington, Trial testimony June 19, 2006.
- Teets v. Ford Motor Company, U.S. District Court, Eastern District of Tennessee, January 18, 2005
- Todd v. Jantz, District Court, Park County, CO 2002CV162, March 2004
- Tubar v. City of Kent, US District Court for Western District of Washington, Docket # C05-2254JCC, May 2009.
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- United States of America v. Wheatly, North Carolina Eastern District, February 2004.
- Velazques v. USA, US District Court, Central District of CA, #SACV98-565LHM, December 8, 1999.
- Vencill v. Elwell, District Court, Arapahoe County CO 98CV4001, June 2000
- Wang v. Wang and Wagenaar, Superior Court of WA, Whatcom County, September 29, 1997.
- Woodruff v. Underdue, North Carolina Superior Court, 98-CVS-091, August 1999.
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- State of Arizona v. Artz, Arizona Superior Court, Pima County, January 2006.
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- State of Arizona v. Haffner, Arizona Superior Court, Pima County, December 2006.
- State of Arizona v. Lopez-Valle, Arizona Superior Court, Pima County, July 2008.
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- Brody v. Broward County, Florida Circuit Court 17th Judicial District, Broward Co., Nov. 2005
- Beers v. The Reynolds Co., Florida Circuit Court 15th Judicial District, Palm Beach Co., June 2007
- Thomas vs. Purefoy. In the Circuit Court of the Second Judicial Circuit, in and for Leon County, Florida.
- Addison vs. Broward County Sheriff's Office. In the Circuit Court of the 17th Judicial Circuit in and for Broward County, Florida.
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- McMullen vs. Marvin Allen, Meadow Lark Transport, Inc. et al. In the 413 Judicial District Court. Johnson County, Texas.
- Chapa, et al. vs. Swift Transportation Co., Inc. et al. In the 293rd Judicial District Court, Dimmit County Texas.
- State of Arizona v. Gaylene J. Wathogoma, Superior Court Of The State of Arizona, Maricopa County, June 2008
- Pascual v. Steiner, Superior Court, San Diego County, December 2005

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- Aldana v. Castro, Superior Court, Imperial County, January 2008
- Myron v. Sakkab, Superior Court, San Diego County, September 2008
- Piccone v. Galavis, Superior Court, Imperial County, August 2008

CALIFORNIA

- Berner v. Robbins, Mendocino County Superior Court, Ukiah, California, June 15, 2009.
- Bradley v. Rayne Water Company, heard in Santa Barbara, Santa Barbara County Court, 1997.
- Buell-Wilson v. Ford Motor Co., San Diego, California, June 3, 2004.
- Dashjian v DeGrood, Santa Monica Superior Court, July 12, 1999.
- Farmer v. Maloney et al, Shasta County Superior Court, Redding, California, January 3, 2007.
- Gillilan v. Southern Pacific Milling and Caltrans, in Santa Monica, Santa Barbara County Court, 1997.
- Knighton v. Felix, Superior Court of California, San Luis Obispo, October 1, 1998.
- Mehri v. Vallco, Santa Clara County Superior Court, San Jose, California, November 13, 2007.
- People v. Rivas, Parole Revocation Hearing, San Francisco, California, November 9, 2006.
- Pereira v. Gleason, Municipal Court, San Andreas, Calaveras County, California, March 27, 2008.
- Shi v. Coach USA, Superior Court of San Francisco, March 2007
- Tony Martin Jr. v. State of California Department of Transportation, Superior Court of the State of CA, for the County of Los Angeles, October 5, 2006
- Weston v. Hertz (Calif. Supreme Court) heard in Long Beach, LA County, August 1997.
- Yellen v. Audi (Calif. Supreme Court) heard in Van Nuys, LA County, 1997.
- Nieman V C&A Transportation Services - Circuit Court, Klamath Co, OR 6/10/2009
- Mann V Laidlaw - Superior Court, 4th Judicial Dist, 8/10/2009
- Bautista v. Strickland-Superior Court of California, Tuolumne County, September 29, 2009
- People v. Vellanoweth, Superior Court, Sacramento, 07 July 2008
- Smith v. State of California, Victorville Superior Court, May 2009
- Pascual v. Steiner, Superior Court, San Diego County, December 2005
- Youssofi/Ellsworth v. Blocker, Superior Court, San Diego County, December 2008
- Aldana v. Castro, Superior Court, Imperial County, January 2008
- Myron v. Sakkab, Superior Court, San Diego County, September 2008
- Piccone v. Galavis, Superior Court, Imperial County, August 2008

JAPAN
Hanaoka v. DaimlerChrysler Corporation, Tokyo District Civil Department Division No. 5, Section A, July 14, 2008

| | | |
|---|---|---|
| Vehicle : | CHEVROLET-CAVALIER 4DR SEDAN BASE/LS | FORD-EXPEDITION MAX 4WD SUV EDDIE BAUER/LIMI |
| Database: | DB_USDBASE | DB_USDBASE |
| RecordID: | 30 | 15 |

**START VALUES**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **17.50** | **0.00** |
| Heading angle [deg] : | 8.53 | 90.00 |
| Velocity direction (ß) [deg] : | 0.00 | 90.00 |
| Yaw velocity [Deg/s] : | 0.00 | 0.00 |
| Center of gravity x [ft] : | 2.00 | 15.27 |
| Center of gravity y [ft] : | -7.88 | -18.49 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.00 | 0.00 |
| Roll velocity [Deg/s] : | 0.00 | 0.00 |
| Pitch velocity [Deg/s] : | 0.00 | 0.00 |

**END VALUES**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.38** | **0.04** |
| Heading angle [deg] : | 4.47 | 89.87 |
| Velocity direction (ß) [deg] : | 6.04 | -13.25 |
| Yaw velocity [Deg/s] : | 0.43 | 0.02 |
| Center of gravity x [ft] : | 15.28 | 15.29 |
| Center of gravity y [ft] : | -7.02 | -18.50 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | -0.60 | 0.29 |
| Pitch angle [deg] : | 2.38 | -0.11 |
| Roll velocity [Deg/s] : | 1.07 | 1.61 |
| Pitch velocity [Deg/s] : | 0.31 | -0.22 |

**1.COLLISION**

| | | | |
|---|---|---|---|
| Vehicle : | 1 CHEVROLET | | 1 CHEVROLET |
| Driver : | | | |
| t [s]: | 0.00 | | 0.00 |
| **Pre Impact vel. [mph]:** | **17.50** | | **17.50** |
| **Post Impact vel. [mph]:** | **17.50** | | **17.50** |
| Velocity change (dV) [mph] : | 0.00 | | 0.00 |
| EES [mph] : | 0.00 | | 0.00 |
| Def. Energy [kJ]: | 0.00 | | 0.00 |
| Stiffness [lb/in]: | 0.0 | | 0.0 |
| Coefficient of restitution (e) : | | 0.10 | |
| Separation speed [mph]: | | 0.0 | |
| Friction coefficient (mu) : | | 0.60 | |
| Point of Impact x [ft] : | | 14.40 | |
| Point of Impact y [ft] : | | -9.87 | |
| Point of Impact z [ft] : | | 1.48 | |
| Angle of contact plane (phi) [deg] : | | 5.83 | |
| Angle of contact plane (psi) [deg] : | | 0.00 | |
| Total Deformation Energy [ft-lb] : | | 0.00 | |
| Moment arm about C.G. [ft] : | 0.00 | | 0.00 |
| PDOF (SAE) [deg] : | -90.00 | | 90.00 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **17.50** | **17.50** |
| Heading angle [deg] : | 8.53 | 8.53 |
| Velocity direction (ß) [deg] : | 0.00 | 0.00 |
| Yaw velocity [Deg/s] : | 0.00 | 0.00 |
| Center of gravity x [ft] : | 2.00 | 2.00 |
| Center of gravity y [ft] : | -7.88 | -7.88 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.00 | 0.00 |
| Roll velocity [Deg/s] : | 0.00 | 0.00 |
| Pitch velocity [Deg/s] : | 0.00 | 0.00 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **17.50** | **17.50** |
| Heading angle [deg] : | 8.53 | 8.53 |
| Velocity direction (ß) [deg] : | 0.00 | 0.00 |
| Yaw velocity [Deg/s] : | 0.00 | 0.00 |
| Center of gravity x [ft] : | 2.00 | 2.00 |
| Center of gravity y [ft] : | -7.88 | -7.88 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.00 | 0.00 |
| Roll velocity [Deg/s] : | 0.00 | 0.00 |
| Pitch velocity [Deg/s] : | 0.00 | 0.00 |

**2.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.36 | 0.36 |
| **Pre Impact vel. [mph]:** | **11.87** | **0.00** |
| **Post Impact vel. [mph]:** | **11.19** | **0.52** |
| Velocity change (dV) [mph] : | 1.19 | 0.52 |
| Deformation depth [ft] : | 0.06 | 0.08 |
| EES [mph] : | 2.50 | 1.94 |
| Def. Energy [kJ]: | 0.57 | 0.80 |
| Stiffness [lb/in]: | 26104.9 | 18805.2 |
| Coefficient of restitution (e) : | 0.10 | |
| Separation speed [mph]: | 10.1 | |
| Friction coefficient (mu) : | 0.60 | |
| Point of Impact x [ft] : | 14.16 | |
| Point of Impact y [ft] : | -9.88 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 8.42 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 1368.66 | |
| Impulse [lb-s] : | 148.99 | |
| Direction of impulse [deg] : | 129.38 | |
| Vertical direction of impulse [deg] : | 0.30 | |
| Moment arm about C.G. [ft] : | 1.99 | 4.60 |
| PDOF (SAE) [deg] : | 55.70 | -39.38 |
| dV/EES : | 0.37 | 0.37 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.87** | **0.00** |
| Heading angle [deg] : | 5.08 | 90.00 |
| Velocity direction (ß) [deg] : | 2.00 | -90.00 |
| Yaw velocity [Deg/s] : | -11.98 | 0.00 |

| | | |
|---|---|---|
| Center of gravity x [ft] : | 9.78 | 15.27 |
| Center of gravity y [ft] : | -7.68 | -18.49 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.54 | 0.00 |
| Pitch angle [deg] : | 2.70 | 0.00 |
| Roll velocity [Deg/s] : | -2.82 | 0.00 |
| Pitch velocity [Deg/s] : | 3.94 | -0.00 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.19** | **0.52** |
| Heading angle [deg] : | 5.08 | 90.00 |
| Velocity direction (ß) [deg] : | 6.85 | -50.62 |
| Yaw velocity [Deg/s] : | -0.01 | -7.82 |
| Center of gravity x [ft] : | 9.78 | 15.27 |
| Center of gravity y [ft] : | -7.68 | -18.49 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | 1.54 | 0.00 |
| Pitch angle [deg] : | 2.70 | 0.00 |
| Roll velocity [Deg/s] : | 4.66 | -1.30 |
| Pitch velocity [Deg/s] : | 5.32 | 0.54 |

**3.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.45 | 0.45 |
| **Pre Impact vel. [mph]:** | **9.71** | **0.06** |
| **Post Impact vel. [mph]:** | **9.71** | **0.06** |
| Velocity change (dV) [mph] : | 0.01 | 0.01 |
| Deformation depth [ft] : | 0.06 | 0.08 |
| EES [mph] : | 0.23 | 0.17 |
| Def. Energy [kJ]: | 0.00 | 0.01 |
| Stiffness [lb/in]: | 219.7 | 174.5 |
| Coefficient of restitution (e) : | 0.10 | |
| Separation speed [mph]: | 9.6 | |
| Friction coefficient (mu) : | 0.60 | |
| Point of Impact x [ft] : | 14.32 | |
| Point of Impact y [ft] : | -9.87 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 6.29 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 11.22 | |
| Impulse [lb-s] : | 1.55 | |
| Direction of impulse [deg] : | -114.67 | |
| Vertical direction of impulse [deg] : | 0.06 | |
| Moment arm about C.G. [ft] : | 3.87 | 4.48 |
| PDOF (SAE) [deg] : | -60.35 | -155.46 |
| dV/EES : | 0.04 | 0.04 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **9.71** | **0.06** |
| Heading angle [deg] : | 4.97 | 89.87 |
| Velocity direction (ß) [deg] : | 6.87 | -19.38 |
| Yaw velocity [Deg/s] : | -2.15 | -0.00 |
| Center of gravity x [ft] : | 11.15 | 15.29 |
| Center of gravity y [ft] : | -7.52 | -18.50 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | 1.47 | 0.19 |
| Pitch angle [deg] : | 2.97 | -0.09 |

| | | |
|---|---|---|
| Roll velocity [Deg/s] : | -4.39 | 2.50 |
| Pitch velocity [Deg/s] : | 1.12 | -0.84 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **9.71** | **0.06** |
| Heading angle [deg] : | 4.97 | 89.87 |
| Velocity direction (ß) [deg] : | 6.81 | -14.43 |
| Yaw velocity [Deg/s] : | -2.39 | -0.08 |
| Center of gravity x [ft] : | 11.15 | 15.29 |
| Center of gravity y [ft] : | -7.52 | -18.50 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | 1.47 | 0.19 |
| Pitch angle [deg] : | 2.97 | -0.09 |
| Roll velocity [Deg/s] : | -4.50 | 2.49 |
| Pitch velocity [Deg/s] : | 1.13 | -0.85 |

**4.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.50 | 0.50 |
| **Pre Impact vel. [mph]:** | **8.96** | **0.04** |
| **Post Impact vel. [mph]:** | **8.94** | **0.05** |
| Velocity change (dV) [mph] : | 0.04 | 0.02 |
| Deformation depth [ft] : | 0.06 | 0.08 |
| EES [mph] : | 0.40 | 0.30 |
| Def. Energy [kJ]: | 0.01 | 0.02 |
| Stiffness [lb/in]: | 724.7 | 544.1 |
| Coefficient of restitution (e) : | 0.10 | |
| Separation speed [mph]: | 8.8 | |
| Friction coefficient (mu) : | 0.60 | |
| Point of Impact x [ft] : | 14.39 | |
| Point of Impact y [ft] : | -9.87 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 5.82 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 34.01 | |
| Impulse [lb-s] : | 5.10 | |
| Direction of impulse [deg] : | -115.14 | |
| Vertical direction of impulse [deg] : | -0.54 | |
| Moment arm about C.G. [ft] : | 3.42 | 4.48 |
| PDOF (SAE) [deg] : | -60.00 | -154.99 |
| dV/EES : | 0.08 | 0.08 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **8.96** | **0.04** |
| Heading angle [deg] : | 4.86 | 89.87 |
| Velocity direction (ß) [deg] : | 6.89 | -13.39 |
| Yaw velocity [Deg/s] : | -2.75 | -0.00 |
| Center of gravity x [ft] : | 11.75 | 15.29 |
| Center of gravity y [ft] : | -7.45 | -18.50 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | 1.21 | 0.28 |
| Pitch angle [deg] : | 2.98 | -0.11 |
| Roll velocity [Deg/s] : | -6.45 | 1.62 |
| Pitch velocity [Deg/s] : | -0.38 | -0.34 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **8.94** | **0.05** |
| Heading angle [deg] : | 4.86 | 89.87 |
| Velocity direction (ß) [deg] : | 6.67 | 8.42 |
| Yaw velocity [Deg/s] : | -3.45 | -0.26 |
| Center of gravity x [ft] : | 11.75 | 15.29 |
| Center of gravity y [ft] : | -7.45 | -18.50 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 1.21 | 0.28 |
| Pitch angle [deg] : | 2.98 | -0.11 |
| Roll velocity [Deg/s] : | -6.77 | 1.59 |
| Pitch velocity [Deg/s] : | -0.35 | -0.37 |

**SEQUENCES**

1 CHEVROLET :

REACTION
Reaction time [sec] : 1.00

BRAKE LAG
Threshold time [sec] : 0.20

BRAKE
maximum stopping distance [ft] : 32.81
Brake force [%]
Axle 1, left : 0.00
Axle 1, right : 0.00
Axle 2, left : 0.00
Axle 2, right : 0.00
mean brake acceleration [g] : 0.00

START VALUES
Velocity [mph] : 17.50
Friction coefficient : 0.75

BRAKE
maximum stopping distance [ft] : 300.00
Brake force [%]
Axle 1, left : 215.77
Axle 1, right : 215.77
Axle 2, left : 40.90
Axle 2, right : 40.90
mean brake acceleration [g] : -0.75

2 FORD-EXPE :

REACTION
Reaction time [sec] : 1.00

BRAKE LAG
Threshold time [sec] : 0.20

BRAKE
maximum stopping distance [ft] : 32.81
Brake force [%]
Axle 1, left : 0.00
Axle 1, right : 0.00
Axle 2, left : 0.00
Axle 2, right : 0.00
mean brake acceleration [g] : 0.00

START VALUES
Velocity [mph] : 0.00
Friction coefficient : 0.75

BRAKE

| | |
|---|---|
| maximum stopping distance [ft] : | 300.00 |
| Brake force [%] | |
| Axle 1, left : | 222.73 |
| Axle 1, right : | 222.73 |
| Axle 2, left : | 81.92 |
| Axle 2, right : | 81.92 |
| mean brake acceleration [g] : | -0.75 |

**INPUT VALUES**

Vehicle : CHEVROLET-CAVALIER 4DR SEDAN BASE/LS FORD-EXPEDITION MAX 4WD SUV EDDIE BAUER/LIMI

| | | |
|---|---|---|
| Database: | DB_USDBASE | DB_USDBASE |
| RecordID: | 30 | 15 |
| Length [in] : | 180.31 | 221.26 |
| Width [in] : | 67.32 | 78.74 |
| Height [in] : | 54.72 | 77.56 |
| Number of axles : | 2 | 2 |
| Wheelbase [in] : | 103.94 | 131.10 |
| Front overhang [in] : | 38.98 | 39.37 |
| Front track width [in] : | 57.48 | 66.93 |
| Rear track width [in] : | 57.09 | 67.32 |
| Mass (empty) [lb] : | 2601.47<br>(2746.47) | 6155.34<br>(6330.34) |
| Mass of front occupants [lb] : | 145.00 | 175.00 |
| Mass of rear occupants [lb] : | 0.00 | 0.00 |
| Mass of cargo in trunk [lb] : | 0.00 | 0.00 |
| Mass of roof cargo [lb] : | 0.00 | 0.00 |
| Distance C.G. - front axle [in] : | 37.42<br>(37.36) | 65.55<br>(65.01) |
| C.G. height above ground [in] : | 22.00<br>(22.00) | 22.00<br>(22.00) |
| Roll moment of inertia [lbfts^2] : | 400.48<br>(421.63) | 1466.66<br>(1507.20) |
| Pitch moment of inertia [lbfts^2] : | 1334.94<br>(1405.42) | 4888.86<br>(5024.01) |
| Yaw moment of inertia [lbfts^2] : | 1334.94<br>(1405.42) | 4888.86<br>(5024.01) |
| Stiffness, axle 1, left [lb/in] : | 141.01 | 260.66 |
| Stiffness, axle 1, right [lb/in] : | 141.01 | 260.66 |
| Stiffness, axle 2, left [lb/in] : | 79.32 | 260.66 |
| Stiffness, axle 2, right [lb/in] : | 79.32 | 260.66 |
| Damping, axle 1, left [lb-s/ft] : | 190.37 | 351.90 |
| Damping, axle 1, right [lb-s/ft] : | 190.37 | 351.90 |
| Damping, axle 2, left [lb-s/ft] : | 107.08 | 351.90 |
| Damping, axle 2, right [lb-s/ft] : | 107.08 | 351.90 |
| Max. slip angle,axle 1, left [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 1, right [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 2, left [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 2, right [deg]: | 10.00 | 10.00 |
| ABS : | No | No |

Characters: 11620

| | | |
|---|---|---|
| Vehicle : | CHEVROLET-CAVALIER 4DR SEDAN BASE/LS | FORD-EXPEDITION MAX 4WD SUV EDDIE BAUER/LIMI |
| Database: | DB_USDBASE | DB_USDBASE |
| RecordID: | 30 | 15 |

**START VALUES**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **14.00** | **8.00** |
| Heading angle [deg] : | 0.00 | 90.00 |
| Velocity direction (ß) [deg] : | 0.00 | 90.00 |
| Yaw velocity [Deg/s] : | 0.00 | 0.00 |
| Center of gravity x [ft] : | 8.64 | 15.27 |
| Center of gravity y [ft] : | -6.90 | -18.49 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.00 | 0.00 |
| Roll velocity [Deg/s] : | 0.00 | 0.00 |
| Pitch velocity [Deg/s] : | 0.00 | 0.00 |

**END VALUES**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.14** | **0.33** |
| Heading angle [deg] : | 10.34 | 86.91 |
| Velocity direction (ß) [deg] : | 114.44 | 93.56 |
| Yaw velocity [Deg/s] : | -3.54 | 1.13 |
| Center of gravity x [ft] : | 15.47 | 16.20 |
| Center of gravity y [ft] : | 3.52 | -5.23 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.00 |
| Roll angle [deg] : | -7.99 | -0.37 |
| Pitch angle [deg] : | 0.52 | 1.57 |
| Roll velocity [Deg/s] : | 2.23 | -0.54 |
| Pitch velocity [Deg/s] : | -0.04 | 0.36 |

**1.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.06 | 0.06 |
| **Pre Impact vel. [mph]:** | **13.15** | **8.42** |
| **Post Impact vel. [mph]:** | **13.12** | **6.54** |
| Velocity change (dV) [mph] : | 4.42 | 1.92 |
| Deformation depth [ft] : | 0.27 | 0.30 |
| EES [mph] : | 4.72 | 3.26 |
| Def. Energy [kJ]: | 2.05 | 2.25 |
| Stiffness [lb/in]: | 4721.2 | 4303.4 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 14.5 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.33 | |
| Point of Impact y [ft] : | -9.30 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -169.93 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 4296.55 | |
| Impulse [lb-s] : | 553.10 | |
| Direction of impulse [deg] : | 100.07 | |
| Vertical direction of impulse [deg] : | 0.00 | |

| | | |
|---|---|---|
| Moment arm about C.G. [ft] : | 3.91 | 0.55 |
| PDOF (SAE) [deg] : | 79.93 | -10.07 |
| dV/EES : | 0.77 | 0.77 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **13.15** | **8.42** |
| Heading angle [deg] : | 0.00 | 90.00 |
| Velocity direction (ß) [deg] : | 0.00 | 90.00 |
| Yaw velocity [Deg/s] : | 0.00 | 0.00 |
| Center of gravity x [ft] : | 9.93 | 15.27 |
| Center of gravity y [ft] : | -6.90 | -17.71 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.22 | -0.07 |
| Roll velocity [Deg/s] : | 0.00 | 0.00 |
| Pitch velocity [Deg/s] : | 6.30 | -1.96 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **13.12** | **6.54** |
| Heading angle [deg] : | 0.00 | 90.00 |
| Velocity direction (ß) [deg] : | 19.36 | 87.06 |
| Yaw velocity [Deg/s] : | 88.19 | -3.45 |
| Center of gravity x [ft] : | 9.93 | 15.27 |
| Center of gravity y [ft] : | -6.90 | -17.71 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.22 | -0.07 |
| Roll velocity [Deg/s] : | 27.26 | -1.29 |
| Pitch velocity [Deg/s] : | 7.69 | 0.24 |

**2.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.13 | 0.13 |
| **Pre Impact vel. [mph]:** | **12.21** | **7.01** |
| **Post Impact vel. [mph]:** | **12.41** | **6.65** |
| Velocity change (dV) [mph] : | 0.84 | 0.36 |
| Deformation depth [ft] : | 0.22 | 0.29 |
| EES [mph] : | 0.79 | 0.59 |
| Def. Energy [kJ]: | 0.06 | 0.07 |
| Stiffness [lb/in]: | 188.3 | 144.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 13.5 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.49 | |
| Point of Impact y [ft] : | -8.64 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 8.13 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 130.78 | |
| Impulse [lb-s] : | 104.51 | |
| Direction of impulse [deg] : | 98.13 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.08 | 0.40 |
| PDOF (SAE) [deg] : | 87.18 | -8.24 |
| dV/EES : | 0.84 | 0.84 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.21** | **7.01** |
| Heading angle [deg] : | 5.31 | 89.89 |
| Velocity direction (ß) [deg] : | 19.42 | 88.91 |
| Yaw velocity [Deg/s] : | 75.88 | -0.70 |
| Center of gravity x [ft] : | 11.07 | 15.29 |
| Center of gravity y [ft] : | -6.50 | -17.06 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 1.14 | 0.09 |
| Pitch angle [deg] : | 0.75 | -0.13 |
| Roll velocity [Deg/s] : | 8.46 | 2.15 |
| Pitch velocity [Deg/s] : | 10.04 | -1.74 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.41** | **6.65** |
| Heading angle [deg] : | 5.31 | 89.89 |
| Velocity direction (ß) [deg] : | 23.20 | 88.41 |
| Yaw velocity [Deg/s] : | 88.97 | -1.17 |
| Center of gravity x [ft] : | 11.07 | 15.29 |
| Center of gravity y [ft] : | -6.50 | -17.06 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 1.14 | 0.09 |
| Pitch angle [deg] : | 0.75 | -0.13 |
| Roll velocity [Deg/s] : | 14.05 | 1.95 |
| Pitch velocity [Deg/s] : | 10.37 | -1.32 |

**3.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.18 | 0.18 |
| **Pre Impact vel. [mph]:** | **11.76** | **6.98** |
| **Post Impact vel. [mph]:** | **12.12** | **6.42** |
| Velocity change (dV) [mph] : | 1.30 | 0.56 |
| Deformation depth [ft] : | 0.24 | 0.34 |
| EES [mph] : | 1.09 | 0.86 |
| Def. Energy [kJ]: | 0.11 | 0.16 |
| Stiffness [lb/in]: | 317.0 | 221.4 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 12.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.26 | |
| Point of Impact y [ft] : | -8.26 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 10.16 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 266.55 | |
| Impulse [lb-s] : | 162.43 | |
| Direction of impulse [deg] : | 100.16 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 2.05 | 0.45 |
| PDOF (SAE) [deg] : | 88.94 | -10.30 |
| dV/EES : | 0.91 | 0.91 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.76** | **6.98** |
| Heading angle [deg] : | 9.10 | 89.86 |
| Velocity direction (ß) [deg] : | 23.16 | 88.97 |
| Yaw velocity [Deg/s] : | 80.33 | -0.37 |
| Center of gravity x [ft] : | 11.80 | 15.30 |

| | | |
|---|---|---|
| Center of gravity y [ft] : | -6.18 | -16.61 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.52 | 0.18 |
| Pitch angle [deg] : | 1.14 | -0.21 |
| Roll velocity [Deg/s] : | 1.73 | 2.12 |
| Pitch velocity [Deg/s] : | 10.57 | -2.12 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.12** | **6.42** |
| Heading angle [deg] : | 9.10 | 89.86 |
| Velocity direction (ß) [deg] : | 29.15 | 88.00 |
| Yaw velocity [Deg/s] : | 93.85 | -1.20 |
| Center of gravity x [ft] : | 11.80 | 15.30 |
| Center of gravity y [ft] : | -6.18 | -16.61 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.52 | 0.18 |
| Pitch angle [deg] : | 1.14 | -0.21 |
| Roll velocity [Deg/s] : | 10.42 | 1.74 |
| Pitch velocity [Deg/s] : | 10.97 | -1.48 |

**4.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.22 | 0.22 |
| **Pre Impact vel. [mph]:** | **11.46** | **6.75** |
| **Post Impact vel. [mph]:** | **12.00** | **6.06** |
| Velocity change (dV) [mph] : | 1.65 | 0.72 |
| Deformation depth [ft] : | 0.28 | 0.40 |
| EES [mph] : | 1.31 | 1.03 |
| Def. Energy [kJ]: | 0.16 | 0.23 |
| Stiffness [lb/in]: | 334.5 | 231.1 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 11.8 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.03 | |
| Point of Impact y [ft] : | -7.91 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -166.14 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 382.87 | |
| Impulse [lb-s] : | 206.36 | |
| Direction of impulse [deg] : | 103.86 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.00 | 0.74 |
| PDOF (SAE) [deg] : | 89.25 | -14.03 |
| dV/EES : | 0.97 | 0.97 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.46** | **6.75** |
| Heading angle [deg] : | 13.11 | 89.83 |
| Velocity direction (ß) [deg] : | 29.02 | 88.80 |
| Yaw velocity [Deg/s] : | 85.03 | -0.37 |
| Center of gravity x [ft] : | 12.48 | 15.31 |
| Center of gravity y [ft] : | -5.81 | -16.17 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.75 | 0.28 |
| Pitch angle [deg] : | 1.50 | -0.29 |
| Roll velocity [Deg/s] : | -2.54 | 2.15 |

| | | |
|---|---|---|
| Pitch velocity [Deg/s] : | 10.17 | -2.00 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.00** | **6.06** |
| Heading angle [deg] : | 13.11 | 89.83 |
| Velocity direction (ß) [deg] : | 36.64 | 87.05 |
| Yaw velocity [Deg/s] : | 93.39 | -2.11 |
| Center of gravity x [ft] : | 12.48 | 15.31 |
| Center of gravity y [ft] : | -5.81 | -16.17 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.75 | 0.28 |
| Pitch angle [deg] : | 1.50 | -0.29 |
| Roll velocity [Deg/s] : | 8.08 | 1.51 |
| Pitch velocity [Deg/s] : | 10.46 | -1.20 |

**5.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.27 | 0.27 |
| **Pre Impact vel. [mph]:** | **11.34** | **6.39** |
| **Post Impact vel. [mph]:** | **11.95** | **5.74** |
| Velocity change (dV) [mph] : | 1.59 | 0.69 |
| Deformation depth [ft] : | 0.32 | 0.47 |
| EES [mph] : | 1.24 | 0.98 |
| Def. Energy [kJ]: | 0.14 | 0.20 |
| Stiffness [lb/in]: | 223.4 | 155.9 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 10.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 13.86 | |
| Point of Impact y [ft] : | -7.58 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 17.66 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 343.27 | |
| Impulse [lb-s] : | 198.85 | |
| Direction of impulse [deg] : | 107.66 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 0.05 | 1.08 |
| PDOF (SAE) [deg] : | 89.44 | -17.88 |
| dV/EES : | 0.98 | 0.98 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.34** | **6.39** |
| Heading angle [deg] : | 17.10 | 89.78 |
| Velocity direction (ß) [deg] : | 36.48 | 88.40 |
| Yaw velocity [Deg/s] : | 84.44 | -0.71 |
| Center of gravity x [ft] : | 13.10 | 15.32 |
| Center of gravity y [ft] : | -5.35 | -15.76 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.87 | 0.39 |
| Pitch angle [deg] : | 1.80 | -0.35 |
| Roll velocity [Deg/s] : | -5.65 | 2.61 |
| Pitch velocity [Deg/s] : | 8.96 | -1.60 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.95** | **5.74** |
| Heading angle [deg] : | 17.10 | 89.78 |
| Velocity direction (ß) [deg] : | 43.71 | 86.13 |
| Yaw velocity [Deg/s] : | 84.74 | -3.16 |
| Center of gravity x [ft] : | 13.10 | 15.32 |
| Center of gravity y [ft] : | -5.35 | -15.76 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.87 | 0.39 |
| Pitch angle [deg] : | 1.80 | -0.35 |
| Roll velocity [Deg/s] : | 3.90 | 1.84 |
| Pitch velocity [Deg/s] : | 9.00 | -0.85 |

**6.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.31 | 0.31 |
| **Pre Impact vel. [mph]:** | **11.27** | **6.06** |
| **Post Impact vel. [mph]:** | **11.85** | **5.52** |
| Velocity change (dV) [mph] : | 1.36 | 0.59 |
| Deformation depth [ft] : | 0.37 | 0.52 |
| EES [mph] : | 1.08 | 0.85 |
| Def. Energy [kJ]: | 0.11 | 0.15 |
| Stiffness [lb/in]: | 132.3 | 93.8 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 9.6 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 13.74 | |
| Point of Impact y [ft] : | -7.28 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 21.29 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 259.88 | |
| Impulse [lb-s] : | 170.08 | |
| Direction of impulse [deg] : | 111.29 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 0.80 | 1.45 |
| PDOF (SAE) [deg] : | 89.44 | -21.59 |
| dV/EES : | 0.97 | 0.97 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.27** | **6.06** |
| Heading angle [deg] : | 20.73 | 89.70 |
| Velocity direction (ß) [deg] : | 43.48 | 87.95 |
| Yaw velocity [Deg/s] : | 76.95 | -1.01 |
| Center of gravity x [ft] : | 13.65 | 15.34 |
| Center of gravity y [ft] : | -4.82 | -15.37 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.79 | 0.53 |
| Pitch angle [deg] : | 2.04 | -0.40 |
| Roll velocity [Deg/s] : | -10.17 | 3.22 |
| Pitch velocity [Deg/s] : | 7.23 | -1.20 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.85** | **5.52** |
| Heading angle [deg] : | 20.73 | 89.70 |
| Velocity direction (ß) [deg] : | 49.57 | 85.53 |
| Yaw velocity [Deg/s] : | 71.32 | -3.83 |
| Center of gravity x [ft] : | 13.65 | 15.34 |

| | | |
|---|---|---|
| Center of gravity y [ft] : | -4.82 | -15.37 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.79 | 0.53 |
| Pitch angle [deg] : | 2.04 | -0.40 |
| Roll velocity [Deg/s] : | -2.71 | 2.45 |
| Pitch velocity [Deg/s] : | 7.07 | -0.59 |

**7.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.36 | 0.36 |
| **Pre Impact vel. [mph]:** | **11.13** | **5.84** |
| **Post Impact vel. [mph]:** | **11.62** | **5.42** |
| Velocity change (dV) [mph] : | 1.08 | 0.47 |
| Deformation depth [ft] : | 0.41 | 0.56 |
| EES [mph] : | 0.90 | 0.70 |
| Def. Energy [kJ]: | 0.07 | 0.10 |
| Stiffness [lb/in]: | 74.1 | 54.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 8.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 13.68 | |
| Point of Impact y [ft] : | -6.97 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 24.36 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 177.53 | |
| Impulse [lb-s] : | 135.38 | |
| Direction of impulse [deg] : | 114.36 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.54 | 1.78 |
| PDOF (SAE) [deg] : | 89.45 | -24.76 |
| dV/EES : | 0.93 | 0.93 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.13** | **5.84** |
| Heading angle [deg] : | 23.81 | 89.60 |
| Velocity direction (ß) [deg] : | 49.23 | 87.62 |
| Yaw velocity [Deg/s] : | 65.58 | -1.17 |
| Center of gravity x [ft] : | 14.14 | 15.36 |
| Center of gravity y [ft] : | -4.25 | -14.99 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.42 | 0.69 |
| Pitch angle [deg] : | 2.23 | -0.43 |
| Roll velocity [Deg/s] : | -16.05 | 3.63 |
| Pitch velocity [Deg/s] : | 5.33 | -0.91 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.62** | **5.42** |
| Heading angle [deg] : | 23.81 | 89.60 |
| Velocity direction (ß) [deg] : | 54.07 | 85.39 |
| Yaw velocity [Deg/s] : | 57.03 | -3.92 |
| Center of gravity x [ft] : | 14.14 | 15.36 |
| Center of gravity y [ft] : | -4.25 | -14.99 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.42 | 0.69 |
| Pitch angle [deg] : | 2.23 | -0.43 |
| Roll velocity [Deg/s] : | -10.70 | 2.94 |

| | | |
|---|---|---|
| Pitch velocity [Deg/s] : | 5.13 | -0.45 |

**8.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.40 | 0.40 |
| **Pre Impact vel. [mph]:** | **10.89** | **5.74** |
| **Post Impact vel. [mph]:** | **9.62** | **5.89** |
| Velocity change (dV) [mph] : | 2.58 | 1.12 |
| Deformation depth [ft] : | 0.98 | 1.31 |
| EES [mph] : | 2.95 | 2.25 |
| Def. Energy [kJ]: | 0.80 | 1.07 |
| Stiffness [lb/in]: | 139.8 | 103.8 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 2.3 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 13.66 | |
| Point of Impact y [ft] : | -6.66 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -90.50 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 1872.78 | |
| Impulse [lb-s] : | 322.79 | |
| Direction of impulse [deg] : | 179.50 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.02 | 7.95 |
| PDOF (SAE) [deg] : | 26.75 | -90.00 |
| dV/EES : | 0.68 | 0.68 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **10.89** | **5.74** |
| Heading angle [deg] : | 26.25 | 89.50 |
| Velocity direction (ß) [deg] : | 53.86 | 87.49 |
| Yaw velocity [Deg/s] : | 52.04 | -1.17 |
| Center of gravity x [ft] : | 14.58 | 15.38 |
| Center of gravity y [ft] : | -3.65 | -14.63 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | 0.78 | 0.86 |
| Pitch angle [deg] : | 2.36 | -0.46 |
| Roll velocity [Deg/s] : | -20.36 | 3.58 |
| Pitch velocity [Deg/s] : | 3.41 | -0.73 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **9.62** | **5.89** |
| Heading angle [deg] : | 26.25 | 89.50 |
| Velocity direction (ß) [deg] : | 66.45 | 76.55 |
| Yaw velocity [Deg/s] : | 12.34 | -30.40 |
| Center of gravity x [ft] : | 14.58 | 15.38 |
| Center of gravity y [ft] : | -3.65 | -14.63 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | 0.78 | 0.86 |
| Pitch angle [deg] : | 2.36 | -0.46 |
| Roll velocity [Deg/s] : | -18.90 | 0.03 |
| Pitch velocity [Deg/s] : | 6.99 | -1.17 |

**9.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.52 | 0.52 |
| **Pre Impact vel. [mph]:** | **7.73** | **6.64** |
| **Post Impact vel. [mph]:** | **7.57** | **6.66** |
| Velocity change (dV) [mph] : | 0.50 | 0.22 |
| Deformation depth [ft] : | 0.88 | 1.22 |
| EES [mph] : | 0.58 | 0.45 |
| Def. Energy [kJ]: | 0.03 | 0.04 |
| Stiffness [lb/in]: | 6.6 | 4.8 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 0.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.01 | |
| Point of Impact y [ft] : | -5.60 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -92.61 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 73.13 | |
| Impulse [lb-s] : | 62.70 | |
| Direction of impulse [deg] : | 177.39 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.33 | 7.91 |
| PDOF (SAE) [deg] : | 29.85 | -90.00 |
| dV/EES : | 0.67 | 0.67 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **7.73** | **6.64** |
| Heading angle [deg] : | 27.24 | 87.39 |
| Velocity direction (ß) [deg] : | 66.49 | 82.31 |
| Yaw velocity [Deg/s] : | 6.69 | -9.17 |
| Center of gravity x [ft] : | 15.16 | 15.58 |
| Center of gravity y [ft] : | -2.31 | -13.59 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | -0.00 |
| Roll angle [deg] : | -2.18 | 1.02 |
| Pitch angle [deg] : | 2.71 | -0.55 |
| Roll velocity [Deg/s] : | -28.18 | 3.74 |
| Pitch velocity [Deg/s] : | -0.40 | -0.94 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **7.57** | **6.66** |
| Heading angle [deg] : | 27.24 | 87.39 |
| Velocity direction (ß) [deg] : | 70.03 | 80.45 |
| Yaw velocity [Deg/s] : | -1.76 | -14.83 |
| Center of gravity x [ft] : | 15.16 | 15.58 |
| Center of gravity y [ft] : | -2.31 | -13.59 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | -0.00 |
| Roll angle [deg] : | -2.18 | 1.02 |
| Pitch angle [deg] : | 2.71 | -0.55 |
| Roll velocity [Deg/s] : | -28.04 | 3.07 |
| Pitch velocity [Deg/s] : | 0.70 | -1.04 |

**10.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.56 | 0.56 |

| | | |
|---|---|---|
| **Pre Impact vel. [mph]:** | **6.84** | **6.97** |
| **Post Impact vel. [mph]:** | **7.22** | **6.78** |
| Velocity change (dV) [mph] : | 0.48 | 0.21 |
| | | |
| Deformation depth [ft] : | 0.48 | 0.63 |
| EES [mph] : | 0.42 | 0.32 |
| Def. Energy [kJ]: | 0.02 | 0.02 |
| Stiffness [lb/in]: | 12.2 | 9.2 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 0.5 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.16 | |
| Point of Impact y [ft] : | -5.17 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -159.86 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 38.45 | |
| Impulse [lb-s] : | 60.70 | |
| Direction of impulse [deg] : | 110.14 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 2.22 | 1.35 |
| PDOF (SAE) [deg] : | 97.02 | -23.23 |
| dV/EES : | 0.90 | 0.90 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.84** | **6.97** |
| Heading angle [deg] : | 27.16 | 86.91 |
| Velocity direction (ß) [deg] : | 70.13 | 82.83 |
| Yaw velocity [Deg/s] : | -1.87 | -7.65 |
| Center of gravity x [ft] : | 15.32 | 15.65 |
| Center of gravity y [ft] : | -1.87 | -13.14 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | -0.00 |
| Roll angle [deg] : | -3.40 | 1.19 |
| Pitch angle [deg] : | 2.68 | -0.58 |
| Roll velocity [Deg/s] : | -25.89 | 4.34 |
| Pitch velocity [Deg/s] : | -1.57 | -0.77 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **7.22** | **6.78** |
| Heading angle [deg] : | 27.16 | 86.91 |
| Velocity direction (ß) [deg] : | 72.60 | 82.02 |
| Yaw velocity [Deg/s] : | -7.39 | -8.59 |
| Center of gravity x [ft] : | 15.32 | 15.65 |
| Center of gravity y [ft] : | -1.87 | -13.14 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | -0.00 |
| Roll angle [deg] : | -3.40 | 1.19 |
| Pitch angle [deg] : | 2.68 | -0.58 |
| Roll velocity [Deg/s] : | -23.88 | 4.05 |
| Pitch velocity [Deg/s] : | -1.35 | -0.57 |

**11.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| | | |
| t [s]: | 0.61 | 0.61 |
| **Pre Impact vel. [mph]:** | **6.49** | **7.09** |
| **Post Impact vel. [mph]:** | **6.44** | **7.10** |
| Velocity change (dV) [mph] : | 0.21 | 0.09 |
| | | |
| Deformation depth [ft] : | 0.97 | 1.33 |
| EES [mph] : | 0.25 | 0.19 |

| | | |
|---|---|---|
| Def. Energy [kJ]: | 0.01 | 0.01 |
| Stiffness [lb/in]: | 1.0 | 0.7 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.0 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.29 | |
| Point of Impact y [ft] : | -4.73 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.35 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 13.26 | |
| Impulse [lb-s] : | 26.72 | |
| Direction of impulse [deg] : | 176.65 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.35 | 7.86 |
| PDOF (SAE) [deg] : | 30.19 | -90.00 |
| dV/EES : | 0.67 | 0.67 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.49** | **7.09** |
| Heading angle [deg] : | 26.84 | 86.65 |
| Velocity direction (ß) [deg] : | 72.75 | 84.21 |
| Yaw velocity [Deg/s] : | -6.84 | -3.76 |
| Center of gravity x [ft] : | 15.45 | 15.70 |
| Center of gravity y [ft] : | -1.44 | -12.68 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -4.41 | 1.40 |
| Pitch angle [deg] : | 2.55 | -0.60 |
| Roll velocity [Deg/s] : | -20.86 | 4.32 |
| Pitch velocity [Deg/s] : | -2.98 | -0.38 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.44** | **7.10** |
| Heading angle [deg] : | 26.84 | 86.65 |
| Velocity direction (ß) [deg] : | 74.60 | 83.47 |
| Yaw velocity [Deg/s] : | -10.44 | -6.15 |
| Center of gravity x [ft] : | 15.45 | 15.70 |
| Center of gravity y [ft] : | -1.44 | -12.68 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -4.41 | 1.40 |
| Pitch angle [deg] : | 2.55 | -0.60 |
| Roll velocity [Deg/s] : | -20.76 | 4.04 |
| Pitch velocity [Deg/s] : | -2.38 | -0.44 |

**12.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.65 | 0.65 |
| **Pre Impact vel. [mph]:** | **5.71** | **7.42** |
| **Post Impact vel. [mph]:** | **5.69** | **7.42** |
| Velocity change (dV) [mph] : | 0.12 | 0.05 |
| Deformation depth [ft] : | 1.07 | 1.43 |
| EES [mph] : | 0.14 | 0.10 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.2 | 0.2 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.9 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.42 | |

| | | |
|---|---|---|
| Point of Impact y [ft] : | -4.28 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.53 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 3.97 | |
| Impulse [lb-s] : | 14.69 | |
| Direction of impulse [deg] : | 176.47 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.29 | 7.82 |
| PDOF (SAE) [deg] : | 29.94 | -90.00 |
| dV/EES : | 0.68 | 0.68 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.71** | **7.42** |
| Heading angle [deg] : | 26.41 | 86.47 |
| Velocity direction (ß) [deg] : | 74.82 | 84.86 |
| Yaw velocity [Deg/s] : | -9.30 | -2.76 |
| Center of gravity x [ft] : | 15.56 | 15.75 |
| Center of gravity y [ft] : | -1.06 | -12.21 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.03 | -0.00 |
| Roll angle [deg] : | -5.27 | 1.55 |
| Pitch angle [deg] : | 2.38 | -0.61 |
| Roll velocity [Deg/s] : | -16.89 | 2.45 |
| Pitch velocity [Deg/s] : | -3.49 | -0.28 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.69** | **7.42** |
| Heading angle [deg] : | 26.41 | 86.47 |
| Velocity direction (ß) [deg] : | 75.98 | 84.47 |
| Yaw velocity [Deg/s] : | -11.24 | -4.07 |
| Center of gravity x [ft] : | 15.56 | 15.75 |
| Center of gravity y [ft] : | -1.06 | -12.21 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.03 | -0.00 |
| Roll angle [deg] : | -5.27 | 1.55 |
| Pitch angle [deg] : | 2.38 | -0.61 |
| Roll velocity [Deg/s] : | -16.82 | 2.30 |
| Pitch velocity [Deg/s] : | -3.13 | -0.31 |

**13.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.70 | 0.70 |
| **Pre Impact vel. [mph]:** | **4.95** | **7.74** |
| **Post Impact vel. [mph]:** | **4.94** | **7.74** |
| Velocity change (dV) [mph] : | 0.08 | 0.03 |
| Deformation depth [ft] : | 1.20 | 1.56 |
| EES [mph] : | 0.09 | 0.07 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.1 | 0.1 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 2.9 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.58 | |
| Point of Impact y [ft] : | -3.84 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.65 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 1.67 | |
| Impulse [lb-s] : | 9.60 | |

| | | |
|---|---|---|
| Direction of impulse [deg] : | 176.35 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.18 | 7.77 |
| PDOF (SAE) [deg] : | 29.61 | -90.00 |
| dV/EES : | 0.68 | 0.68 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **4.95** | **7.74** |
| Heading angle [deg] : | 25.96 | 86.35 |
| Velocity direction (ß) [deg] : | 76.27 | 85.40 |
| Yaw velocity [Deg/s] : | -9.69 | -1.92 |
| Center of gravity x [ft] : | 15.64 | 15.79 |
| Center of gravity y [ft] : | -0.72 | -11.71 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -5.94 | 1.61 |
| Pitch angle [deg] : | 2.17 | -0.62 |
| Roll velocity [Deg/s] : | -12.52 | 0.13 |
| Pitch velocity [Deg/s] : | -3.83 | -0.18 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **4.94** | **7.74** |
| Heading angle [deg] : | 25.96 | 86.35 |
| Velocity direction (ß) [deg] : | 77.15 | 85.16 |
| Yaw velocity [Deg/s] : | -10.92 | -2.77 |
| Center of gravity x [ft] : | 15.64 | 15.79 |
| Center of gravity y [ft] : | -0.72 | -11.71 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -5.94 | 1.61 |
| Pitch angle [deg] : | 2.17 | -0.62 |
| Roll velocity [Deg/s] : | -12.45 | 0.03 |
| Pitch velocity [Deg/s] : | -3.59 | -0.20 |

**14.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.74 | 0.74 |
| **Pre Impact vel. [mph]:** | **4.20** | **8.07** |
| **Post Impact vel. [mph]:** | **4.19** | **8.07** |
| Velocity change (dV) [mph] : | 0.05 | 0.02 |
| Deformation depth [ft] : | 1.37 | 1.72 |
| EES [mph] : | 0.06 | 0.05 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.0 | 0.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 3.9 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.76 | |
| Point of Impact y [ft] : | -3.40 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.73 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 0.83 | |
| Impulse [lb-s] : | 6.86 | |
| Direction of impulse [deg] : | 176.27 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.03 | 7.70 |
| PDOF (SAE) [deg] : | 29.26 | -90.01 |
| dV/EES : | 0.69 | 0.69 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **4.20** | **8.07** |
| Heading angle [deg] : | 25.53 | 86.26 |
| Velocity direction (ß) [deg] : | 77.49 | 85.81 |
| Yaw velocity [Deg/s] : | -9.11 | -1.30 |
| Center of gravity x [ft] : | 15.71 | 15.83 |
| Center of gravity y [ft] : | -0.43 | -11.18 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | -6.41 | 1.56 |
| Pitch angle [deg] : | 1.95 | -0.62 |
| Roll velocity [Deg/s] : | -8.36 | -2.03 |
| Pitch velocity [Deg/s] : | -3.88 | -0.10 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **4.19** | **8.07** |
| Heading angle [deg] : | 25.53 | 86.26 |
| Velocity direction (ß) [deg] : | 78.23 | 85.64 |
| Yaw velocity [Deg/s] : | -9.94 | -1.90 |
| Center of gravity x [ft] : | 15.71 | 15.83 |
| Center of gravity y [ft] : | -0.43 | -11.18 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | -6.41 | 1.56 |
| Pitch angle [deg] : | 1.95 | -0.62 |
| Roll velocity [Deg/s] : | -8.30 | -2.10 |
| Pitch velocity [Deg/s] : | -3.70 | -0.11 |

**15.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.79 | 0.79 |
| **Pre Impact vel. [mph]:** | **3.45** | **8.40** |
| **Post Impact vel. [mph]:** | **5.59** | **7.50** |
| Velocity change (dV) [mph] : | 2.44 | 1.06 |
| Deformation depth [ft] : | 0.78 | 1.08 |
| EES [mph] : | 2.11 | 1.64 |
| Def. Energy [kJ]: | 0.41 | 0.57 |
| Stiffness [lb/in]: | 111.2 | 80.4 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 3.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.95 | |
| Point of Impact y [ft] : | -2.96 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 25.71 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 977.66 | |
| Impulse [lb-s] : | 305.55 | |
| Direction of impulse [deg] : | 115.71 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.93 | 2.51 |
| PDOF (SAE) [deg] : | 89.45 | -29.50 |
| dV/EES : | 0.90 | 0.90 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **3.45** | **8.40** |
| Heading angle [deg] : | 25.16 | 86.21 |
| Velocity direction (ß) [deg] : | 78.63 | 86.11 |

| | | |
|---|---|---|
| Yaw velocity [Deg/s] : | -8.00 | -0.85 |
| Center of gravity x [ft] : | 15.76 | 15.87 |
| Center of gravity y [ft] : | -0.18 | -10.64 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.00 |
| Roll angle [deg] : | -6.71 | 1.42 |
| Pitch angle [deg] : | 1.74 | -0.62 |
| Roll velocity [Deg/s] : | -4.85 | -3.70 |
| Pitch velocity [Deg/s] : | -3.63 | -0.03 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.59** | **7.50** |
| Heading angle [deg] : | 25.16 | 86.21 |
| Velocity direction (ß) [deg] : | 93.89 | 82.11 |
| Yaw velocity [Deg/s] : | -31.93 | -9.61 |
| Center of gravity x [ft] : | 15.76 | 15.87 |
| Center of gravity y [ft] : | -0.18 | -10.64 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.00 |
| Roll angle [deg] : | -6.71 | 1.42 |
| Pitch angle [deg] : | 1.74 | -0.62 |
| Roll velocity [Deg/s] : | 7.04 | -5.40 |
| Pitch velocity [Deg/s] : | -0.76 | 0.82 |

**16.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.83 | 0.83 |
| **Pre Impact vel. [mph]:** | **4.86** | **7.81** |
| **Post Impact vel. [mph]:** | **6.31** | **7.20** |
| Velocity change (dV) [mph] : | 1.46 | 0.63 |
| Deformation depth [ft] : | 0.82 | 1.06 |
| EES [mph] : | 1.19 | 0.89 |
| Def. Energy [kJ]: | 0.13 | 0.17 |
| Stiffness [lb/in]: | 31.9 | 24.7 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 3.3 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.12 | |
| Point of Impact y [ft] : | -2.46 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -169.79 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 297.63 | |
| Impulse [lb-s] : | 182.13 | |
| Direction of impulse [deg] : | 100.21 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.07 | 0.57 |
| PDOF (SAE) [deg] : | 103.55 | -14.30 |
| dV/EES : | 0.97 | 0.97 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **4.86** | **7.81** |
| Heading angle [deg] : | 23.76 | 85.91 |
| Velocity direction (ß) [deg] : | 94.77 | 84.36 |
| Yaw velocity [Deg/s] : | -30.92 | -4.49 |
| Center of gravity x [ft] : | 15.73 | 15.93 |
| Center of gravity y [ft] : | 0.16 | -10.14 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.02 | 0.00 |
| Roll angle [deg] : | -6.50 | 1.29 |

| | | |
|---|---|---|
| Pitch angle [deg] : | 1.53 | -0.58 |
| Roll velocity [Deg/s] : | 3.93 | -1.91 |
| Pitch velocity [Deg/s] : | -1.21 | 0.62 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.31** | **7.20** |
| Heading angle [deg] : | 23.76 | 85.91 |
| Velocity direction (ß) [deg] : | 96.03 | 82.99 |
| Yaw velocity [Deg/s] : | -38.91 | -5.68 |
| Center of gravity x [ft] : | 15.73 | 15.93 |
| Center of gravity y [ft] : | 0.16 | -10.14 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.02 | 0.00 |
| Roll angle [deg] : | -6.50 | 1.29 |
| Pitch angle [deg] : | 1.53 | -0.58 |
| Roll velocity [Deg/s] : | 11.55 | -2.47 |
| Pitch velocity [Deg/s] : | -0.90 | 1.30 |

**17.COLLISION**

| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
|---|---|---|
| Driver : | | |
| t [s]: | 0.90 | 0.90 |
| **Pre Impact vel. [mph]:** | **5.20** | **7.71** |
| **Post Impact vel. [mph]:** | **5.10** | **7.71** |
| Velocity change (dV) [mph] : | 0.82 | 0.36 |
| Deformation depth [ft] : | 1.83 | 2.04 |
| EES [mph] : | 0.94 | 0.66 |
| Def. Energy [kJ]: | 0.08 | 0.09 |
| Stiffness [lb/in]: | 4.1 | 3.6 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 2.4 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.33 | |
| Point of Impact y [ft] : | -1.68 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -94.29 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 172.59 | |
| Impulse [lb-s] : | 102.69 | |
| Direction of impulse [deg] : | -4.29 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 2.44 | 7.62 |
| PDOF (SAE) [deg] : | -154.58 | 90.00 |
| dV/EES : | 0.72 | 0.72 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.20** | **7.71** |
| Heading angle [deg] : | 21.13 | 85.71 |
| Velocity direction (ß) [deg] : | 97.19 | 85.05 |
| Yaw velocity [Deg/s] : | -36.58 | -1.40 |
| Center of gravity x [ft] : | 15.66 | 16.00 |
| Center of gravity y [ft] : | 0.74 | -9.37 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.01 | 0.00 |
| Roll angle [deg] : | -6.10 | 1.19 |
| Pitch angle [deg] : | 1.18 | -0.52 |
| Roll velocity [Deg/s] : | 2.46 | -1.53 |
| Pitch velocity [Deg/s] : | -0.69 | 0.51 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.10** | **7.71** |
| Heading angle [deg] : | 21.13 | 85.71 |
| Velocity direction (ß) [deg] : | 88.11 | 87.70 |
| Yaw velocity [Deg/s] : | -26.57 | 7.52 |
| Center of gravity x [ft] : | 15.66 | 16.00 |
| Center of gravity y [ft] : | 0.74 | -9.37 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.01 | 0.00 |
| Roll angle [deg] : | -6.10 | 1.19 |
| Pitch angle [deg] : | 1.18 | -0.52 |
| Roll velocity [Deg/s] : | 1.08 | -0.42 |
| Pitch velocity [Deg/s] : | -3.09 | 0.70 |

**18.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.95 | 0.95 |
| **Pre Impact vel. [mph]:** | **4.38** | **8.04** |
| **Post Impact vel. [mph]:** | **6.12** | **7.32** |
| Velocity change (dV) [mph] : | 1.85 | 0.80 |
| Deformation depth [ft] : | 0.87 | 1.18 |
| EES [mph] : | 1.54 | 1.18 |
| Def. Energy [kJ]: | 0.22 | 0.30 |
| Stiffness [lb/in]: | 48.0 | 35.3 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 2.8 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.45 | |
| Point of Impact y [ft] : | -1.23 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -157.24 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 513.43 | |
| Impulse [lb-s] : | 231.87 | |
| Direction of impulse [deg] : | 112.76 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.08 | 2.42 |
| PDOF (SAE) [deg] : | 87.26 | -26.83 |
| dV/EES : | 0.94 | 0.94 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **4.38** | **8.04** |
| Heading angle [deg] : | 20.02 | 85.93 |
| Velocity direction (ß) [deg] : | 89.02 | 87.02 |
| Yaw velocity [Deg/s] : | -24.02 | 3.21 |
| Center of gravity x [ft] : | 15.67 | 16.03 |
| Center of gravity y [ft] : | 1.05 | -8.85 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | -6.16 | 1.06 |
| Pitch angle [deg] : | 0.96 | -0.50 |
| Roll velocity [Deg/s] : | -1.98 | -4.32 |
| Pitch velocity [Deg/s] : | -1.55 | 0.16 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.12** | **7.32** |
| Heading angle [deg] : | 20.02 | 85.93 |
| Velocity direction (ß) [deg] : | 96.02 | 84.29 |

| | | |
|---|---|---|
| Yaw velocity [Deg/s] : | -34.22 | -3.20 |
| Center of gravity x [ft] : | 15.67 | 16.03 |
| Center of gravity y [ft] : | 1.05 | -8.85 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | -6.16 | 1.06 |
| Pitch angle [deg] : | 0.96 | -0.50 |
| Roll velocity [Deg/s] : | 8.41 | -5.54 |
| Pitch velocity [Deg/s] : | -0.29 | 0.87 |

**19.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.99 | 0.99 |
| **Pre Impact vel. [mph]:** | **5.40** | **7.65** |
| **Post Impact vel. [mph]:** | **6.67** | **7.11** |
| Velocity change (dV) [mph] : | 1.28 | 0.56 |
| Deformation depth [ft] : | 0.90 | 1.14 |
| EES [mph] : | 1.03 | 0.77 |
| Def. Energy [kJ]: | 0.10 | 0.12 |
| Stiffness [lb/in]: | 20.1 | 15.8 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 2.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.59 | |
| Point of Impact y [ft] : | -0.75 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -171.39 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 221.74 | |
| Impulse [lb-s] : | 160.16 | |
| Direction of impulse [deg] : | 98.61 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 0.37 | 0.67 |
| PDOF (SAE) [deg] : | 99.92 | -12.77 |
| dV/EES : | 0.99 | 0.99 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.40** | **7.65** |
| Heading angle [deg] : | 18.53 | 85.84 |
| Velocity direction (ß) [deg] : | 96.63 | 85.48 |
| Yaw velocity [Deg/s] : | -32.55 | -1.29 |
| Center of gravity x [ft] : | 15.63 | 16.07 |
| Center of gravity y [ft] : | 1.43 | -8.36 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | -5.97 | 0.87 |
| Pitch angle [deg] : | 0.81 | -0.48 |
| Roll velocity [Deg/s] : | 1.84 | -3.58 |
| Pitch velocity [Deg/s] : | 0.32 | 0.30 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.67** | **7.11** |
| Heading angle [deg] : | 18.53 | 85.84 |
| Velocity direction (ß) [deg] : | 97.01 | 84.46 |
| Yaw velocity [Deg/s] : | -34.99 | -2.51 |
| Center of gravity x [ft] : | 15.63 | 16.07 |
| Center of gravity y [ft] : | 1.43 | -8.36 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | -5.97 | 0.87 |

| | | |
|---|---|---|
| Pitch angle [deg] : | 0.81 | -0.48 |
| Roll velocity [Deg/s] : | 9.18 | -4.02 |
| Pitch velocity [Deg/s] : | 0.18 | 0.91 |

**20.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 1.05 | 1.05 |
| **Pre Impact vel. [mph]:** | **5.70** | **6.82** |
| **Post Impact vel. [mph]:** | **6.00** | **6.70** |
| Velocity change (dV) [mph] : | 0.30 | 0.13 |
| Deformation depth [ft] : | 0.88 | 1.16 |
| EES [mph] : | 0.25 | 0.19 |
| Def. Energy [kJ]: | 0.01 | 0.01 |
| Stiffness [lb/in]: | 1.2 | 0.9 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 2.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.74 | |
| Point of Impact y [ft] : | -0.11 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 17.06 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 13.02 | |
| Impulse [lb-s] : | 38.10 | |
| Direction of impulse [deg] : | 107.06 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 0.44 | 1.87 |
| PDOF (SAE) [deg] : | 89.44 | -21.33 |
| dV/EES : | 0.97 | 0.97 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.70** | **6.82** |
| Heading angle [deg] : | 16.50 | 85.73 |
| Velocity direction (ß) [deg] : | 97.69 | 85.07 |
| Yaw velocity [Deg/s] : | -32.98 | -1.85 |
| Center of gravity x [ft] : | 15.56 | 16.12 |
| Center of gravity y [ft] : | 1.96 | -7.74 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | -5.78 | 0.67 |
| Pitch angle [deg] : | 0.63 | -0.35 |
| Roll velocity [Deg/s] : | -0.75 | -3.58 |
| Pitch velocity [Deg/s] : | 0.88 | 3.66 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.00** | **6.70** |
| Heading angle [deg] : | 16.50 | 85.73 |
| Velocity direction (ß) [deg] : | 98.16 | 84.65 |
| Yaw velocity [Deg/s] : | -33.66 | -2.66 |
| Center of gravity x [ft] : | 15.56 | 16.12 |
| Center of gravity y [ft] : | 1.96 | -7.74 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | -5.78 | 0.67 |
| Pitch angle [deg] : | 0.63 | -0.35 |
| Roll velocity [Deg/s] : | 1.02 | -3.75 |
| Pitch velocity [Deg/s] : | 0.95 | 3.79 |

**21.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 1.09 | 1.09 |
| **Pre Impact vel. [mph]:** | **5.28** | **6.27** |
| **Post Impact vel. [mph]:** | **5.15** | **6.27** |
| Velocity change (dV) [mph] : | 0.85 | 0.37 |
| Deformation depth [ft] : | 2.57 | 2.38 |
| EES [mph] : | 1.00 | 0.63 |
| Def. Energy [kJ]: | 0.09 | 0.08 |
| Stiffness [lb/in]: | 2.3 | 2.5 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.4 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.86 | |
| Point of Impact y [ft] : | 0.31 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -94.39 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 176.51 | |
| Impulse [lb-s] : | 106.33 | |
| Direction of impulse [deg] : | -4.39 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.99 | 7.58 |
| PDOF (SAE) [deg] : | -160.59 | 90.01 |
| dV/EES : | 0.73 | 0.73 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.28** | **6.27** |
| Heading angle [deg] : | 15.02 | 85.62 |
| Velocity direction (ß) [deg] : | 98.82 | 84.79 |
| Yaw velocity [Deg/s] : | -32.05 | -2.36 |
| Center of gravity x [ft] : | 15.51 | 16.16 |
| Center of gravity y [ft] : | 2.33 | -7.32 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | -5.89 | 0.50 |
| Pitch angle [deg] : | 0.54 | -0.14 |
| Roll velocity [Deg/s] : | -4.55 | -3.58 |
| Pitch velocity [Deg/s] : | 1.35 | 5.47 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.15** | **6.27** |
| Heading angle [deg] : | 15.02 | 85.62 |
| Velocity direction (ß) [deg] : | 89.59 | 88.16 |
| Yaw velocity [Deg/s] : | -23.63 | 6.83 |
| Center of gravity x [ft] : | 15.51 | 16.16 |
| Center of gravity y [ft] : | 2.33 | -7.32 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | -5.89 | 0.50 |
| Pitch angle [deg] : | 0.54 | -0.14 |
| Roll velocity [Deg/s] : | -5.95 | -2.23 |
| Pitch velocity [Deg/s] : | -0.94 | 5.55 |

**22.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |

| | | |
|---|---|---|
| t [s]: | 1.14 | 1.14 |
| **Pre Impact vel. [mph]:** | **4.43** | **5.82** |
| **Post Impact vel. [mph]:** | **4.42** | **5.82** |
| Velocity change (dV) [mph] : | 0.05 | 0.02 |
| | | |
| Deformation depth [ft] : | 2.84 | 2.47 |
| EES [mph] : | 0.05 | 0.03 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.0 | 0.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.92 | |
| Point of Impact y [ft] : | 0.66 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -94.13 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 0.50 | |
| Impulse [lb-s] : | 5.65 | |
| Direction of impulse [deg] : | -4.13 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.94 | 7.55 |
| PDOF (SAE) [deg] : | -161.84 | 90.00 |
| dV/EES : | 0.74 | 0.74 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **4.43** | **5.82** |
| Heading angle [deg] : | 14.03 | 85.87 |
| Velocity direction (ß) [deg] : | 90.42 | 88.55 |
| Yaw velocity [Deg/s] : | -21.20 | 4.88 |
| Center of gravity x [ft] : | 15.50 | 16.17 |
| Center of gravity y [ft] : | 2.64 | -6.92 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -6.23 | 0.40 |
| Pitch angle [deg] : | 0.43 | 0.13 |
| Roll velocity [Deg/s] : | -8.27 | -2.24 |
| Pitch velocity [Deg/s] : | 0.60 | 6.13 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **4.42** | **5.82** |
| Heading angle [deg] : | 14.03 | 85.87 |
| Velocity direction (ß) [deg] : | 89.83 | 88.74 |
| Yaw velocity [Deg/s] : | -20.77 | 5.36 |
| Center of gravity x [ft] : | 15.50 | 16.17 |
| Center of gravity y [ft] : | 2.64 | -6.92 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -6.23 | 0.40 |
| Pitch angle [deg] : | 0.43 | 0.13 |
| Roll velocity [Deg/s] : | -8.34 | -2.16 |
| Pitch velocity [Deg/s] : | 0.48 | 6.13 |

**23.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| | | |
| t [s]: | 1.18 | 1.18 |
| **Pre Impact vel. [mph]:** | **3.70** | **5.35** |
| **Post Impact vel. [mph]:** | **3.69** | **5.35** |
| Velocity change (dV) [mph] : | 0.04 | 0.02 |

| | | |
|---|---|---|
| Deformation depth [ft] : | 3.14 | 2.55 |
| EES [mph] : | 0.05 | 0.03 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.0 | 0.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.9 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.98 | |
| Point of Impact y [ft] : | 0.98 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.92 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 0.38 | |
| Impulse [lb-s] : | 4.99 | |
| Direction of impulse [deg] : | -3.92 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.89 | 7.50 |
| PDOF (SAE) [deg] : | -162.93 | 90.00 |
| dV/EES : | 0.74 | 0.74 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **3.70** | **5.35** |
| Heading angle [deg] : | 13.15 | 86.08 |
| Velocity direction (ß) [deg] : | 90.90 | 88.84 |
| Yaw velocity [Deg/s] : | -18.48 | 4.09 |
| Center of gravity x [ft] : | 15.50 | 16.18 |
| Center of gravity y [ft] : | 2.91 | -6.55 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -6.64 | 0.30 |
| Pitch angle [deg] : | 0.39 | 0.40 |
| Roll velocity [Deg/s] : | -9.06 | -2.58 |
| Pitch velocity [Deg/s] : | 1.70 | 5.89 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **3.69** | **5.35** |
| Heading angle [deg] : | 13.15 | 86.08 |
| Velocity direction (ß) [deg] : | 90.28 | 89.02 |
| Yaw velocity [Deg/s] : | -18.10 | 4.52 |
| Center of gravity x [ft] : | 15.50 | 16.18 |
| Center of gravity y [ft] : | 2.91 | -6.55 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -6.64 | 0.30 |
| Pitch angle [deg] : | 0.39 | 0.40 |
| Roll velocity [Deg/s] : | -9.12 | -2.51 |
| Pitch velocity [Deg/s] : | 1.59 | 5.89 |

**24.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 1.23 | 1.23 |
| **Pre Impact vel. [mph]:** | **2.97** | **4.76** |
| **Post Impact vel. [mph]:** | **2.96** | **4.76** |
| Velocity change (dV) [mph] : | 0.04 | 0.02 |
| Deformation depth [ft] : | 3.46 | 2.63 |
| EES [mph] : | 0.04 | 0.03 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.0 | 0.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 2.0 | |

| | | |
|---|---|---|
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 16.04 | |
| Point of Impact y [ft] : | 1.25 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.74 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 0.31 | |
| Impulse [lb-s] : | 4.49 | |
| Direction of impulse [deg] : | -3.74 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.84 | 7.44 |
| PDOF (SAE) [deg] : | -163.88 | 90.00 |
| dV/EES : | 0.74 | 0.74 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **2.97** | **4.76** |
| Heading angle [deg] : | 12.38 | 86.26 |
| Velocity direction (ß) [deg] : | 91.68 | 89.02 |
| Yaw velocity [Deg/s] : | -16.04 | 3.60 |
| Center of gravity x [ft] : | 15.50 | 16.19 |
| Center of gravity y [ft] : | 3.12 | -6.22 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.03 | -0.00 |
| Roll angle [deg] : | -7.04 | 0.18 |
| Pitch angle [deg] : | 0.39 | 0.65 |
| Roll velocity [Deg/s] : | -8.70 | -2.84 |
| Pitch velocity [Deg/s] : | 2.41 | 5.69 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **2.96** | **4.76** |
| Heading angle [deg] : | 12.38 | 86.26 |
| Velocity direction (ß) [deg] : | 90.99 | 89.21 |
| Yaw velocity [Deg/s] : | -15.71 | 3.98 |
| Center of gravity x [ft] : | 15.50 | 16.19 |
| Center of gravity y [ft] : | 3.12 | -6.22 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.03 | -0.00 |
| Roll angle [deg] : | -7.04 | 0.18 |
| Pitch angle [deg] : | 0.39 | 0.65 |
| Roll velocity [Deg/s] : | -8.75 | -2.77 |
| Pitch velocity [Deg/s] : | 2.31 | 5.70 |

**25.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 1.27 | 1.27 |
| **Pre Impact vel. [mph]:** | **2.24** | **4.02** |
| **Post Impact vel. [mph]:** | **2.24** | **4.02** |
| Velocity change (dV) [mph] : | 0.03 | 0.01 |
| Deformation depth [ft] : | 3.78 | 2.69 |
| EES [mph] : | 0.04 | 0.02 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.0 | 0.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 2.0 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 16.08 | |
| Point of Impact y [ft] : | 1.47 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.58 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |

| | | |
|---|---|---|
| Total Deformation Energy [ft-lb] : | 0.26 | |
| Impulse [lb-s] : | 4.15 | |
| Direction of impulse [deg] : | -3.58 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.79 | 7.38 |
| PDOF (SAE) [deg] : | -164.71 | 90.00 |
| dV/EES : | 0.75 | 0.75 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **2.24** | **4.02** |
| Heading angle [deg] : | 11.71 | 86.42 |
| Velocity direction (ß) [deg] : | 92.96 | 89.18 |
| Yaw velocity [Deg/s] : | -13.83 | 3.28 |
| Center of gravity x [ft] : | 15.49 | 16.19 |
| Center of gravity y [ft] : | 3.29 | -5.93 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.03 | -0.00 |
| Roll angle [deg] : | -7.42 | 0.05 |
| Pitch angle [deg] : | 0.42 | 0.91 |
| Roll velocity [Deg/s] : | -7.58 | -2.91 |
| Pitch velocity [Deg/s] : | 2.73 | 5.52 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **2.24** | **4.02** |
| Heading angle [deg] : | 11.71 | 86.42 |
| Velocity direction (ß) [deg] : | 92.12 | 89.38 |
| Yaw velocity [Deg/s] : | -13.54 | 3.63 |
| Center of gravity x [ft] : | 15.49 | 16.19 |
| Center of gravity y [ft] : | 3.29 | -5.93 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.03 | -0.00 |
| Roll angle [deg] : | -7.42 | 0.05 |
| Pitch angle [deg] : | 0.42 | 0.91 |
| Roll velocity [Deg/s] : | -7.63 | -2.84 |
| Pitch velocity [Deg/s] : | 2.64 | 5.52 |

**26.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 1.32 | 1.32 |
| **Pre Impact vel. [mph]:** | **1.51** | **3.28** |
| **Post Impact vel. [mph]:** | **1.51** | **3.28** |
| Velocity change (dV) [mph] : | 0.03 | 0.01 |
| Deformation depth [ft] : | 4.11 | 2.75 |
| EES [mph] : | 0.04 | 0.02 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.0 | 0.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.9 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 16.12 | |
| Point of Impact y [ft] : | 1.64 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.43 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 0.24 | |
| Impulse [lb-s] : | 4.05 | |
| Direction of impulse [deg] : | -3.43 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.73 | 7.32 |
| PDOF (SAE) [deg] : | -165.43 | 90.00 |

| | | |
|---|---|---|
| dV/EES : | 0.75 | 0.75 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **1.51** | **3.28** |
| Heading angle [deg] : | 11.14 | 86.57 |
| Velocity direction (ß) [deg] : | 95.41 | 89.33 |
| Yaw velocity [Deg/s] : | -11.72 | 2.91 |
| Center of gravity x [ft] : | 15.49 | 16.19 |
| Center of gravity y [ft] : | 3.41 | -5.70 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.01 |
| Roll angle [deg] : | -7.72 | -0.07 |
| Pitch angle [deg] : | 0.47 | 1.14 |
| Roll velocity [Deg/s] : | -5.88 | -2.68 |
| Pitch velocity [Deg/s] : | 2.61 | 4.72 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **1.51** | **3.28** |
| Heading angle [deg] : | 11.14 | 86.57 |
| Velocity direction (ß) [deg] : | 94.19 | 89.58 |
| Yaw velocity [Deg/s] : | -11.44 | 3.25 |
| Center of gravity x [ft] : | 15.49 | 16.19 |
| Center of gravity y [ft] : | 3.41 | -5.70 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.01 |
| Roll angle [deg] : | -7.72 | -0.07 |
| Pitch angle [deg] : | 0.47 | 1.14 |
| Roll velocity [Deg/s] : | -5.92 | -2.60 |
| Pitch velocity [Deg/s] : | 2.52 | 4.72 |

**27.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 1.36 | 1.36 |
| **Pre Impact vel. [mph]:** | **0.80** | **2.54** |
| **Post Impact vel. [mph]:** | **0.80** | **2.54** |
| Velocity change (dV) [mph] : | 0.03 | 0.01 |
| Deformation depth [ft] : | 4.44 | 2.80 |
| EES [mph] : | 0.03 | 0.02 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.0 | 0.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.9 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 16.15 | |
| Point of Impact y [ft] : | 1.77 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.31 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 0.18 | |
| Impulse [lb-s] : | 3.46 | |
| Direction of impulse [deg] : | -3.31 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.68 | 7.26 |
| PDOF (SAE) [deg] : | -166.02 | 90.01 |
| dV/EES : | 0.75 | 0.75 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.80** | **2.54** |

| | | |
|---|---|---|
| Heading angle [deg] : | 10.67 | 86.70 |
| Velocity direction (ß) [deg] : | 101.70 | 89.50 |
| Yaw velocity [Deg/s] : | -9.14 | 2.49 |
| Center of gravity x [ft] : | 15.48 | 16.19 |
| Center of gravity y [ft] : | 3.49 | -5.51 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.01 | -0.01 |
| Roll angle [deg] : | -7.94 | -0.18 |
| Pitch angle [deg] : | 0.51 | 1.32 |
| Roll velocity [Deg/s] : | -3.59 | -2.28 |
| Pitch velocity [Deg/s] : | 2.03 | 3.60 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.80** | **2.54** |
| Heading angle [deg] : | 10.67 | 86.70 |
| Velocity direction (ß) [deg] : | 99.78 | 89.77 |
| Yaw velocity [Deg/s] : | -8.91 | 2.78 |
| Center of gravity x [ft] : | 15.48 | 16.19 |
| Center of gravity y [ft] : | 3.49 | -5.51 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | -0.01 | -0.01 |
| Roll angle [deg] : | -7.94 | -0.18 |
| Pitch angle [deg] : | 0.51 | 1.32 |
| Roll velocity [Deg/s] : | -3.62 | -2.21 |
| Pitch velocity [Deg/s] : | 1.95 | 3.60 |

**28.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 1.41 | 1.41 |
| **Pre Impact vel. [mph]:** | **0.23** | **1.80** |
| **Post Impact vel. [mph]:** | **0.23** | **1.80** |
| Velocity change (dV) [mph] : | 0.00 | 0.00 |
| Deformation depth [ft] : | 4.74 | 2.84 |
| EES [mph] : | 0.00 | 0.00 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.0 | 0.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 16.17 | |
| Point of Impact y [ft] : | 1.85 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.20 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 0.00 | |
| Impulse [lb-s] : | 0.00 | |
| Direction of impulse [deg] : | 176.80 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.63 | 7.20 |
| PDOF (SAE) [deg] : | 13.56 | -90.00 |
| dV/EES : | 0.76 | 0.76 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.23** | **1.80** |
| Heading angle [deg] : | 10.36 | 86.80 |
| Velocity direction (ß) [deg] : | 129.11 | 89.61 |
| Yaw velocity [Deg/s] : | -4.68 | 1.97 |
| Center of gravity x [ft] : | 15.47 | 16.20 |
| Center of gravity y [ft] : | 3.52 | -5.37 |
| Center of gravity z [ft] : | 1.82 | 1.83 |

| | | |
|---|---|---|
| Velocity vertical [mph] : | 0.01 | -0.01 |
| Roll angle [deg] : | -8.01 | -0.27 |
| Pitch angle [deg] : | 0.52 | 1.46 |
| Roll velocity [Deg/s] : | 1.25 | -1.80 |
| Pitch velocity [Deg/s] : | 0.51 | 2.40 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.23** | **1.80** |
| Heading angle [deg] : | 10.36 | 86.80 |
| Velocity direction (ß) [deg] : | 129.12 | 89.61 |
| Yaw velocity [Deg/s] : | -4.68 | 1.97 |
| Center of gravity x [ft] : | 15.47 | 16.20 |
| Center of gravity y [ft] : | 3.52 | -5.37 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.01 |
| Roll angle [deg] : | -8.01 | -0.27 |
| Pitch angle [deg] : | 0.52 | 1.46 |
| Roll velocity [Deg/s] : | 1.25 | -1.80 |
| Pitch velocity [Deg/s] : | 0.51 | 2.40 |

**29.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 1.45 | 1.45 |
| **Pre Impact vel. [mph]:** | **0.18** | **1.06** |
| **Post Impact vel. [mph]:** | **0.17** | **1.06** |
| Velocity change (dV) [mph] : | 0.03 | 0.01 |
| Deformation depth [ft] : | 4.87 | 2.86 |
| EES [mph] : | 0.03 | 0.02 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.0 | 0.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.0 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 16.18 | |
| Point of Impact y [ft] : | 1.89 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.14 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 0.17 | |
| Impulse [lb-s] : | 3.43 | |
| Direction of impulse [deg] : | -3.14 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.58 | 7.15 |
| PDOF (SAE) [deg] : | -166.52 | 90.01 |
| dV/EES : | 0.76 | 0.76 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.18** | **1.06** |
| Heading angle [deg] : | 10.34 | 86.87 |
| Velocity direction (ß) [deg] : | 133.57 | 89.39 |
| Yaw velocity [Deg/s] : | -4.06 | 1.23 |
| Center of gravity x [ft] : | 15.47 | 16.20 |
| Center of gravity y [ft] : | 3.52 | -5.27 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.01 |
| Roll angle [deg] : | -7.99 | -0.33 |
| Pitch angle [deg] : | 0.52 | 1.54 |
| Roll velocity [Deg/s] : | 2.30 | -1.27 |
| Pitch velocity [Deg/s] : | 0.14 | 1.29 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.17** | **1.06** |
| Heading angle [deg] : | 10.34 | 86.87 |
| Velocity direction (ß) [deg] : | 127.06 | 90.03 |
| Yaw velocity [Deg/s] : | -3.85 | 1.51 |
| Center of gravity x [ft] : | 15.47 | 16.20 |
| Center of gravity y [ft] : | 3.52 | -5.27 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.01 |
| Roll angle [deg] : | -7.99 | -0.33 |
| Pitch angle [deg] : | 0.52 | 1.54 |
| Roll velocity [Deg/s] : | 2.27 | -1.20 |
| Pitch velocity [Deg/s] : | 0.07 | 1.29 |

**30.COLLISION**

| | | | |
|---|---|---|---|
| Vehicle : | 1 CHEVROLET | | 2 FORD-EXPE |
| Driver : | | | |
| t [s]: | 1.50 | | 1.50 |
| **Pre Impact vel. [mph]:** | **0.17** | | **0.33** |
| **Post Impact vel. [mph]:** | **0.14** | | **0.33** |
| Velocity change (dV) [mph] : | 0.04 | | 0.02 |
| Deformation depth [ft] : | 4.93 | | 2.87 |
| EES [mph] : | 0.05 | | 0.03 |
| Def. Energy [kJ]: | 0.00 | | 0.00 |
| Stiffness [lb/in]: | 0.0 | | 0.0 |
| Coefficient of restitution (e) : | | 0.00 | |
| Separation speed [mph]: | | 0.2 | |
| Friction coefficient (mu) : | | 0.00 | |
| Point of Impact x [ft] : | | 16.19 | |
| Point of Impact y [ft] : | | 1.91 | |
| Point of Impact z [ft] : | | 1.48 | |
| Angle of contact plane (phi) [deg] : | | -93.09 | |
| Angle of contact plane (psi) [deg] : | | 0.00 | |
| Total Deformation Energy [ft-lb] : | | 0.38 | |
| Impulse [lb-s] : | | 5.11 | |
| Direction of impulse [deg] : | | -3.09 | |
| Vertical direction of impulse [deg] : | | 0.00 | |
| Moment arm about C.G. [ft] : | 1.56 | | 7.13 |
| PDOF (SAE) [deg] : | -166.57 | | 90.00 |
| dV/EES : | 0.76 | | 0.76 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.17** | **0.33** |
| Heading angle [deg] : | 10.34 | 86.91 |
| Velocity direction (ß) [deg] : | 127.06 | 90.47 |
| Yaw velocity [Deg/s] : | -3.85 | 0.72 |
| Center of gravity x [ft] : | 15.47 | 16.20 |
| Center of gravity y [ft] : | 3.52 | -5.23 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.00 |
| Roll angle [deg] : | -7.99 | -0.37 |
| Pitch angle [deg] : | 0.52 | 1.57 |
| Roll velocity [Deg/s] : | 2.27 | -0.65 |
| Pitch velocity [Deg/s] : | 0.07 | 0.36 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.14** | **0.33** |

| | | |
|---|---|---|
| Heading angle [deg] : | 10.34 | 86.91 |
| Velocity direction (ß) [deg] : | 114.44 | 93.56 |
| Yaw velocity [Deg/s] : | -3.54 | 1.13 |
| Center of gravity x [ft] : | 15.47 | 16.20 |
| Center of gravity y [ft] : | 3.52 | -5.23 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.00 |
| Roll angle [deg] : | -7.99 | -0.37 |
| Pitch angle [deg] : | 0.52 | 1.57 |
| Roll velocity [Deg/s] : | 2.23 | -0.54 |
| Pitch velocity [Deg/s] : | -0.04 | 0.36 |

**SEQUENCES**

1 CHEVROLET :

REACTION
Reaction time [sec] : 1.00

BRAKE LAG
Threshold time [sec] : 0.20

BRAKE
maximum stopping distance [ft] : 32.81
Brake force [%]
Axle 1, left : 0.00
Axle 1, right : 0.00
Axle 2, left : 0.00
Axle 2, right : 0.00
mean brake acceleration [g] : 0.00

START VALUES
Velocity [mph] : 14.00
Friction coefficient : 0.75

BRAKE
maximum stopping distance [ft] : 300.00
Brake force [%]
Axle 1, left : 215.77
Axle 1, right : 215.77
Axle 2, left : 40.90
Axle 2, right : 40.90
mean brake acceleration [g] : -0.75

2 FORD-EXPE :

REACTION
Reaction time [sec] : 1.00

BRAKE LAG
Threshold time [sec] : 0.20

BRAKE
maximum stopping distance [ft] : 32.81
Brake force [%]
Axle 1, left : 0.00
Axle 1, right : 0.00
Axle 2, left : 0.00
Axle 2, right : 0.00
mean brake acceleration [g] : 0.00

START VALUES
Velocity [mph] : 8.00
Friction coefficient : 0.75

ACCELERATE
Maximum acceleration time [s] : 1.00
Accelerative force [%]
Axle 1, left : 0.00

| | |
|---|---|
| Axle 1, right : | 0.00 |
| Axle 2, left : | 67.00 |
| Axle 2, right : | 67.00 |
| Average acceleration [g] : | 0.33 |

BRAKE LAG

| | |
|---|---|
| Threshold time [sec] : | 0.20 |

BRAKE

| | |
|---|---|
| maximum stopping distance [ft] : | 300.00 |
| Brake force [%] | |
| Axle 1, left : | 222.73 |
| Axle 1, right : | 222.73 |
| Axle 2, left : | 81.92 |
| Axle 2, right : | 81.92 |
| mean brake acceleration [g] : | -0.75 |

**INPUT VALUES**

Vehicle : CHEVROLET-CAVALIER 4DR SEDAN BASE/LS FORD-EXPEDITION MAX 4WD SUV EDDIE BAUER/LIMI

| | | |
|---|---|---|
| Database: | DB_USDBASE | DB_USDBASE |
| RecordID: | 30 | 15 |
| Length [in] : | 180.31 | 221.26 |
| Width [in] : | 67.32 | 78.74 |
| Height [in] : | 54.72 | 77.56 |
| Number of axles : | 2 | 2 |
| Wheelbase [in] : | 103.94 | 131.10 |
| Front overhang [in] : | 38.98 | 39.37 |
| Front track width [in] : | 57.48 | 66.93 |
| Rear track width [in] : | 57.09 | 67.32 |
| Mass (empty) [lb] : | 2601.47<br>(2746.47) | 6155.34<br>(6330.34) |
| Mass of front occupants [lb] : | 145.00 | 175.00 |
| Mass of rear occupants [lb] : | 0.00 | 0.00 |
| Mass of cargo in trunk [lb] : | 0.00 | 0.00 |
| Mass of roof cargo [lb] : | 0.00 | 0.00 |
| Distance C.G. - front axle [in] : | 37.42<br>(37.36) | 65.55<br>(65.01) |
| C.G. height above ground [in] : | 22.00<br>(22.00) | 22.00<br>(22.00) |
| Roll moment of inertia [lbfts^2] : | 400.48<br>(421.63) | 1466.66<br>(1507.20) |
| Pitch moment of inertia [lbfts^2] : | 1334.94<br>(1405.42) | 4888.86<br>(5024.01) |
| Yaw moment of inertia [lbfts^2] : | 1334.94<br>(1405.42) | 4888.86<br>(5024.01) |
| Stiffness, axle 1, left [lb/in] : | 141.01 | 260.66 |
| Stiffness, axle 1, right [lb/in] : | 141.01 | 260.66 |
| Stiffness, axle 2, left [lb/in] : | 79.32 | 260.66 |
| Stiffness, axle 2, right [lb/in] : | 79.32 | 260.66 |
| Damping, axle 1, left [lb-s/ft] : | 190.37 | 351.90 |
| Damping, axle 1, right [lb-s/ft] : | 190.37 | 351.90 |
| Damping, axle 2, left [lb-s/ft] : | 107.08 | 351.90 |
| Damping, axle 2, right [lb-s/ft] : | 107.08 | 351.90 |
| Max. slip angle,axle 1, left [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 1, right [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 2, left [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 2, right [deg]: | 10.00 | 10.00 |
| ABS : | No | No |

Characters: 62285

3/26/2015
0.5 second post collision acceleration

| | | |
|---|---|---|
| Vehicle : | CHEVROLET-CAVALIER 4DR SEDAN BASE/LS | FORD-EXPEDITION MAX 4WD SUV EDDIE BAUER/LIMI |
| Database: | DB_USDBASE | DB_USDBASE |
| RecordID: | 30 | 15 |

**START VALUES**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **14.00** | **8.00** |
| Heading angle [deg] : | 0.00 | 90.00 |
| Velocity direction (ß) [deg] : | 0.00 | 90.00 |
| Yaw velocity [Deg/s] : | 0.00 | 0.00 |
| Center of gravity x [ft] : | 8.64 | 15.27 |
| Center of gravity y [ft] : | -6.90 | -18.49 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.00 | 0.00 |
| Roll velocity [Deg/s] : | 0.00 | 0.00 |
| Pitch velocity [Deg/s] : | 0.00 | 0.00 |

**END VALUES**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.38** | **0.24** |
| Heading angle [deg] : | 28.38 | 82.58 |
| Velocity direction (ß) [deg] : | 60.09 | 87.42 |
| Yaw velocity [Deg/s] : | 3.42 | -0.90 |
| Center of gravity x [ft] : | 15.62 | 16.30 |
| Center of gravity y [ft] : | 0.29 | -10.18 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | -6.74 | 0.46 |
| Pitch angle [deg] : | 1.16 | 1.62 |
| Roll velocity [Deg/s] : | 2.27 | -0.96 |
| Pitch velocity [Deg/s] : | -0.00 | -0.02 |

**1.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.06 | 0.06 |
| **Pre Impact vel. [mph]:** | **13.15** | **8.53** |
| **Post Impact vel. [mph]:** | **13.13** | **6.63** |
| Velocity change (dV) [mph] : | 4.48 | 1.94 |
| Deformation depth [ft] : | 0.27 | 0.30 |
| EES [mph] : | 4.78 | 3.30 |
| Def. Energy [kJ]: | 2.10 | 2.30 |
| Stiffness [lb/in]: | 4747.7 | 4328.2 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 14.5 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.33 | |
| Point of Impact y [ft] : | -9.30 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -169.88 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 4405.21 | |
| Impulse [lb-s] : | 560.34 | |

| | | |
|---|---|---|
| Direction of impulse [deg] : | 100.12 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.91 | 0.55 |
| PDOF (SAE) [deg] : | 79.88 | -10.09 |
| dV/EES : | 0.77 | 0.77 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **13.15** | **8.53** |
| Heading angle [deg] : | 0.00 | 90.03 |
| Velocity direction (ß) [deg] : | 0.00 | 90.01 |
| Yaw velocity [Deg/s] : | 0.00 | 0.87 |
| Center of gravity x [ft] : | 9.93 | 15.27 |
| Center of gravity y [ft] : | -6.90 | -17.70 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.22 | -0.09 |
| Roll velocity [Deg/s] : | 0.00 | 0.02 |
| Pitch velocity [Deg/s] : | 6.30 | -2.48 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **13.13** | **6.63** |
| Heading angle [deg] : | 0.00 | 90.03 |
| Velocity direction (ß) [deg] : | 19.61 | 87.06 |
| Yaw velocity [Deg/s] : | 89.23 | -2.65 |
| Center of gravity x [ft] : | 9.93 | 15.27 |
| Center of gravity y [ft] : | -6.90 | -17.70 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.22 | -0.09 |
| Roll velocity [Deg/s] : | 27.61 | -1.28 |
| Pitch velocity [Deg/s] : | 7.71 | -0.26 |

**2.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.13 | 0.13 |
| **Pre Impact vel. [mph]:** | **12.29** | **7.17** |
| **Post Impact vel. [mph]:** | **12.48** | **6.83** |
| Velocity change (dV) [mph] : | 0.80 | 0.35 |
| Deformation depth [ft] : | 0.23 | 0.29 |
| EES [mph] : | 0.76 | 0.57 |
| Def. Energy [kJ]: | 0.05 | 0.07 |
| Stiffness [lb/in]: | 174.4 | 134.3 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 13.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.49 | |
| Point of Impact y [ft] : | -8.67 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 8.16 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 122.01 | |
| Impulse [lb-s] : | 100.15 | |
| Direction of impulse [deg] : | 98.16 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.16 | 0.40 |
| PDOF (SAE) [deg] : | 86.83 | -8.19 |
| dV/EES : | 0.83 | 0.83 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.29** | **7.17** |
| Heading angle [deg] : | 4.99 | 89.97 |
| Velocity direction (ß) [deg] : | 19.67 | 88.91 |
| Yaw velocity [Deg/s] : | 77.71 | -0.08 |
| Center of gravity x [ft] : | 10.98 | 15.29 |
| Center of gravity y [ft] : | -6.52 | -17.09 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 1.11 | 0.08 |
| Pitch angle [deg] : | 0.71 | -0.17 |
| Roll velocity [Deg/s] : | 9.85 | 2.23 |
| Pitch velocity [Deg/s] : | 9.93 | -2.35 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.48** | **6.83** |
| Heading angle [deg] : | 4.99 | 89.97 |
| Velocity direction (ß) [deg] : | 23.27 | 88.44 |
| Yaw velocity [Deg/s] : | 90.61 | -0.54 |
| Center of gravity x [ft] : | 10.98 | 15.29 |
| Center of gravity y [ft] : | -6.52 | -17.09 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 1.11 | 0.08 |
| Pitch angle [deg] : | 0.71 | -0.17 |
| Roll velocity [Deg/s] : | 15.19 | 2.05 |
| Pitch velocity [Deg/s] : | 10.26 | -1.96 |

**3.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.17 | 0.17 |
| **Pre Impact vel. [mph]:** | **11.84** | **7.24** |
| **Post Impact vel. [mph]:** | **12.08** | **6.93** |
| Velocity change (dV) [mph] : | 0.74 | 0.32 |
| Deformation depth [ft] : | 0.24 | 0.34 |
| EES [mph] : | 0.63 | 0.50 |
| Def. Energy [kJ]: | 0.04 | 0.05 |
| Stiffness [lb/in]: | 105.5 | 74.3 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 13.0 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.27 | |
| Point of Impact y [ft] : | -8.27 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 5.54 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 89.53 | |
| Impulse [lb-s] : | 92.17 | |
| Direction of impulse [deg] : | 95.54 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 2.34 | 0.22 |
| PDOF (SAE) [deg] : | 93.31 | -5.57 |
| dV/EES : | 0.89 | 0.89 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.84** | **7.24** |
| Heading angle [deg] : | 8.85 | 89.97 |
| Velocity direction (ß) [deg] : | 23.25 | 89.04 |

| | | |
|---|---|---|
| Yaw velocity [Deg/s] : | 81.79 | 0.27 |
| Center of gravity x [ft] : | 11.72 | 15.30 |
| Center of gravity y [ft] : | -6.21 | -16.63 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 1.53 | 0.19 |
| Pitch angle [deg] : | 1.09 | -0.29 |
| Roll velocity [Deg/s] : | 2.55 | 2.27 |
| Pitch velocity [Deg/s] : | 10.56 | -2.83 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.08** | **6.93** |
| Heading angle [deg] : | 8.85 | 89.97 |
| Velocity direction (ß) [deg] : | 26.57 | 88.74 |
| Yaw velocity [Deg/s] : | 90.55 | 0.50 |
| Center of gravity x [ft] : | 11.72 | 15.30 |
| Center of gravity y [ft] : | -6.21 | -16.63 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 1.53 | 0.19 |
| Pitch angle [deg] : | 1.09 | -0.29 |
| Roll velocity [Deg/s] : | 7.52 | 2.15 |
| Pitch velocity [Deg/s] : | 10.72 | -2.46 |

**4.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.22 | 0.22 |
| **Pre Impact vel. [mph]:** | **11.42** | **7.34** |
| **Post Impact vel. [mph]:** | **12.12** | **6.40** |
| Velocity change (dV) [mph] : | 2.24 | 0.97 |
| Deformation depth [ft] : | 0.31 | 0.44 |
| EES [mph] : | 1.79 | 1.41 |
| Def. Energy [kJ]: | 0.29 | 0.42 |
| Stiffness [lb/in]: | 516.2 | 360.8 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 11.8 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.09 | |
| Point of Impact y [ft] : | -7.91 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -166.45 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 715.66 | |
| Impulse [lb-s] : | 280.33 | |
| Direction of impulse [deg] : | 103.55 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.15 | 0.75 |
| PDOF (SAE) [deg] : | 89.17 | -13.56 |
| dV/EES : | 0.96 | 0.96 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.42** | **7.34** |
| Heading angle [deg] : | 12.72 | 89.99 |
| Velocity direction (ß) [deg] : | 26.44 | 89.22 |
| Yaw velocity [Deg/s] : | 82.26 | 0.57 |
| Center of gravity x [ft] : | 12.41 | 15.31 |
| Center of gravity y [ft] : | -5.86 | -16.15 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.65 | 0.28 |

| | | |
|---|---|---|
| Pitch angle [deg] : | 1.45 | -0.41 |
| Roll velocity [Deg/s] : | -3.98 | 1.92 |
| Pitch velocity [Deg/s] : | 10.20 | -2.85 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.12** | **6.40** |
| Heading angle [deg] : | 12.72 | 89.99 |
| Velocity direction (ß) [deg] : | 36.82 | 87.07 |
| Yaw velocity [Deg/s] : | 95.29 | -1.82 |
| Center of gravity x [ft] : | 12.41 | 15.31 |
| Center of gravity y [ft] : | -5.86 | -16.15 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.65 | 0.28 |
| Pitch angle [deg] : | 1.45 | -0.41 |
| Roll velocity [Deg/s] : | 10.56 | 1.09 |
| Pitch velocity [Deg/s] : | 10.64 | -1.76 |

**5.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.27 | 0.27 |
| **Pre Impact vel. [mph]:** | **11.32** | **6.91** |
| **Post Impact vel. [mph]:** | **12.17** | **5.89** |
| Velocity change (dV) [mph] : | 2.65 | 1.15 |
| Deformation depth [ft] : | 0.38 | 0.54 |
| EES [mph] : | 2.11 | 1.66 |
| Def. Energy [kJ]: | 0.41 | 0.58 |
| Stiffness [lb/in]: | 477.4 | 334.2 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 9.5 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 13.89 | |
| Point of Impact y [ft] : | -7.49 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -155.84 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 991.29 | |
| Impulse [lb-s] : | 332.18 | |
| Direction of impulse [deg] : | 114.16 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 0.23 | 2.02 |
| PDOF (SAE) [deg] : | 83.48 | -24.21 |
| dV/EES : | 0.97 | 0.97 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.32** | **6.91** |
| Heading angle [deg] : | 17.64 | 89.95 |
| Velocity direction (ß) [deg] : | 36.62 | 88.71 |
| Yaw velocity [Deg/s] : | 84.31 | -0.10 |
| Center of gravity x [ft] : | 13.17 | 15.32 |
| Center of gravity y [ft] : | -5.30 | -15.61 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.84 | 0.41 |
| Pitch angle [deg] : | 1.83 | -0.52 |
| Roll velocity [Deg/s] : | -6.41 | 2.60 |
| Pitch velocity [Deg/s] : | 8.80 | -2.08 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.17** | **5.89** |
| Heading angle [deg] : | 17.64 | 89.95 |
| Velocity direction (ß) [deg] : | 48.92 | 83.89 |
| Yaw velocity [Deg/s] : | 81.02 | -7.76 |
| Center of gravity x [ft] : | 13.17 | 15.32 |
| Center of gravity y [ft] : | -5.30 | -15.61 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.84 | 0.41 |
| Pitch angle [deg] : | 1.83 | -0.52 |
| Roll velocity [Deg/s] : | 9.03 | 1.00 |
| Pitch velocity [Deg/s] : | 9.23 | -0.91 |

**6.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.34 | 0.34 |
| **Pre Impact vel. [mph]:** | **11.06** | **6.51** |
| **Post Impact vel. [mph]:** | **9.30** | **6.69** |
| Velocity change (dV) [mph] : | 3.12 | 1.35 |
| Deformation depth [ft] : | 1.07 | 1.36 |
| EES [mph] : | 3.54 | 2.63 |
| Def. Energy [kJ]: | 1.15 | 1.46 |
| Stiffness [lb/in]: | 167.1 | 131.2 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.0 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 13.75 | |
| Point of Impact y [ft] : | -6.96 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -90.31 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 2610.60 | |
| Impulse [lb-s] : | 390.12 | |
| Direction of impulse [deg] : | 179.69 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 2.56 | 8.01 |
| PDOF (SAE) [deg] : | 23.27 | -90.00 |
| dV/EES : | 0.70 | 0.70 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.06** | **6.51** |
| Heading angle [deg] : | 22.96 | 89.69 |
| Velocity direction (ß) [deg] : | 48.32 | 87.59 |
| Yaw velocity [Deg/s] : | 70.99 | -1.15 |
| Center of gravity x [ft] : | 13.95 | 15.36 |
| Center of gravity y [ft] : | -4.41 | -14.98 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.61 | 0.68 |
| Pitch angle [deg] : | 2.18 | -0.59 |
| Roll velocity [Deg/s] : | -15.97 | 4.39 |
| Pitch velocity [Deg/s] : | 6.15 | -1.30 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **9.30** | **6.69** |
| Heading angle [deg] : | 22.96 | 89.69 |
| Velocity direction (ß) [deg] : | 62.88 | 75.94 |

| | | |
|---|---|---|
| Yaw velocity [Deg/s] : | 30.33 | -36.76 |
| Center of gravity x [ft] : | 13.95 | 15.36 |
| Center of gravity y [ft] : | -4.41 | -14.98 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.61 | 0.68 |
| Pitch angle [deg] : | 2.18 | -0.59 |
| Roll velocity [Deg/s] : | -13.78 | 0.37 |
| Pitch velocity [Deg/s] : | 10.13 | -1.72 |

**7.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.41 | 0.41 |
| **Pre Impact vel. [mph]:** | **8.15** | **7.30** |
| **Post Impact vel. [mph]:** | **8.46** | **7.13** |
| Velocity change (dV) [mph] : | 0.49 | 0.21 |
| Deformation depth [ft] : | 0.46 | 0.63 |
| EES [mph] : | 0.41 | 0.32 |
| Def. Energy [kJ]: | 0.02 | 0.02 |
| Stiffness [lb/in]: | 12.1 | 8.9 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 0.8 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.06 | |
| Point of Impact y [ft] : | -6.28 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 25.35 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 37.10 | |
| Impulse [lb-s] : | 61.94 | |
| Direction of impulse [deg] : | 115.35 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.41 | 2.10 |
| PDOF (SAE) [deg] : | 89.45 | -27.63 |
| dV/EES : | 0.93 | 0.93 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **8.15** | **7.30** |
| Heading angle [deg] : | 24.80 | 87.72 |
| Velocity direction (ß) [deg] : | 62.70 | 78.15 |
| Yaw velocity [Deg/s] : | 23.01 | -21.63 |
| Center of gravity x [ft] : | 14.36 | 15.53 |
| Center of gravity y [ft] : | -3.61 | -14.28 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.09 | 0.71 |
| Pitch angle [deg] : | 2.64 | -0.68 |
| Roll velocity [Deg/s] : | -28.32 | 0.72 |
| Pitch velocity [Deg/s] : | 4.38 | -1.48 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **8.46** | **7.13** |
| Heading angle [deg] : | 24.80 | 87.72 |
| Velocity direction (ß) [deg] : | 65.36 | 77.11 |
| Yaw velocity [Deg/s] : | 19.43 | -23.12 |
| Center of gravity x [ft] : | 14.36 | 15.53 |
| Center of gravity y [ft] : | -3.61 | -14.28 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.09 | 0.71 |

| | | |
|---|---|---|
| Pitch angle [deg] : | 2.64 | -0.68 |
| Roll velocity [Deg/s] : | -25.92 | 0.40 |
| Pitch velocity [Deg/s] : | 4.38 | -1.28 |

## 8.COLLISION

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.46 | 0.46 |
| **Pre Impact vel. [mph]:** | **7.72** | **7.50** |
| **Post Impact vel. [mph]:** | **8.15** | **7.28** |
| Velocity change (dV) [mph] : | 0.66 | 0.29 |
| Deformation depth [ft] : | 0.50 | 0.68 |
| EES [mph] : | 0.55 | 0.43 |
| Def. Energy [kJ]: | 0.03 | 0.04 |
| Stiffness [lb/in]: | 18.8 | 13.9 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 0.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.26 | |
| Point of Impact y [ft] : | -5.83 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 26.15 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 66.47 | |
| Impulse [lb-s] : | 82.27 | |
| Direction of impulse [deg] : | 116.15 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.48 | 2.29 |
| PDOF (SAE) [deg] : | 89.45 | -29.29 |
| dV/EES : | 0.92 | 0.92 |

### VALUES BEFORE COLLISION

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **7.72** | **7.50** |
| Heading angle [deg] : | 25.60 | 86.86 |
| Velocity direction (ß) [deg] : | 65.28 | 79.34 |
| Yaw velocity [Deg/s] : | 16.58 | -15.80 |
| Center of gravity x [ft] : | 14.58 | 15.62 |
| Center of gravity y [ft] : | -3.13 | -13.80 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | -1.14 | 0.79 |
| Pitch angle [deg] : | 2.76 | -0.72 |
| Roll velocity [Deg/s] : | -29.51 | 2.70 |
| Pitch velocity [Deg/s] : | 1.13 | -1.05 |

### VALUES AFTER COLLISION

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **8.15** | **7.28** |
| Heading angle [deg] : | 25.60 | 86.86 |
| Velocity direction (ß) [deg] : | 68.87 | 77.99 |
| Yaw velocity [Deg/s] : | 11.59 | -17.95 |
| Center of gravity x [ft] : | 14.58 | 15.62 |
| Center of gravity y [ft] : | -3.13 | -13.80 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | -1.14 | 0.79 |
| Pitch angle [deg] : | 2.76 | -0.72 |
| Roll velocity [Deg/s] : | -26.39 | 2.25 |
| Pitch velocity [Deg/s] : | 1.24 | -0.79 |

### 9.COLLISION

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.50 | 0.50 |
| **Pre Impact vel. [mph]:** | **7.42** | **7.65** |
| **Post Impact vel. [mph]:** | **7.35** | **7.67** |
| Velocity change (dV) [mph] : | 0.25 | 0.11 |
| Deformation depth [ft] : | 1.05 | 1.42 |
| EES [mph] : | 0.28 | 0.22 |
| Def. Energy [kJ]: | 0.01 | 0.01 |
| Stiffness [lb/in]: | 1.1 | 0.8 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.1 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.44 | |
| Point of Impact y [ft] : | -5.38 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -93.78 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 17.13 | |
| Impulse [lb-s] : | 31.54 | |
| Direction of impulse [deg] : | 176.22 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 2.74 | 7.84 |
| PDOF (SAE) [deg] : | 29.85 | -90.00 |
| dV/EES : | 0.70 | 0.70 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **7.42** | **7.65** |
| Heading angle [deg] : | 26.07 | 86.22 |
| Velocity direction (ß) [deg] : | 68.80 | 80.43 |
| Yaw velocity [Deg/s] : | 9.87 | -11.39 |
| Center of gravity x [ft] : | 14.77 | 15.71 |
| Center of gravity y [ft] : | -2.65 | -13.32 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | -0.00 |
| Roll angle [deg] : | -2.35 | 0.96 |
| Pitch angle [deg] : | 2.76 | -0.75 |
| Roll velocity [Deg/s] : | -27.65 | 4.52 |
| Pitch velocity [Deg/s] : | -1.51 | -0.62 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **7.35** | **7.67** |
| Heading angle [deg] : | 26.07 | 86.22 |
| Velocity direction (ß) [deg] : | 70.67 | 79.62 |
| Yaw velocity [Deg/s] : | 6.38 | -14.20 |
| Center of gravity x [ft] : | 14.77 | 15.71 |
| Center of gravity y [ft] : | -2.65 | -13.32 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | -0.00 |
| Roll angle [deg] : | -2.35 | 0.96 |
| Pitch angle [deg] : | 2.76 | -0.75 |
| Roll velocity [Deg/s] : | -27.46 | 4.22 |
| Pitch velocity [Deg/s] : | -0.98 | -0.67 |

### 10.COLLISION

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |

| | | |
|---|---|---|
| t [s]: | 0.55 | 0.55 |
| **Pre Impact vel. [mph]:** | **6.61** | **7.39** |
| **Post Impact vel. [mph]:** | **7.10** | **7.15** |
| Velocity change (dV) [mph] : | 0.68 | 0.29 |
| | | |
| Deformation depth [ft] : | 0.57 | 0.78 |
| EES [mph] : | 0.57 | 0.44 |
| Def. Energy [kJ]: | 0.03 | 0.04 |
| Stiffness [lb/in]: | 15.2 | 11.2 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.2 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.63 | |
| Point of Impact y [ft] : | -4.93 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 26.90 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 70.97 | |
| Impulse [lb-s] : | 84.50 | |
| Direction of impulse [deg] : | 116.90 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.49 | 2.52 |
| PDOF (SAE) [deg] : | 89.44 | -31.25 |
| dV/EES : | 0.92 | 0.92 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.61** | **7.39** |
| Heading angle [deg] : | 26.34 | 85.65 |
| Velocity direction (ß) [deg] : | 70.58 | 79.81 |
| Yaw velocity [Deg/s] : | 5.81 | -12.16 |
| Center of gravity x [ft] : | 14.92 | 15.80 |
| Center of gravity y [ft] : | -2.22 | -12.83 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | -0.00 |
| Roll angle [deg] : | -3.55 | 1.10 |
| Pitch angle [deg] : | 2.67 | -0.68 |
| Roll velocity [Deg/s] : | -26.00 | 1.65 |
| Pitch velocity [Deg/s] : | -3.15 | 2.99 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **7.10** | **7.15** |
| Heading angle [deg] : | 26.34 | 85.65 |
| Velocity direction (ß) [deg] : | 74.53 | 78.40 |
| Yaw velocity [Deg/s] : | 0.67 | -14.60 |
| Center of gravity x [ft] : | 14.92 | 15.80 |
| Center of gravity y [ft] : | -2.22 | -12.83 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | -0.00 |
| Roll angle [deg] : | -3.55 | 1.10 |
| Pitch angle [deg] : | 2.67 | -0.68 |
| Roll velocity [Deg/s] : | -22.79 | 1.16 |
| Pitch velocity [Deg/s] : | -2.82 | 3.23 |

**11.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| | | |
| t [s]: | 0.59 | 0.59 |
| **Pre Impact vel. [mph]:** | **6.37** | **6.75** |
| **Post Impact vel. [mph]:** | **6.42** | **6.74** |
| Velocity change (dV) [mph] : | 0.25 | 0.11 |

| | | |
|---|---|---|
| Deformation depth [ft] : | 1.11 | 1.48 |
| EES [mph] : | 0.28 | 0.21 |
| Def. Energy [kJ]: | 0.01 | 0.01 |
| Stiffness [lb/in]: | 0.9 | 0.7 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.3 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.79 | |
| Point of Impact y [ft] : | -4.50 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -94.96 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 16.26 | |
| Impulse [lb-s] : | 30.88 | |
| Direction of impulse [deg] : | -4.96 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 2.71 | 7.76 |
| PDOF (SAE) [deg] : | -148.66 | 90.00 |
| dV/EES : | 0.70 | 0.70 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.37** | **6.75** |
| Heading angle [deg] : | 26.38 | 85.04 |
| Velocity direction (ß) [deg] : | 74.50 | 78.57 |
| Yaw velocity [Deg/s] : | 0.62 | -12.92 |
| Center of gravity x [ft] : | 15.04 | 15.89 |
| Center of gravity y [ft] : | -1.80 | -12.38 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -4.53 | 1.11 |
| Pitch angle [deg] : | 2.50 | -0.45 |
| Roll velocity [Deg/s] : | -20.82 | -0.45 |
| Pitch velocity [Deg/s] : | -4.37 | 5.77 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.42** | **6.74** |
| Heading angle [deg] : | 26.38 | 85.04 |
| Velocity direction (ß) [deg] : | 72.34 | 79.48 |
| Yaw velocity [Deg/s] : | 3.98 | -10.19 |
| Center of gravity x [ft] : | 15.04 | 15.89 |
| Center of gravity y [ft] : | -1.80 | -12.38 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -4.53 | 1.11 |
| Pitch angle [deg] : | 2.50 | -0.45 |
| Roll velocity [Deg/s] : | -21.08 | -0.10 |
| Pitch velocity [Deg/s] : | -5.01 | 5.82 |

**12.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.64 | 0.64 |
| **Pre Impact vel. [mph]:** | **5.69** | **6.31** |
| **Post Impact vel. [mph]:** | **6.05** | **6.14** |
| Velocity change (dV) [mph] : | 0.50 | 0.22 |
| Deformation depth [ft] : | 0.61 | 0.84 |
| EES [mph] : | 0.42 | 0.32 |
| Def. Energy [kJ]: | 0.02 | 0.02 |
| Stiffness [lb/in]: | 7.2 | 5.3 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.2 | |

| | | |
|---|---|---|
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.94 | |
| Point of Impact y [ft] : | -4.11 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 27.16 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 38.42 | |
| Impulse [lb-s] : | 62.12 | |
| Direction of impulse [deg] : | 117.16 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.42 | 2.66 |
| PDOF (SAE) [deg] : | 89.44 | -32.55 |
| dV/EES : | 0.92 | 0.92 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.69** | **6.31** |
| Heading angle [deg] : | 26.60 | 84.61 |
| Velocity direction (ß) [deg] : | 72.03 | 79.79 |
| Yaw velocity [Deg/s] : | 4.95 | -9.07 |
| Center of gravity x [ft] : | 15.16 | 15.97 |
| Center of gravity y [ft] : | -1.42 | -11.96 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -5.38 | 1.08 |
| Pitch angle [deg] : | 2.28 | -0.15 |
| Roll velocity [Deg/s] : | -17.51 | -1.22 |
| Pitch velocity [Deg/s] : | -5.70 | 7.00 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **6.05** | **6.14** |
| Heading angle [deg] : | 26.60 | 84.61 |
| Velocity direction (ß) [deg] : | 75.37 | 78.57 |
| Yaw velocity [Deg/s] : | 1.34 | -10.96 |
| Center of gravity x [ft] : | 15.16 | 15.97 |
| Center of gravity y [ft] : | -1.42 | -11.96 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -5.38 | 1.08 |
| Pitch angle [deg] : | 2.28 | -0.15 |
| Roll velocity [Deg/s] : | -15.07 | -1.66 |
| Pitch velocity [Deg/s] : | -5.35 | 7.17 |

**13.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.68 | 0.68 |
| **Pre Impact vel. [mph]:** | **5.31** | **5.67** |
| **Post Impact vel. [mph]:** | **5.55** | **5.57** |
| Velocity change (dV) [mph] : | 0.28 | 0.12 |
| Deformation depth [ft] : | 0.63 | 0.84 |
| EES [mph] : | 0.22 | 0.17 |
| Def. Energy [kJ]: | 0.00 | 0.01 |
| Stiffness [lb/in]: | 1.9 | 1.4 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 1.1 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.07 | |
| Point of Impact y [ft] : | -3.75 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -165.19 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |

| | | |
|---|---|---|
| Total Deformation Energy [ft-lb] : | 10.72 | |
| Impulse [lb-s] : | 34.67 | |
| Direction of impulse [deg] : | 104.81 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 0.87 | 1.05 |
| PDOF (SAE) [deg] : | 101.90 | -20.65 |
| dV/EES : | 0.97 | 0.97 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.31** | **5.67** |
| Heading angle [deg] : | 26.71 | 84.16 |
| Velocity direction (ß) [deg] : | 75.08 | 78.97 |
| Yaw velocity [Deg/s] : | 2.43 | -9.33 |
| Center of gravity x [ft] : | 15.25 | 16.05 |
| Center of gravity y [ft] : | -1.06 | -11.57 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -5.98 | 1.00 |
| Pitch angle [deg] : | 2.04 | 0.19 |
| Roll velocity [Deg/s] : | -11.94 | -2.02 |
| Pitch velocity [Deg/s] : | -5.63 | 7.17 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **5.55** | **5.57** |
| Heading angle [deg] : | 26.71 | 84.16 |
| Velocity direction (ß) [deg] : | 76.50 | 78.43 |
| Yaw velocity [Deg/s] : | 1.18 | -9.75 |
| Center of gravity x [ft] : | 15.25 | 16.05 |
| Center of gravity y [ft] : | -1.06 | -11.57 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.02 | -0.00 |
| Roll angle [deg] : | -5.98 | 1.00 |
| Pitch angle [deg] : | 2.04 | 0.19 |
| Roll velocity [Deg/s] : | -10.49 | -2.19 |
| Pitch velocity [Deg/s] : | -5.60 | 7.29 |

**14.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.79 | 0.79 |
| **Pre Impact vel. [mph]:** | **3.74** | **3.91** |
| **Post Impact vel. [mph]:** | **3.82** | **3.87** |
| Velocity change (dV) [mph] : | 0.11 | 0.05 |
| Deformation depth [ft] : | 0.63 | 0.86 |
| EES [mph] : | 0.09 | 0.07 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.3 | 0.2 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 0.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.29 | |
| Point of Impact y [ft] : | -3.03 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 27.65 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 1.80 | |
| Impulse [lb-s] : | 13.40 | |
| Direction of impulse [deg] : | 117.65 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.37 | 2.82 |
| PDOF (SAE) [deg] : | 89.44 | -34.33 |

| | | |
|---|---|---|
| dV/EES : | 0.92 | 0.92 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **3.74** | **3.91** |
| Heading angle [deg] : | 27.09 | 83.32 |
| Velocity direction (ß) [deg] : | 75.16 | 79.46 |
| Yaw velocity [Deg/s] : | 4.63 | -6.16 |
| Center of gravity x [ft] : | 15.43 | 16.19 |
| Center of gravity y [ft] : | -0.34 | -10.82 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.01 |
| Roll angle [deg] : | -6.75 | 0.77 |
| Pitch angle [deg] : | 1.50 | 0.96 |
| Roll velocity [Deg/s] : | -4.14 | -1.74 |
| Pitch velocity [Deg/s] : | -4.54 | 6.30 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **3.82** | **3.87** |
| Heading angle [deg] : | 27.09 | 83.32 |
| Velocity direction (ß) [deg] : | 76.24 | 79.03 |
| Yaw velocity [Deg/s] : | 3.88 | -6.60 |
| Center of gravity x [ft] : | 15.43 | 16.19 |
| Center of gravity y [ft] : | -0.34 | -10.82 |
| Center of gravity z [ft] : | 1.82 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.01 |
| Roll angle [deg] : | -6.75 | 0.77 |
| Pitch angle [deg] : | 1.50 | 0.96 |
| Roll velocity [Deg/s] : | -3.58 | -1.87 |
| Pitch velocity [Deg/s] : | -4.45 | 6.34 |

**15.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.89 | 0.89 |
| **Pre Impact vel. [mph]:** | **2.20** | **2.24** |
| **Post Impact vel. [mph]:** | **2.29** | **2.20** |
| Velocity change (dV) [mph] : | 0.12 | 0.05 |
| Deformation depth [ft] : | 0.63 | 0.87 |
| EES [mph] : | 0.11 | 0.08 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.4 | 0.3 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 0.3 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.41 | |
| Point of Impact y [ft] : | -2.62 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 28.22 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 2.44 | |
| Impulse [lb-s] : | 15.55 | |
| Direction of impulse [deg] : | 118.22 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.40 | 2.91 |
| PDOF (SAE) [deg] : | 89.45 | -35.38 |
| dV/EES : | 0.91 | 0.91 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **2.20** | **2.24** |

| | | |
|---|---|---|
| Heading angle [deg] : | 27.67 | 82.84 |
| Velocity direction (ß) [deg] : | 72.86 | 80.60 |
| Yaw velocity [Deg/s] : | 6.62 | -3.35 |
| Center of gravity x [ft] : | 15.55 | 16.27 |
| Center of gravity y [ft] : | 0.08 | -10.39 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.01 |
| Roll angle [deg] : | -6.89 | 0.61 |
| Pitch angle [deg] : | 1.22 | 1.44 |
| Roll velocity [Deg/s] : | -0.14 | -1.31 |
| Pitch velocity [Deg/s] : | -2.52 | 3.25 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **2.29** | **2.20** |
| Heading angle [deg] : | 27.67 | 82.84 |
| Velocity direction (ß) [deg] : | 75.07 | 79.74 |
| Yaw velocity [Deg/s] : | 5.74 | -3.87 |
| Center of gravity x [ft] : | 15.55 | 16.27 |
| Center of gravity y [ft] : | 0.08 | -10.39 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.01 | -0.01 |
| Roll angle [deg] : | -6.89 | 0.61 |
| Pitch angle [deg] : | 1.22 | 1.44 |
| Roll velocity [Deg/s] : | 0.53 | -1.47 |
| Pitch velocity [Deg/s] : | -2.41 | 3.29 |

**16.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.98 | 0.98 |
| **Pre Impact vel. [mph]:** | **0.86** | **0.72** |
| **Post Impact vel. [mph]:** | **0.82** | **0.72** |
| Velocity change (dV) [mph] : | 0.14 | 0.06 |
| Deformation depth [ft] : | 1.08 | 1.42 |
| EES [mph] : | 0.15 | 0.11 |
| Def. Energy [kJ]: | 0.00 | 0.00 |
| Stiffness [lb/in]: | 0.3 | 0.2 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 0.1 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 15.45 | |
| Point of Impact y [ft] : | -2.45 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -97.37 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 4.87 | |
| Impulse [lb-s] : | 16.96 | |
| Direction of impulse [deg] : | 172.63 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 2.72 | 7.57 |
| PDOF (SAE) [deg] : | 35.62 | -90.00 |
| dV/EES : | 0.70 | 0.70 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.86** | **0.72** |
| Heading angle [deg] : | 28.25 | 82.63 |
| Velocity direction (ß) [deg] : | 63.53 | 83.77 |
| Yaw velocity [Deg/s] : | 6.50 | -1.18 |
| Center of gravity x [ft] : | 15.61 | 16.30 |
| Center of gravity y [ft] : | 0.27 | -10.20 |
| Center of gravity z [ft] : | 1.83 | 1.83 |

| | | |
|---|---|---|
| Velocity vertical [mph] : | 0.00 | -0.00 |
| Roll angle [deg] : | -6.79 | 0.49 |
| Pitch angle [deg] : | 1.15 | 1.61 |
| Roll velocity [Deg/s] : | 1.38 | -1.16 |
| Pitch velocity [Deg/s] : | -0.80 | 0.67 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.82** | **0.72** |
| Heading angle [deg] : | 28.25 | 82.63 |
| Velocity direction (ß) [deg] : | 72.48 | 79.12 |
| Yaw velocity [Deg/s] : | 4.66 | -2.65 |
| Center of gravity x [ft] : | 15.61 | 16.30 |
| Center of gravity y [ft] : | 0.27 | -10.20 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.00 | -0.00 |
| Roll angle [deg] : | -6.79 | 0.49 |
| Pitch angle [deg] : | 1.15 | 1.61 |
| Roll velocity [Deg/s] : | 1.72 | -1.52 |
| Pitch velocity [Deg/s] : | -0.38 | 0.66 |

**SEQUENCES**

1 CHEVROLET :

REACTION
Reaction time [sec] : 1.00

BRAKE LAG
Threshold time [sec] : 0.20

BRAKE
maximum stopping distance [ft] : 32.81
Brake force [%]
Axle 1, left : 0.00
Axle 1, right : 0.00
Axle 2, left : 0.00
Axle 2, right : 0.00
mean brake acceleration [g] : 0.00

START VALUES
Velocity [mph] : 14.00
Friction coefficient : 0.75

BRAKE
maximum stopping distance [ft] : 300.00
Brake force [%]
Axle 1, left : 215.77
Axle 1, right : 215.77
Axle 2, left : 40.90
Axle 2, right : 40.90
mean brake acceleration [g] : -0.75

2 FORD-EXPE :

REACTION
Reaction time [sec] : 1.00

BRAKE LAG
Threshold time [sec] : 0.20

BRAKE
maximum stopping distance [ft] : 32.81
Brake force [%]
Axle 1, left : 0.00
Axle 1, right : 0.00

| | |
|---|---|
| Axle 2, left : | 0.00 |
| Axle 2, right : | 0.00 |
| mean brake acceleration [g] : | 0.00 |

START VALUES

| | |
|---|---|
| Velocity [mph] : | 8.00 |
| Friction coefficient : | 0.75 |

ACCELERATE

| | |
|---|---|
| Maximum acceleration time [s] : | 0.50 |
| Accelerative force [%] | |
| Axle 1, left : | 0.00 |
| Axle 1, right : | 35.00 |
| Axle 2, left : | 67.00 |
| Axle 2, right : | 67.00 |
| Average acceleration [g] : | 0.42 |

BRAKE LAG

| | |
|---|---|
| Threshold time [sec] : | 0.20 |

BRAKE

| | |
|---|---|
| maximum stopping distance [ft] : | 300.00 |
| Brake force [%] | |
| Axle 1, left : | 222.73 |
| Axle 1, right : | 222.73 |
| Axle 2, left : | 81.92 |
| Axle 2, right : | 81.92 |
| mean brake acceleration [g] : | -0.75 |

**INPUT VALUES**

Vehicle : CHEVROLET-CAVALIER 4DR SEDAN BASE/LS FORD-EXPEDITION MAX 4WD SUV EDDIE BAUER/LIMI

| | | |
|---|---|---|
| Database: | DB_USDBASE | DB_USDBASE |
| RecordID: | 30 | 15 |
| Length [in] : | 180.31 | 221.26 |
| Width [in] : | 67.32 | 78.74 |
| Height [in] : | 54.72 | 77.56 |
| Number of axles : | 2 | 2 |
| Wheelbase [in] : | 103.94 | 131.10 |
| Front overhang [in] : | 38.98 | 39.37 |
| Front track width [in] : | 57.48 | 66.93 |
| Rear track width [in] : | 57.09 | 67.32 |
| Mass (empty) [lb] : | 2601.47 (2746.47) | 6155.34 (6330.34) |
| Mass of front occupants [lb] : | 145.00 | 175.00 |
| Mass of rear occupants [lb] : | 0.00 | 0.00 |
| Mass of cargo in trunk [lb] : | 0.00 | 0.00 |
| Mass of roof cargo [lb] : | 0.00 | 0.00 |
| Distance C.G. - front axle [in] : | 37.42 (37.36) | 65.55 (65.01) |
| C.G. height above ground [in] : | 22.00 (22.00) | 22.00 (22.00) |
| Roll moment of inertia [lbfts^2] : | 400.48 (421.63) | 1466.66 (1507.20) |
| Pitch moment of inertia [lbfts^2] : | 1334.94 (1405.42) | 4888.86 (5024.01) |
| Yaw moment of inertia [lbfts^2] : | 1334.94 (1405.42) | 4888.86 (5024.01) |
| Stiffness, axle 1, left [lb/in] : | 141.01 | 260.66 |
| Stiffness, axle 1, right [lb/in] : | 141.01 | 260.66 |
| Stiffness, axle 2, left [lb/in] : | 79.32 | 260.66 |
| Stiffness, axle 2, right [lb/in] : | 79.32 | 260.66 |
| Damping, axle 1, left [lb-s/ft] : | 190.37 | 351.90 |
| Damping, axle 1, right [lb-s/ft] : | 190.37 | 351.90 |
| Damping, axle 2, left [lb-s/ft] : | 107.08 | 351.90 |
| Damping, axle 2, right [lb-s/ft] : | 107.08 | 351.90 |
| Max. slip angle,axle 1, left [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 1, right [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 2, left [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 2, right [deg]: | 10.00 | 10.00 |
| ABS : | No | No |

Characters: 35318

3/26/2015
0.25 second post collision acceleration

Vehicle : CHEVROLET-CAVALIER 4DR SEDAN BASE/LS FORD-EXPEDITION MAX 4WD SUV EDDIE BAUER/LIMI

| | | |
|---|---|---|
| Database: | DB_USDBASE | DB_USDBASE |
| RecordID: | 30 | 15 |

**START VALUES**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **14.00** | **8.00** |
| Heading angle [deg] : | 0.00 | 90.00 |
| Velocity direction (ß) [deg] : | 0.00 | 90.00 |
| Yaw velocity [Deg/s] : | 0.00 | 0.00 |
| Center of gravity x [ft] : | 8.64 | 15.27 |
| Center of gravity y [ft] : | -6.90 | -18.49 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.00 | 0.00 |
| Roll velocity [Deg/s] : | 0.00 | 0.00 |
| Pitch velocity [Deg/s] : | 0.00 | 0.00 |

**END VALUES**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **0.20** | **0.20** |
| Heading angle [deg] : | 33.77 | 85.86 |
| Velocity direction (ß) [deg] : | -83.03 | 54.19 |
| Yaw velocity [Deg/s] : | -0.01 | -0.66 |
| Center of gravity x [ft] : | 16.62 | 15.71 |
| Center of gravity y [ft] : | -0.65 | -14.02 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | 0.00 | -0.01 |
| Roll angle [deg] : | 0.63 | 1.14 |
| Pitch angle [deg] : | -0.12 | 1.31 |
| Roll velocity [Deg/s] : | 7.83 | 4.37 |
| Pitch velocity [Deg/s] : | -3.96 | 2.09 |

**1.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.06 | 0.06 |
| **Pre Impact vel. [mph]:** | **13.15** | **8.42** |
| **Post Impact vel. [mph]:** | **13.12** | **6.54** |
| Velocity change (dV) [mph] : | 4.42 | 1.92 |
| Deformation depth [ft] : | 0.27 | 0.30 |
| EES [mph] : | 4.72 | 3.26 |
| Def. Energy [kJ]: | 2.05 | 2.25 |
| Stiffness [lb/in]: | 4721.2 | 4303.4 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 14.5 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.33 | |
| Point of Impact y [ft] : | -9.30 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -169.93 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 4296.55 | |
| Impulse [lb-s] : | 553.10 | |

| | | |
|---|---|---|
| Direction of impulse [deg] : | 100.07 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.91 | 0.55 |
| PDOF (SAE) [deg] : | 79.93 | -10.07 |
| dV/EES : | 0.77 | 0.77 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **13.15** | **8.42** |
| Heading angle [deg] : | 0.00 | 90.00 |
| Velocity direction (ß) [deg] : | 0.00 | 90.00 |
| Yaw velocity [Deg/s] : | 0.00 | 0.00 |
| Center of gravity x [ft] : | 9.93 | 15.27 |
| Center of gravity y [ft] : | -6.90 | -17.71 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.22 | -0.07 |
| Roll velocity [Deg/s] : | 0.00 | 0.00 |
| Pitch velocity [Deg/s] : | 6.30 | -1.96 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **13.12** | **6.54** |
| Heading angle [deg] : | 0.00 | 90.00 |
| Velocity direction (ß) [deg] : | 19.36 | 87.06 |
| Yaw velocity [Deg/s] : | 88.19 | -3.45 |
| Center of gravity x [ft] : | 9.93 | 15.27 |
| Center of gravity y [ft] : | -6.90 | -17.71 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 0.00 | 0.00 |
| Pitch angle [deg] : | 0.22 | -0.07 |
| Roll velocity [Deg/s] : | 27.26 | -1.29 |
| Pitch velocity [Deg/s] : | 7.69 | 0.24 |

**2.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.13 | 0.13 |
| **Pre Impact vel. [mph]:** | **12.21** | **7.01** |
| **Post Impact vel. [mph]:** | **12.41** | **6.65** |
| Velocity change (dV) [mph] : | 0.84 | 0.36 |
| Deformation depth [ft] : | 0.22 | 0.29 |
| EES [mph] : | 0.79 | 0.59 |
| Def. Energy [kJ]: | 0.06 | 0.07 |
| Stiffness [lb/in]: | 188.3 | 144.0 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 13.5 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.49 | |
| Point of Impact y [ft] : | -8.64 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 8.13 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 130.78 | |
| Impulse [lb-s] : | 104.51 | |
| Direction of impulse [deg] : | 98.13 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.08 | 0.40 |
| PDOF (SAE) [deg] : | 87.18 | -8.24 |
| dV/EES : | 0.84 | 0.84 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.21** | **7.01** |
| Heading angle [deg] : | 5.31 | 89.89 |
| Velocity direction (ß) [deg] : | 19.42 | 88.91 |
| Yaw velocity [Deg/s] : | 75.88 | -0.70 |
| Center of gravity x [ft] : | 11.07 | 15.29 |
| Center of gravity y [ft] : | -6.50 | -17.06 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 1.14 | 0.09 |
| Pitch angle [deg] : | 0.75 | -0.13 |
| Roll velocity [Deg/s] : | 8.46 | 2.15 |
| Pitch velocity [Deg/s] : | 10.04 | -1.74 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.41** | **6.65** |
| Heading angle [deg] : | 5.31 | 89.89 |
| Velocity direction (ß) [deg] : | 23.20 | 88.41 |
| Yaw velocity [Deg/s] : | 88.97 | -1.17 |
| Center of gravity x [ft] : | 11.07 | 15.29 |
| Center of gravity y [ft] : | -6.50 | -17.06 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | 0.00 |
| Roll angle [deg] : | 1.14 | 0.09 |
| Pitch angle [deg] : | 0.75 | -0.13 |
| Roll velocity [Deg/s] : | 14.05 | 1.95 |
| Pitch velocity [Deg/s] : | 10.37 | -1.32 |

**3.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.18 | 0.18 |
| **Pre Impact vel. [mph]:** | **11.76** | **6.98** |
| **Post Impact vel. [mph]:** | **12.12** | **6.42** |
| Velocity change (dV) [mph] : | 1.30 | 0.56 |
| Deformation depth [ft] : | 0.24 | 0.34 |
| EES [mph] : | 1.09 | 0.86 |
| Def. Energy [kJ]: | 0.11 | 0.16 |
| Stiffness [lb/in]: | 317.0 | 221.4 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 12.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.26 | |
| Point of Impact y [ft] : | -8.26 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 10.16 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 266.55 | |
| Impulse [lb-s] : | 162.43 | |
| Direction of impulse [deg] : | 100.16 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 2.05 | 0.45 |
| PDOF (SAE) [deg] : | 88.94 | -10.30 |
| dV/EES : | 0.91 | 0.91 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.76** | **6.98** |
| Heading angle [deg] : | 9.10 | 89.86 |
| Velocity direction (ß) [deg] : | 23.16 | 88.97 |

| | | |
|---|---|---|
| Yaw velocity [Deg/s] : | 80.33 | -0.37 |
| Center of gravity x [ft] : | 11.80 | 15.30 |
| Center of gravity y [ft] : | -6.18 | -16.61 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.52 | 0.18 |
| Pitch angle [deg] : | 1.14 | -0.21 |
| Roll velocity [Deg/s] : | 1.73 | 2.12 |
| Pitch velocity [Deg/s] : | 10.57 | -2.12 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.12** | **6.42** |
| Heading angle [deg] : | 9.10 | 89.86 |
| Velocity direction (ß) [deg] : | 29.15 | 88.00 |
| Yaw velocity [Deg/s] : | 93.85 | -1.20 |
| Center of gravity x [ft] : | 11.80 | 15.30 |
| Center of gravity y [ft] : | -6.18 | -16.61 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.52 | 0.18 |
| Pitch angle [deg] : | 1.14 | -0.21 |
| Roll velocity [Deg/s] : | 10.42 | 1.74 |
| Pitch velocity [Deg/s] : | 10.97 | -1.48 |

**4.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.22 | 0.22 |
| **Pre Impact vel. [mph]:** | **11.46** | **6.75** |
| **Post Impact vel. [mph]:** | **12.00** | **6.06** |
| Velocity change (dV) [mph] : | 1.65 | 0.72 |
| Deformation depth [ft] : | 0.28 | 0.40 |
| EES [mph] : | 1.31 | 1.03 |
| Def. Energy [kJ]: | 0.16 | 0.23 |
| Stiffness [lb/in]: | 334.5 | 231.1 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 11.8 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 14.03 | |
| Point of Impact y [ft] : | -7.91 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -166.14 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 382.87 | |
| Impulse [lb-s] : | 206.36 | |
| Direction of impulse [deg] : | 103.86 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.00 | 0.74 |
| PDOF (SAE) [deg] : | 89.25 | -14.03 |
| dV/EES : | 0.97 | 0.97 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.46** | **6.75** |
| Heading angle [deg] : | 13.11 | 89.83 |
| Velocity direction (ß) [deg] : | 29.02 | 88.80 |
| Yaw velocity [Deg/s] : | 85.03 | -0.37 |
| Center of gravity x [ft] : | 12.48 | 15.31 |
| Center of gravity y [ft] : | -5.81 | -16.17 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.75 | 0.28 |

| | | |
|---|---|---|
| Pitch angle [deg] : | 1.50 | -0.29 |
| Roll velocity [Deg/s] : | -2.54 | 2.15 |
| Pitch velocity [Deg/s] : | 10.17 | -2.00 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **12.00** | **6.06** |
| Heading angle [deg] : | 13.11 | 89.83 |
| Velocity direction (ß) [deg] : | 36.64 | 87.05 |
| Yaw velocity [Deg/s] : | 93.39 | -2.11 |
| Center of gravity x [ft] : | 12.48 | 15.31 |
| Center of gravity y [ft] : | -5.81 | -16.17 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.75 | 0.28 |
| Pitch angle [deg] : | 1.50 | -0.29 |
| Roll velocity [Deg/s] : | 8.08 | 1.51 |
| Pitch velocity [Deg/s] : | 10.46 | -1.20 |

**5.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.27 | 0.27 |
| **Pre Impact vel. [mph]:** | **11.34** | **6.23** |
| **Post Impact vel. [mph]:** | **11.90** | **5.63** |
| Velocity change (dV) [mph] : | 1.48 | 0.64 |
| Deformation depth [ft] : | 0.32 | 0.46 |
| EES [mph] : | 1.16 | 0.91 |
| Def. Energy [kJ]: | 0.12 | 0.18 |
| Stiffness [lb/in]: | 195.2 | 136.1 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 10.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 13.86 | |
| Point of Impact y [ft] : | -7.59 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 17.66 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 298.50 | |
| Impulse [lb-s] : | 185.44 | |
| Direction of impulse [deg] : | 107.66 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 0.05 | 1.08 |
| PDOF (SAE) [deg] : | 89.44 | -17.89 |
| dV/EES : | 0.98 | 0.98 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.34** | **6.23** |
| Heading angle [deg] : | 17.10 | 89.77 |
| Velocity direction (ß) [deg] : | 36.48 | 88.24 |
| Yaw velocity [Deg/s] : | 84.44 | -0.98 |
| Center of gravity x [ft] : | 13.10 | 15.32 |
| Center of gravity y [ft] : | -5.35 | -15.76 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.87 | 0.39 |
| Pitch angle [deg] : | 1.80 | -0.34 |
| Roll velocity [Deg/s] : | -5.65 | 2.35 |
| Pitch velocity [Deg/s] : | 8.96 | -0.68 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.90** | **5.63** |
| Heading angle [deg] : | 17.10 | 89.77 |
| Velocity direction (ß) [deg] : | 43.25 | 86.07 |
| Yaw velocity [Deg/s] : | 84.71 | -3.27 |
| Center of gravity x [ft] : | 13.10 | 15.32 |
| Center of gravity y [ft] : | -5.35 | -15.76 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.87 | 0.39 |
| Pitch angle [deg] : | 1.80 | -0.34 |
| Roll velocity [Deg/s] : | 3.25 | 1.63 |
| Pitch velocity [Deg/s] : | 9.00 | 0.02 |

**6.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.32 | 0.32 |
| **Pre Impact vel. [mph]:** | **11.07** | **5.14** |
| **Post Impact vel. [mph]:** | **11.46** | **4.75** |
| Velocity change (dV) [mph] : | 1.00 | 0.43 |
| Deformation depth [ft] : | 0.37 | 0.51 |
| EES [mph] : | 0.81 | 0.63 |
| Def. Energy [kJ]: | 0.06 | 0.08 |
| Stiffness [lb/in]: | 73.8 | 52.8 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 9.6 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 13.72 | |
| Point of Impact y [ft] : | -7.25 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 22.04 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 142.78 | |
| Impulse [lb-s] : | 125.10 | |
| Direction of impulse [deg] : | 112.04 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.00 | 1.52 |
| PDOF (SAE) [deg] : | 89.45 | -22.45 |
| dV/EES : | 0.96 | 0.96 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.07** | **5.14** |
| Heading angle [deg] : | 21.49 | 89.59 |
| Velocity direction (ß) [deg] : | 42.98 | 86.51 |
| Yaw velocity [Deg/s] : | 75.27 | -3.28 |
| Center of gravity x [ft] : | 13.77 | 15.35 |
| Center of gravity y [ft] : | -4.72 | -15.33 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.68 | 0.47 |
| Pitch angle [deg] : | 2.09 | -0.23 |
| Roll velocity [Deg/s] : | -12.69 | 1.07 |
| Pitch velocity [Deg/s] : | 6.89 | 3.41 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **11.46** | **4.75** |
| Heading angle [deg] : | 21.49 | 89.59 |
| Velocity direction (ß) [deg] : | 47.65 | 84.25 |

| | | |
|---|---|---|
| Yaw velocity [Deg/s] : | 70.15 | -5.45 |
| Center of gravity x [ft] : | 13.77 | 15.35 |
| Center of gravity y [ft] : | -4.72 | -15.33 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.01 | 0.00 |
| Roll angle [deg] : | 1.68 | 0.47 |
| Pitch angle [deg] : | 2.09 | -0.23 |
| Roll velocity [Deg/s] : | -7.33 | 0.46 |
| Pitch velocity [Deg/s] : | 6.76 | 3.86 |

**7.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.38 | 0.38 |
| **Pre Impact vel. [mph]:** | **10.59** | **4.21** |
| **Post Impact vel. [mph]:** | **10.83** | **3.98** |
| Velocity change (dV) [mph] : | 0.63 | 0.27 |
| Deformation depth [ft] : | 0.40 | 0.55 |
| EES [mph] : | 0.54 | 0.41 |
| Def. Energy [kJ]: | 0.03 | 0.04 |
| Stiffness [lb/in]: | 27.1 | 19.9 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 8.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 13.66 | |
| Point of Impact y [ft] : | -6.97 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | 25.69 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 62.36 | |
| Impulse [lb-s] : | 78.33 | |
| Direction of impulse [deg] : | 115.69 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 1.90 | 1.92 |
| PDOF (SAE) [deg] : | 89.45 | -26.37 |
| dV/EES : | 0.91 | 0.91 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **10.59** | **4.21** |
| Heading angle [deg] : | 25.14 | 89.32 |
| Velocity direction (ß) [deg] : | 47.31 | 84.83 |
| Yaw velocity [Deg/s] : | 63.07 | -4.51 |
| Center of gravity x [ft] : | 14.37 | 15.39 |
| Center of gravity y [ft] : | -4.06 | -14.97 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | 1.02 | 0.50 |
| Pitch angle [deg] : | 2.31 | 0.04 |
| Roll velocity [Deg/s] : | -19.18 | 0.53 |
| Pitch velocity [Deg/s] : | 4.72 | 5.37 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **10.83** | **3.98** |
| Heading angle [deg] : | 25.14 | 89.32 |
| Velocity direction (ß) [deg] : | 50.39 | 82.83 |
| Yaw velocity [Deg/s] : | 56.99 | -6.23 |
| Center of gravity x [ft] : | 14.37 | 15.39 |
| Center of gravity y [ft] : | -4.06 | -14.97 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | 1.02 | 0.50 |

| | | |
|---|---|---|
| Pitch angle [deg] : | 2.31 | 0.04 |
| Roll velocity [Deg/s] : | -16.26 | 0.06 |
| Pitch velocity [Deg/s] : | 4.62 | 5.64 |

**8.COLLISION**

| | | |
|---|---|---|
| Vehicle : | 1 CHEVROLET | 2 FORD-EXPE |
| Driver : | | |
| t [s]: | 0.42 | 0.42 |
| **Pre Impact vel. [mph]:** | **10.11** | **3.52** |
| **Post Impact vel. [mph]:** | **8.80** | **3.77** |
| Velocity change (dV) [mph] : | 2.41 | 1.04 |
| Deformation depth [ft] : | 0.88 | 1.21 |
| EES [mph] : | 2.77 | 2.15 |
| Def. Energy [kJ]: | 0.70 | 0.97 |
| Stiffness [lb/in]: | 153.1 | 110.8 |
| Coefficient of restitution (e) : | 0.00 | |
| Separation speed [mph]: | 3.7 | |
| Friction coefficient (mu) : | 0.00 | |
| Point of Impact x [ft] : | 13.65 | |
| Point of Impact y [ft] : | -6.78 | |
| Point of Impact z [ft] : | 1.48 | |
| Angle of contact plane (phi) [deg] : | -90.93 | |
| Angle of contact plane (psi) [deg] : | 0.00 | |
| Total Deformation Energy [ft-lb] : | 1678.75 | |
| Impulse [lb-s] : | 301.27 | |
| Direction of impulse [deg] : | 179.07 | |
| Vertical direction of impulse [deg] : | 0.00 | |
| Moment arm about C.G. [ft] : | 3.26 | 7.92 |
| PDOF (SAE) [deg] : | 28.53 | -90.00 |
| dV/EES : | 0.67 | 0.67 |

**VALUES BEFORE COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **10.11** | **3.52** |
| Heading angle [deg] : | 27.60 | 89.07 |
| Velocity direction (ß) [deg] : | 50.11 | 83.49 |
| Yaw velocity [Deg/s] : | 52.63 | -4.88 |
| Center of gravity x [ft] : | 14.81 | 15.42 |
| Center of gravity y [ft] : | -3.54 | -14.73 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | 0.23 | 0.51 |
| Pitch angle [deg] : | 2.44 | 0.30 |
| Roll velocity [Deg/s] : | -21.86 | 0.48 |
| Pitch velocity [Deg/s] : | 2.93 | 5.74 |

**VALUES AFTER COLLISION**

| | | |
|---|---|---|
| **Velocity magnitude (v) [mph] :** | **8.80** | **3.77** |
| Heading angle [deg] : | 27.60 | 89.07 |
| Velocity direction (ß) [deg] : | 62.40 | 67.47 |
| Yaw velocity [Deg/s] : | 12.65 | -32.09 |
| Center of gravity x [ft] : | 14.81 | 15.42 |
| Center of gravity y [ft] : | -3.54 | -14.73 |
| Center of gravity z [ft] : | 1.83 | 1.83 |
| Velocity vertical [mph] : | -0.00 | -0.00 |
| Roll angle [deg] : | 0.23 | 0.51 |
| Pitch angle [deg] : | 2.44 | 0.30 |
| Roll velocity [Deg/s] : | -20.71 | -4.03 |
| Pitch velocity [Deg/s] : | 6.55 | 5.50 |

**SEQUENCES**

1 CHEVROLET :

| | |
|---|---|
| REACTION | |
| Reaction time [sec] : | 1.00 |
| BRAKE LAG | |
| Threshold time [sec] : | 0.20 |
| BRAKE | |
| maximum stopping distance [ft] : | 32.81 |
| Brake force [%] | |
| Axle 1, left : | 0.00 |
| Axle 1, right : | 0.00 |
| Axle 2, left : | 0.00 |
| Axle 2, right : | 0.00 |
| mean brake acceleration [g] : | 0.00 |
| START VALUES | |
| Velocity [mph] : | 14.00 |
| Friction coefficient : | 0.75 |
| BRAKE | |
| maximum stopping distance [ft] : | 300.00 |
| Brake force [%] | |
| Axle 1, left : | 215.77 |
| Axle 1, right : | 215.77 |
| Axle 2, left : | 40.90 |
| Axle 2, right : | 40.90 |
| mean brake acceleration [g] : | -0.75 |

2 FORD-EXPE :

| | |
|---|---|
| REACTION | |
| Reaction time [sec] : | 1.00 |
| BRAKE LAG | |
| Threshold time [sec] : | 0.20 |
| BRAKE | |
| maximum stopping distance [ft] : | 32.81 |
| Brake force [%] | |
| Axle 1, left : | 0.00 |
| Axle 1, right : | 0.00 |
| Axle 2, left : | 0.00 |
| Axle 2, right : | 0.00 |
| mean brake acceleration [g] : | 0.00 |
| START VALUES | |
| Velocity [mph] : | 8.00 |
| Friction coefficient : | 0.75 |
| ACCELERATE | |
| Maximum acceleration time [s] : | 0.25 |
| Accelerative force [%] | |
| Axle 1, left : | 0.00 |
| Axle 1, right : | 0.00 |
| Axle 2, left : | 67.00 |
| Axle 2, right : | 67.00 |
| Average acceleration [g] : | 0.33 |
| BRAKE LAG | |
| Threshold time [sec] : | 0.20 |
| BRAKE | |
| maximum stopping distance [ft] : | 300.00 |
| Brake force [%] | |
| Axle 1, left : | 222.73 |
| Axle 1, right : | 222.73 |
| Axle 2, left : | 81.92 |

| | |
|---|---|
| Axle 2, right : | 81.92 |
| mean brake acceleration [g] : | -0.75 |

**INPUT VALUES**

Vehicle : CHEVROLET-CAVALIER 4DR SEDAN BASE/LS FORD-EXPEDITION MAX 4WD SUV EDDIE BAUER/LIMI

| | | |
|---|---|---|
| Database: | DB_USDBASE | DB_USDBASE |
| RecordID: | 30 | 15 |
| Length [in] : | 180.31 | 221.26 |
| Width [in] : | 67.32 | 78.74 |
| Height [in] : | 54.72 | 77.56 |
| Number of axles : | 2 | 2 |
| Wheelbase [in] : | 103.94 | 131.10 |
| Front overhang [in] : | 38.98 | 39.37 |
| Front track width [in] : | 57.48 | 66.93 |
| Rear track width [in] : | 57.09 | 67.32 |
| Mass (empty) [lb] : | 2601.47<br>(2746.47) | 6155.34<br>(6330.34) |
| Mass of front occupants [lb] : | 145.00 | 175.00 |
| Mass of rear occupants [lb] : | 0.00 | 0.00 |
| Mass of cargo in trunk [lb] : | 0.00 | 0.00 |
| Mass of roof cargo [lb] : | 0.00 | 0.00 |
| Distance C.G. - front axle [in] : | 37.42<br>(37.36) | 65.55<br>(65.01) |
| C.G. height above ground [in] : | 22.00<br>(22.00) | 22.00<br>(22.00) |
| Roll moment of inertia [lbfts^2] : | 400.48<br>(421.63) | 1466.66<br>(1507.20) |
| Pitch moment of inertia [lbfts^2] : | 1334.94<br>(1405.42) | 4888.86<br>(5024.01) |
| Yaw moment of inertia [lbfts^2] : | 1334.94<br>(1405.42) | 4888.86<br>(5024.01) |
| Stiffness, axle 1, left [lb/in] : | 141.01 | 260.66 |
| Stiffness, axle 1, right [lb/in] : | 141.01 | 260.66 |
| Stiffness, axle 2, left [lb/in] : | 79.32 | 260.66 |
| Stiffness, axle 2, right [lb/in] : | 79.32 | 260.66 |
| Damping, axle 1, left [lb-s/ft] : | 190.37 | 351.90 |
| Damping, axle 1, right [lb-s/ft] : | 190.37 | 351.90 |
| Damping, axle 2, left [lb-s/ft] : | 107.08 | 351.90 |
| Damping, axle 2, right [lb-s/ft] : | 107.08 | 351.90 |
| Max. slip angle,axle 1, left [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 1, right [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 2, left [deg]: | 10.00 | 10.00 |
| Max. slip angle,axle 2, right [deg]: | 10.00 | 10.00 |
| ABS : | No | No |

Characters: 19867

# 1995 Chevrolet Cavalier

Owner's Manual

0330

## Lamp Controls


The band on the turn signal/multifunction lever controls your vehicle's lamps.

P⋛ **PARKING LAMPS:** This position will turn on the following:

- Parking Lamps
- Side Marker Lamps
- Taillamps
- Instrument Panel Lamps

**HEADLAMPS:** This position will turn on the following:

- Headlamps
- Parking Lamps
- Side Marker Lamps
- Taillamps
- Instrument Panel Lamps

Turn the band clockwise all the way to turn the lamps off.

### Lamps On Reminder

If you open the driver's door with the ignition off and the lamps on, you will hear a warning chime.

0332

*SAE TECHNICAL PAPER SERIES*

**2003-01-0294**

# Threshold Visibility Levels for the Adrian Visibility Model under Nighttime Driving Conditions

**Kurt W. Ising, Travis R. C. Fricker, Jonathan M. Lawrence and Gunter P. Siegmund**
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**Reprinted From: Lighting Technology (SP-1787)**

**2003 SAE World Congress**
**Detroit, Michigan**
**March 3-6, 2003**

SAE International™

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**ISSN 0148-7191**


**Printed in USA**

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## ABSTRACT

Adrian's visibility model is a useful tool for assessing the visibility of an object at night. However, it was developed under laboratory conditions. Thus, it is necessary to determine the visibility levels which are required for detection under nighttime driving conditions. Experimental data from Olson et al were applied to the Adrian visibility model to determine visibility levels at target detection for alerted drivers. The data has been modified to account for experimental delay in the recorded detection points and a correction has been applied to assess driver expectation. Driver age, headlight beam pattern, and target reflectivity were all found to have a significant effect on visibility level at target detection. For alerted drivers, 50th-percentile threshold visibility levels between 1 and 23 were calculated. For unalerted drivers, 50th-percentile threshold visibility levels between 13 and 210 were calculated.

## INTRODUCTION

Assessing a driver's ability to see a pedestrian or other object at night remains a challenging human factors problem. In an attempt to address this problem, Adrian [1] developed a visibility model that assesses visibility based on the contrast between an object and its background. The model incorporated factors for variables such as target size, target reflectivity, observer age and exposure time, and computed a visibility level that was referenced to the contrast needed for most subjects to detect an object under laboratory conditions.

A driver operating a motor vehicle on the road requires a visibility level greater than that needed in the laboratory. Adrian [1,2] proposed a visibility level between 10 and 20 times the laboratory detection level for safe traffic conditions; however, this proposal was based on data from only young laboratory observers and the visual acuity necessary to read roadway signs. Thus, a rigorous determination of the visibility levels required by a broader range of nighttime drivers and targets is still needed.

The goal of this study was to use nighttime visibility data previously acquired by Olson et al [4] to determine threshold visibility levels computed by the Adrian model [1] for perceiving an object on the road ahead while driving at night. The comprehensive nature of the existing nighttime visibility data also allowed the model's ability to account for observer age, vehicle lighting, and target size, position, and reflectivity to be assessed. The results of this study will thus identify strengths and weaknesses in the Adrian model and provide a scientific basis for selecting appropriate threshold visibility levels for drivers under nighttime conditions.

## METHODS

The Adrian model [1] and the nighttime visibility experiments conducted by Olson et al. [4] are described in detail in their respective publications. Only information relevant to the current study is described here. In the Adrian visibility model, a threshold contrast for detection is calculated from the luminance difference between an object and its background. Visibility level is then defined as the ratio of actual contrast to the threshold detection contrast. A visibility level of one is defined as the luminance difference detected with a 99.93% probability by laboratory observers. The model used in this study was based on the equations presented by Adrian [1] and implemented in MS Excel (Microsoft, Redmond, WA).

In the nighttime visibility experiments, Olson et al [4] tested two groups of subjects: 15 young subjects (30 - 40 yrs) and 10 old subjects (> 60 yrs). Subjects drove a station wagon at 40 km/h (25 mph) along a private rural road and identified when they detected various targets stationed along the left and right side of the road. The distance between the subject and the target at detection was termed the response distance.

Although both "pedestrian" and "delineation" targets were tested by Olson et al. [4], only the pedestrian targets were used in the current study. The targets consisted of a "large" 183 cm tall by 30 cm wide (6 ft x 1 ft) rectangle, and a "small" 76 cm tall by 30 cm wide (2½ ft x 1 ft) rectangle. Targets with reflectivity values of 6, 12, and 25 percent were tested, although only data from targets with a 6 and 25 percent reflectivity were used in the current study. Data from all three tested vehicle headlight systems – low beams, high beams, and a modified high beam – were used. The mean response distances reported by Olson for each combination of these conditions are summarized in Table 1.

DATA/MODEL INTEGRATION

Olson et al [4] reported sufficient data to compute the contrast between the target and background when illuminated by the headlights at various vehicle-to-target distances. Each target was placed 100, 150, 200, 300, and 400 feet (30, 46, 61, 91, and 122 m) from the vehicle, and at each distance the luminance of the targets was recorded at five different heights for the large target and three different heights for the small target. The corresponding background luminance was also measured around each target at each vehicle position. Background luminance was measured above and below the targets, as well as at five heights along both sides of the large target and three heights along both sides of the small target. For the current study, it was assumed that the target and background luminance measurements were evenly spaced along the height of the targets. Based on these data, twelve contrast levels were computed around the perimeter of each large target and eight contrast levels were computed around the perimeter of each small target for each vehicle-to-target distance.

Due to uneven illumination from the headlamps and differences in the background, the contrast level around the perimeter of each target varied widely. To accommodate these variations, each target was divided into sub-targets: the large target was divided into five stacked sub-targets 37 cm high by 30 cm wide (1.2 ft x 1 ft), and the small target was divided into three sub-targets 25 cm high by 30 cm wide (0.8 ft x 1 ft). For the model, the size of each sub-target was defined as the diameter of a disc with an area equivalent to that of the sub-target [5,6]. This diameter was 38 cm for the large sub-targets and 31 cm for the small sub-targets. Visibility levels were then calculated using the model for the contrast levels associated with each sub-target.

The actual age of each subject who participated in the nighttime visibility experiment was not available [7]. As a result, the young subjects were assumed to be 35 years old and the old subjects were assumed to be 65 years old. Both ages were within the Adrian model's applicable age range of less than 75 years.

A glare source was fixed to the hood of the test vehicle for all tests. It was positioned relative to the driver to approximate the center of an approaching vehicle about 200 feet (61 m) away. To estimate the position of the glare source, a number of assumptions were made. The test vehicle was described only as a station wagon. Based on this limited description, the dimensions of a generic 1980 station wagon were used to determine an estimated vehicle width (2.01 m), headlight height (0.66 m), and lateral eye position (0.37 m left of the vehicle centerline) [9]. Eye height was set to 1.11 m [8]. Using the reported lane width of 9 ft (2.74 m), the lateral offset to the glare source was set to 2.37 m. The lateral position of the targets relative to the driver was assumed to be 3.75 m to the left and 1.74 m to the right.

The method used to measure response distance introduced a systematic error into the measurements reported in Table 1. When subjects detected a target, they called out "target" and an experimenter riding in the vehicle pressed a button to start a counter that recorded the distance to the target. Based on studies of simple reaction time tasks with visual stimuli and vocal responses, a delay of 300 to 375 ms likely occurred between detection and vocalization [13, 16, 17, 18]. Based on other simple reaction time experiments using auditory stimuli and button-push responses, a second delay of 190 to 260 ms likely occurred between subject vocalization and the start of the counter [14, 15, 19]. Thus, a total delay of about 490 to 635 ms may have been present between target detection and the counter initiation. At a vehicle speed of 25 mph (11.18 m/s), this delay was equal to a distance of 5.5 to 7.1 m. To account for this systematic delay in the current analysis, 6.3 m (the midpoint of the range) was added to the response distances in Table 1 and these larger distances were then termed detection distances.

Subjects in the nighttime visibility experiment both knew they were being tested and were told on which side of the road a target would appear. These subjects were therefore assumed to represent alerted drivers. Since many nighttime collisions involve unalerted drivers, the response distances were also corrected for driver alertness. Roper and Howard [10] showed that the response distance of unalerted drivers was on average 51 ± 9 percent of the response distance of alerted drivers. Thus, the response distances reported in Table 1 were multiplied by 0.51 after first being corrected for the previously described time delay.

The effect of target exposure time is also considered in the Adrian model. Adrian suggested that an appropriate minimum observation time under practical driving conditions was 0.2 seconds, and this value has been used in all calculations.

ANALYSIS

For each vehicle-to-target distance (30, 46, 61, 91, and 122 m), target reflectivity (6, 25%), headlamp system (low, high, mod), lateral target position (left, right), and subject age group (young, old), the visibility level predicted by the Adrian model was computed for the eight and twelve sub-targets of the small and large

Table 1: Response distances from Olson et al. [4] and unalerted and alerted visibility levels computed using the Adrian model [1] as a function of subject age, target size, headlamp system, target position and target reflectivity.

| Age | Target Size | Headlights | Position | Reflectivity | Response Distance (m) | Visibility Level Alerted | Visibility Level Unalerted |
|---|---|---|---|---|---|---|---|
| Old | Large | High | Left | 6% | 32.6 | 23.3 | - |
| | | | | 25% | 53.6 | * | 210.2 |
| | | | Right | 6% | 36.9 | 18.7 | - |
| | | | | 25% | 76.5 | 22.3 | 107.6 |
| | | Low | Left | 6% | 13.4 | - | - |
| | | | | 25% | 46.9 | * | - |
| | | | Right | 6% | 32.6 | 9.5 | - |
| | | | | 25% | 72.8 | 6.3 | 59.8 |
| | | Mod | Right | 6% | 38.1 | 7.4 | - |
| | | | | 25% | 72.5 | 7.8 | 60.6 |
| | Small | High | Left | 6% | 21.6 | - | - |
| | | | | 25% | 55.5 | * | 75.8 |
| | | | Right | 6% | 28.7 | 12.3 | - |
| | | | | 25% | 69.2 | 9.7 | 57.5 |
| | | Low | Left | 6% | 21.9 | - | - |
| | | | | 25% | 43.9 | * | - |
| | | | Right | 6% | 26.5 | 12.3 | - |
| | | | | 25% | 73.5 | 4.3 | 43.7 |
| | | Mod | Right | 6% | 32.0 | 8.4 | - |
| | | | | 25% | 67.7 | 6.7 | 47.1 |
| Young | Large | High | Left | 6% | 62.5 | * | 38.2 |
| | | | | 25% | 107.3 | * | * |
| | | | Right | 6% | 73.5 | 6.2 | 32.6 |
| | | | | 25% | 130.1 | 5.2 | 58.2 |
| | | Low | Left | 6% | 52.7 | * | - |
| | | | | 25% | 102.7 | * | * |
| | | | Right | 6% | 76.5 | 2.4 | 13.5 |
| | | | | 25% | 128.3 | - | 17.2 |
| | | Mod | Right | 6% | 71.9 | 4.6 | 21.4 |
| | | | | 25% | 125.9 | 1.7 | 30.3 |
| | Small | High | Left | 6% | 46.9 | * | - |
| | | | | 25% | 99.7 | * | * |
| | | | Right | 6% | 57.6 | 4.9 | 28.9 |
| | | | | 25% | 113.4 | 4.2 | 35.4 |
| | | Low | Left | 6% | 40.2 | 7.6 | - |
| | | | | 25% | 94.8 | * | * |
| | | | Right | 6% | 63.1 | 2.9 | 22.1 |
| | | | | 25% | 118.0 | 1.4 | 21.8 |
| | | Mod | Right | 6% | 50.0 | 4.7 | - |
| | | | | 25% | 113.1 | 2.8 | 26.7 |

* discarded because of glare, - discarded because of extrapolation

targets respectively. This yielded 768 visibility levels for conditions involving the small target and 1176 visibility levels for conditions involving the large targets. Since the Adrian model requires that the glare source and the target be separated by between 1.5 and 30 degrees, there were some visibility levels that could not be calculated, particularly for left sided targets.

Based on the assumption that the experimental subjects represented alerted observers, the highest visibility level at each position was chosen to represent their visual performance; that is, detection was assumed to be triggered by the highest contrast area on the target. For each combination of age, target size, target reflectivity, headlight system and lateral target position, the maximum visibility level at each of the vehicle-to-target distances were connected using a cubic spline (Figure 1). The second derivative of each spline was set to zero at the end points. The appropriate alerted and unalerted detection distances for each combination of variables was then superimposed on the visibility level data (dashed lines in Figure 1). The intersection point of the alerted dashed line and the cubic spine was then used to represent the visibility level at which the experimental subjects detected the object, and the intersection point of the unalerted dashed line was used

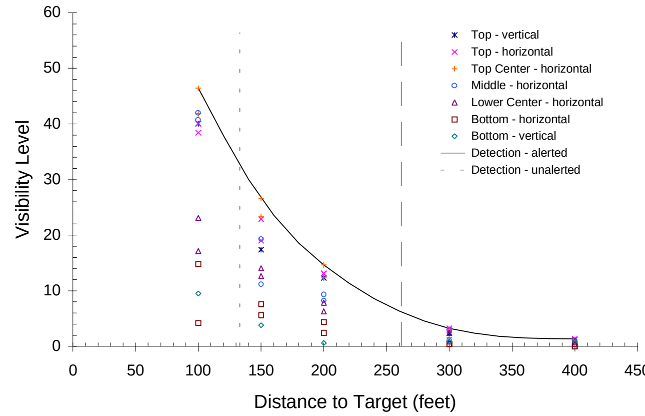


Figure 1: Typical data showing the visibility levels for each vehicle-to-target distance and the cubic spline fit to the maximum visibility level at each vehicle-to-target distance. The dashed vertical lines correspond to the unalerted (left) and alerted (right) detection distances. Data shown for a large target with 6% reflectivity placed on the right side of the road and viewed by young subjects under high beam illumination.

to represent the visibility level at which an unalerted driver would detect the object.

In some cases, the unalerted response distance was shorter than 30 m (100 feet). Because of the rapidly changing visibility levels at these short distances, the cubic spline was not extrapolated and these data were lost to the analysis. Extrapolation was used for response distances longer than 122 m (400 feet) where visibility levels were not changing rapidly. In one case, this extrapolation produced a negative visibility level and this point was discarded. In total, 35 of the 80 conditions were discarded due to glare source proximity and the inability to reliably extrapolate data.

To assess whether the Adrian model completely accounted for observer age, target size, target reflectivity, target position, and headlight system, the data from all tests were pooled and then separately analyzed for differences due to only one of these factors at a time. Since reaction time data are typically not normally distributed, a non-parametric Wilcoxon signed rank test for matched pairs was used for all comparisons [11]. A significance level of $p<0.05$ was used for all tests. In many of the unalerted data sets, there were insufficient data points for a statistical analysis.

## RESULTS

Visibility levels at target detection varied between 1 and 23 for the 50$^{th}$-percentile alerted subjects over the 25 combinations of conditions for which it could be calculated (Table 1). When detection distances were corrected for subject alertness, visibility levels at target detection increased to between 13 and 210 for the 20 conditions for which these levels could be calculated.

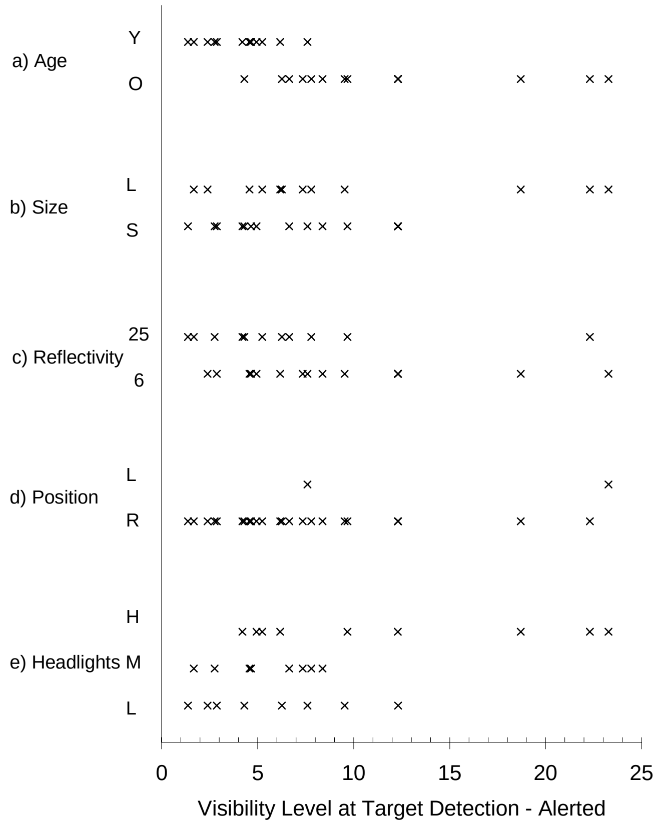


Figure 2. Single factor comparisons of the visibility levels in the pooled alerted data.

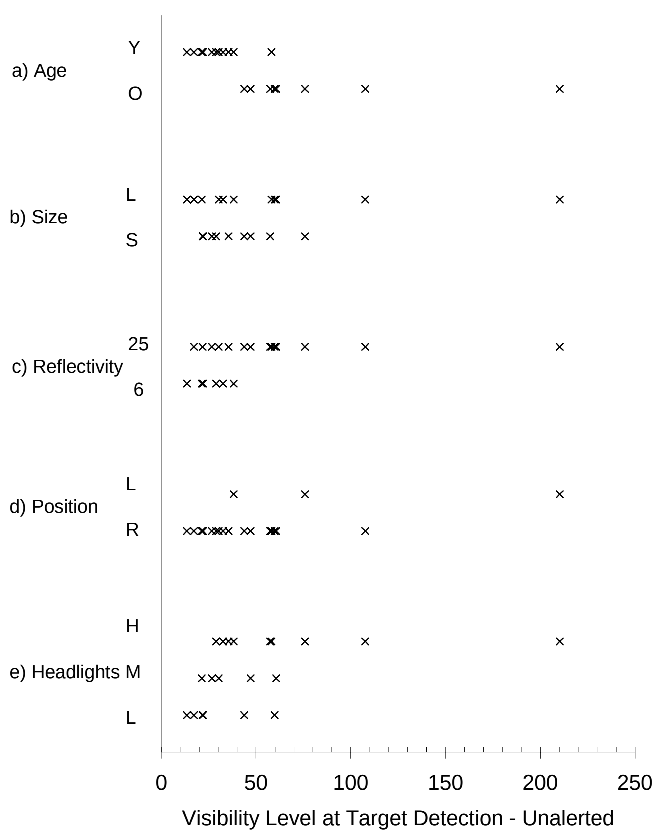


Figure 3. Single factor comparisons of the visibility levels in the pooled unalerted data.

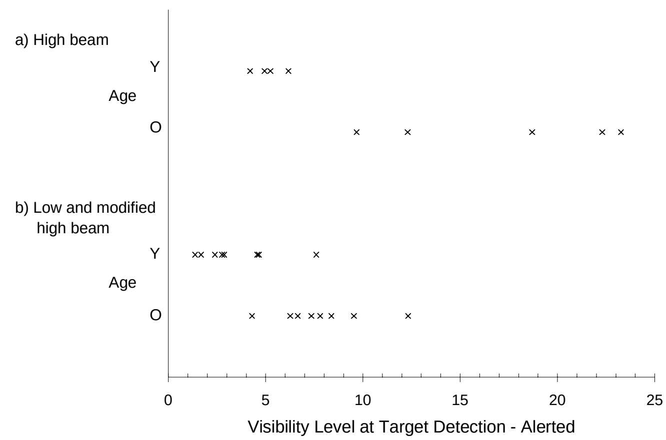


Figure 4. Combined age and headlamp system comparison of the visibility levels in the pooled data.

Based on the single-factor comparisons of visibility levels using the pooled data, the factors for age, headlights, and target reflectivity were not completely accounted for by the Adrian model (Figures 2 and 3). Older drivers required higher visibility levels at target detection than young drivers under both alerted and unalerted conditions ($p<0.05$, Figures 2a and 3a). The 6% reflective targets also required higher visibility levels at detection than the 25% reflective targets for alerted subjects ($p<0.05$, Figure 2c), but there were insufficient data to assess the effect of reflectivity for unalerted subjects (Figure 3c).

Higher visibility levels were required to detect targets under high beam lighting than under low beam lighting for both the alerted and unalerted conditions ($p<0.05$, Figure 2e and 3e). For alerted subjects, higher visibility levels were also required with the high beam system than with the modified system ($p<0.05$, Figure 2e). No significant difference in visibility levels was observed between the modified and low beam systems in the alerted data and there were insufficient data to compare the modified headlight system with either the low or high beam systems in the unalerted data. When the pooled data were first separated by headlight system, the effect of age on visibility level was greater under high beam illumination than under low beam illumination (Figure 4a, b).

Target size did not significantly affect visibility level at target detection for either the alerted or unalerted conditions ($p>0.05$, Figure 2b and 3b). There was insufficient data to assess the significance of target position.

## DISCUSSION

To apply the Adrian visibility model to actual nighttime driving situations, the threshold visibility levels applicable to nighttime driving under various realistic conditions must first be determined. Using $50^{th}$-percentile data derived from a multi-factorial visibility experiment conducted on subjects driving at night, the results of the current analysis suggested that visibility levels of 1 to 23 were required for drivers to detect an object when they were alerted to both the presence and probable location of that object. When these median data were adjusted to estimate the response of unalerted subjects, the required visibility levels increased to between 13 and 210. These broad ranges suggest that detecting objects under nighttime illumination conditions can be considerably more difficult when driving than when in a laboratory setting.

Since a number of assumptions were needed to condition the nighttime visibility experiment for the Adrian model, the results presented here need to be interpreted cautiously. One potential limitation of the current method was the definition of target size. To exploit the detailed contrast data reported by Olson et al. [4], the actual targets were divided into smaller sub-targets and characterized using the diameter of a disc of equal area. Other means of sub-dividing the targets and other means of characterizing target size [5, 6] could produce different results. Despite possible limitations with the definition of target size, the absence of a significant difference in visibility levels between the small and large targets suggested that the Adrian model adequately accounted for target size. Alternatively, the range of sub-target sizes used in the current analysis may have been too narrow to adequately test the size parameter in the Adrian model.

In the current analysis, it was also assumed that the highest visibility level around the perimeter of the target was detected by the subjects. This assumption was chosen because the subjects were alerted to both the presence and probable location of the target. Other detection criteria were also explored, including the second highest visibility level or the highest two visibility levels for adjacent sub-targets. Both criteria produced lower required visibility levels, particularly at the upper end of the required range. Additional work is needed to better understand the criteria used by subjects to detect an object.

The data used to correct the alerted data for unalerted drivers were based on an experiment involving a single 1930-vintage headlamp system, a darkly clothed man-sized target positioned in the middle of the road and an undisclosed range of vehicle approach speeds. Although response distances are known to vary with headlight illumination, target reflectivity, target size, target position, and vehicle speed [3, 10], it remains unclear how the ratio of expected-to-unexpected response distances varies with these same variables. As a result, the visibility levels proposed for unalerted drivers should be interpreted cautiously.

Although the nighttime visibility experiment used for this analysis considered a large number of relevant variables, other potentially-relevant variables or conditions (e.g., vehicle speed, moving targets, non-glare conditions, and reverse contrast) were not considered. Moreover, an analysis of the effect of lateral target position was hindered by the lack of data for left-sided targets. Although Olson [12] suggests that the effect of target eccentricity is small in low light, the visibility levels proposed here may not be applicable under all types of driving conditions, vehicles, and targets.

Despite the limitations of the current analysis, the computed visibility levels of 1 to 23 for alerted subjects encapsulated the ranges previously proposed by Adrian [2] and Hills [3]. Based on 20 to 30 year old subjects, Adrian [2] suggested that visibility levels of 10 to 20 were required to read roadway signs in the luminance range of street lighting. In a separate study, Hills suggested that visibility levels 4 to 30 times the $50^{th}$-percentile laboratory detection threshold may be required for driving [3]. When recast as multiples of the $99.93^{th}$-percentile response for comparison with the Adrian model, these latter values equated to visibility levels of 1.5 to 11.5. The results of the current analysis thus corroborate these previously proposed visibility levels for alerted drivers though they widen the applicable range for the unalerted condition.

The results of the current analysis revealed that the Adrian model did not completely account for observer age, target reflectivity, or headlight illumination level. Within the Adrian model, both the threshold detection contrast and the deleterious effect of disability glare increase with increased observer age. Despite these corrections within the model, the current analysis showed that the visibility level, i.e., the multiple above threshold required for target detection, increased with increasing age. This finding suggested that the Adrian model either did not fully account for the above-mentioned factors or was missing a separate age-dependent factor. In either case, the data presented here provide additional information on how to better interpret the age dependency of the visibility levels computed by the Adrian model.

Although target reflectivity only indirectly enters the model through the target luminance measurements, the 6 and 25 percent reflective targets produced significantly different visibility levels at detection. Despite this finding, the average absolute difference in visibility levels at target detection was only 2.4 and therefore of questionable practical significance.

Vehicle headlighting is also only indirectly included in the Adrian model through the input target and background luminance values. Its significance illustrates one of the limitations of the model, namely the lack of a driver adaptation factor. In the laboratory, a subject's eyes will generally be adapted to the level of the background. In a motor-vehicle, both the headlight beam pattern and the receding nature of a typical roadway environment produce a non-homogeneous background against which the target is viewed. Olson et al [4] measured driver adaptation luminance levels of 0.3 ft-L (1.03 Cd/$m^2$) under low beams and 1.7 ft-L (5.82 Cd/$m^2$) under high beams and reported that the necessary target threshold contrast increased with adaptation luminance. Thus, the high beam condition would have resulted in a higher adaptation luminance for Olson's subjects than the low beam or modified high beam conditions. Since the Adrian model does not account for driver adaptation, it is expected that a higher visibility level would result with high beams. The interaction between headlight illumination and driver age suggests that any correction for adaptation level is likely age dependent.

## CONCLUSION

The Adrian visibility model provides a method for quantifying nighttime scene visibility in terms of the visibility level or multiple over threshold visibility that is required to detect a specific target. Using data for alerted drivers, visibility levels at target detection were between 1 and 23. With a correction for expectation, visibility levels at target detection were between 13 and 210. Driver age was found to significantly affect the visibility level at target detection with older drivers requiring a higher visibility level than younger drivers. Headlight beam patterns were also found to significantly affect visibility level at target detection. A higher visibility level was needed under high beam lighting than under low beam lighting. There was also a weak correlation between target reflectivity and visibility level at target detection, with the 6% target requiring a higher visibility level to detect than the 25% target.

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SAE International

# Validation of High Dynamic Range Photography as a Tool to Accurately Represent Low-Illumination Scenes

2012-01-0078
Published
04/16/2012

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doi:10.4271/2012-01-0078


## ABSTRACT

Previous research [1] described a procedure for creating prints from digital photographs that accurately represent critical features of visual scenes at low levels of illumination. In this procedure, observers adjust the brightness of a digital photographs captured using standard photography until it best matches the visible characteristics of the actual scene. However, standard digital photography cannot capture the full dynamic range of a scene's luminous intensities in many low-illumination settings. High dynamic range (HDR) photography has the potential to more accurately represent a viewer's perception under low illumination. Such a capability can be critical to representing nighttime roadway scenes, where HDR photography can enable the creation of more accurate photographic representations of bright visual stimuli (e.g., vehicle headlamps, street lighting) while also maintaining the integrity of the photograph's darker portions. Using a photographed real-world, low-illumination scene, brightness adjustments and subjective ratings of the visibility of multiple objects were collected from naïve observers using the updated method with both standard and HDR photographs. A comparison of observers' ratings of the gamma-corrected photographs to the actual scene indicates that the HDR photograph represents a majority of the objects in the scene with greater fidelity than does the standard photograph. These findings support the validity of the updated method, using HDR photography, to produce accurate depictions of low-illumination scenes.


## INTRODUCTION

Prior work [1] demonstrated that using a combination of psychophysics and standard photography methods, representative photographs of low-illumination scenes can be produced based on a viewer's perception of one or more regions or objects of interest. Because the previously published method employed standard photography, this method is especially effective when the difference between the brightest and darkest areas is relatively small, representing a low dynamic range. In contrast, this technique's ability to effectively represent a scene can be limited if the areas of interest include a region where there is substantial variability in brightness or contrast (e.g., shadows and highlights). In this case, the photograph may not accurately represent what the viewer experienced because it does not show the high dynamic range of the actual scene. In other words, the photographer must decide to either (1) set the camera to accurately depict the darker portions of the photograph, thereby overexposing the brighter parts of the photograph (e.g., headlights), or (2) set the exposure to properly represent the lit portions of the scene at the expense of underexposing the darker portions.

In the current study, we attempted to create a faithful representation an observer's experience under conditions of low ambient lighting. By using HDR photography, this problem's solution has become more tractable. Put briefly, HDR photography combines different exposures of the same scene into a single photograph, such that the HDR photograph represents the full dynamic range of brightness in the scene [2]. Consequently, a single photograph contains details in both shadows (overexposed photographs) and highlights (underexposed photographs) from the photographed scene. With care, the user can produce an HDR photograph that reproduces both the brighter and darker aspects of a visual scene better than standard photography.

In the present study, we updated the previously published method [1] and directly measured the effectiveness of standard and HDR photographs to represent a low-illumination scene. Participants made psychophysical brightness adjustments to both standard and HDR photographs in order to match those photographs to the real nighttime scene. These adjustments were made at the scene, using a calibrated laptop monitor. Then, each participant was presented a standard and HDR photograph, optimized per their own psychophysical adjustments on the laptop monitor, and was asked to rate the accuracy of each adjusted photograph's representation of numerous objects in the scene. Empirical analysis of participants' ratings revealed that HDR photography created subjectively better representations of some, but not all, of the objects. In contrast, standard photography did not produce a reliably better representation of any single object. Although HDR photography has distinct advantages over standard photography, standard photography remains a suitable alternative for capturing some low-light conditions.

# METHODS

## PARTICIPANTS

Eleven participants (5 females), ranging in age from 29 to 42 years (average age = 32.5 years) participated in the study. Participants had normal or corrected-to-normal vision and none reported having trouble driving at night. Participants were told that the purpose of the study was to evaluate their judgments of, and adjustments to, digitally presented photographs depicting a nighttime scene; however, they were naive to the experimental manipulation of interest. Participants recruited from the community were provided monetary compensation for their participation.

## TEST SCENE

Figure 1 shows the HDR (Fig. 1A) and standard (Fig. 1B) photographs of the low-illumination test scene. A nighttime scene was set up on a street that ended in a cul-de-sac in a business park district of Los Angeles, CA. The scene contained four primary objects of interest: (1) a 2011 Honda CRV sport utility vehicle (SUV), (2) a 0.74-meter-tall, toddler-sized mannequin, (3) a 2006 Chevrolet Silverado pickup truck, and (4) two diamond-shaped retroreflective traffic signs, one positioned above the other. As viewed in Figure 1, the front of the SUV was positioned next to the left curb approximately 35.7 meters from the camera's location, with its headlights aimed in the direction of the participant. The toddler wore blue and red shorts and was positioned just to the right of the SUV's driver's side front tire. The rear of the pickup truck was located next to the right curb approximately 29 meters from the camera's location, with its headlights aimed away from the participant and in the direction of the retroreflective traffic signs. The traffic signs were located at the end of the cul-de-sac, approximately 76.2 meters from the camera's location. The scene also contained sidewalks along both sides of the street, trees, bushes, other traffic signage, telephone poles, and high-pressure sodium streetlights.

A contrast chart was included in some photographs. The contrast chart contained 12 achromatic square-wave gratings of varying orientation. At the participants' viewing distance, six gratings had a spatial frequency of four cycles per degree (cpd) and six had a spatial frequency of 16 cpd. The Michelson contrast of the gratings varied between 0.1 and 0.9 [1]. When used, from the viewpoint of the observer and camera, the chart was placed to the right of the SUV's driver's side front tire, at the feet of the toddler (refer to [1] for further discussion of the contrast chart).

Photographs of the scene were captured with and without contrast charts. All photographs were taken after the end of nautical twilight to ensure that the scene was photographed under the same ambient lighting conditions as those experienced by participants, who were tested at various times after the end of nautical twilight.

## DIGITAL PHOTOGRAPHS

Photographs were acquired using a Nikon D300 12 mega-pixel digital SLR camera with a Nikkor 18-200 mm lens. Using the methods described previously [1], it was determined that the camera does not introduce any non-linear transformations of luminance values. During photograph acquisition, the camera was placed on a tripod at the location where participants stood while viewing the scene. The camera was set to “aperture priority” mode and photographs were taken using ISO 800, 32-mm (50-mm effective) focal length, and an aperture setting of f/8. Nine different photographs were acquired using automatic bracketing at 1EV (exposure value) spacing. Photographs were encoded in NEF (Nikon Electronic Format) format. Three of these nine photographs were selected to create the HDR photograph, as described in the next paragraph. These photographs had shutter speeds of 1/13, 1.3, and 13 seconds, representing a 7 EV range. The standard photograph was taken using ISO 800, 32-mm (50-mm effective) focal length, aperture setting of f/4, and a 1/2-second shutter speed. This photograph most closely

A. B.

***Figure 1. The two unadjusted photographs used in experiment. (A) HDR and (B) standard photographs were presented to each participant. After matching each photograph's brightness to the brightness of the actual scene and correcting for gamma in the presented photograph, the participant rated specific objects in each photograph according to how well the object in the photograph matched the actual object. The contrast chart is to the left side of the scene, just to the right of the SUV, and the toddler is standing behind the chart. The large yellow and small red traffic signs are directly to the left of the truck, which is on the scene's right side. Note the presence of visibly greater headlight veiling glare in the standard photograph.***

matched the overall ambient lighting conditions and appearance of the objects of interest. No flash was used while acquiring any of the photographs.

The HDR photograph was generated using Photomatix Pro 3.2 software (HDRsoft, Montpellier, France). Given the potential subjectivity of post-processing methods, the default Photomatix settings were used. The color saturation of the resulting tone-mapped photograph was reduced in order to better approximate color saturation of the scene. No other custom adjustments were made to the composite photograph throughout the processing pipeline, e.g., white balance adjustment, tonal range compression, contrast adjustment.[1] In the first step, three raw photographs were selected, representing low-, medium-, and high-toned photographs. Using the photographs' RGB/luminance histograms, an overexposed photograph was chosen such that its histogram was saturated on the white/bright side and diminished to zero in the region presenting black/dark pixels, and the underexposed photograph had the opposite pattern (saturation on the dark side and no pixels on the bright side) [2]. The distribution of pixels in the third photograph was generally focused in the mid-range of RGB pixels. These photographs were then combined to yield a 32-bit HDR photograph in Adobe RGB color space, without any tonal compression. Next, this photograph was tone-mapped to compress the dynamic range so the photograph could be presented on non-HDR media, e.g., a standard computer monitor. Tone mapping was performed using the default values for Photomatix's tone-compressor operator, in which pixels are processed independent of the brightness of each of the surrounding pixels. The resulting tone-mapped photograph, which had a greater range of luminance values than the standard photograph, was saved as a 16-bit TIFF for subsequent gamma correction and evaluation by the participant.

The HDR and standard photographs were used as stimuli for the adjustment procedure described below. Test images were generated from each photograph using custom software developed in MatLab® (The MathWorks, Inc., Natick, MA) and described in greater detail in reference [1]. In brief, photograph pixels were transformed from RGB to luminance values using the display screen's gamma modulation. Then, thirty unique images were created by differentially scaling the luminance values in the original photograph. These luminance values were then converted to brightness by applying the CIE 1986 conversion formula [3], i.e.,

$$\text{Brightness} = 116 \times \left(\frac{Y}{Y_n}\right)^{\frac{1}{3}} - 16 \qquad (1)$$

where *Brightness* is the perceived intensity of light by a human observer, $Y$ is the overall luminance value of the scaled image, and $Y_n$ is the overall luminance value of the highest luminance image. Each participant performed a total of ten adjustments. In each adjustment, one of the 30 images was randomly selected and displayed on the computer monitor. Participants could then "scroll through" the 30 images, until he or she identified the image that best represented the scene. The average output of the ten adjustments was then used to adjust the brightness of the respective photograph-the standard or HDR photograph. Lastly, participants rated that brightness-adjusted photograph's ability to accurately represent the actual scene.

1 Though most of the default settings were appropriate for the scene photographed in this study, other situations may exist where it is appropriate to make additional adjustments prior to the critical brightness adjustments on the gamma-corrected photographs, given that the ultimate goal is to create a photograph that most closely approximates the live scene.

# PROCEDURE

All participants were dark adapted for at least 15 minutes prior to viewing the photographed scene. While viewing the scene and making adjustments, participants stood at the same location from where the photographs were taken (Fig. 1). Participants were permitted to freely view the scene before beginning the experimental procedure, but they were not allowed to view any photographs of the scene until the testing session began.

To complete the adjustment procedure for both the standard and HDR photographs, participants were instructed to increase or decrease the brightness of the photograph until it best matched the overall scene in front of them. Participants compared the digital photograph with the contrast chart to the actual scene with the contrast chart. All stimuli were presented on a gamma-calibrated Dell Latitude E6500 LCD laptop monitor. Custom software, developed using the MatLab Psychophysics toolbox [4], was used to adjust the brightness of the photograph (i.e., moving between the scaled test images described above) by pressing the “up” or “down” arrow keys on the keypad, and the space bar was pressed to indicate that the best match had been achieved. This process was repeated a total of ten times. Participants were told that if they need to emphasize any region to match the brightness, it should be in the vicinity of the SUV and truck. They were instructed that if they used the contrast chart, they should try to match the least visible black-and-white gradient in the scene to the respective gradient in the photograph. Participants made adjustments to the standard and HDR photographs separately, with five participants adjusting the standard photograph first and six adjusting the HDR photograph first. To avoid biasing participants' judgments, no reference was ever made to the photographs being “standard” or “HDR” photographs. Instead, the first photograph was always identified as “Photograph A” and “Photograph B” was the second photograph.

After the participant completed the adjustment procedure for both photographs, gamma-corrected standard and HDR photographs were created. For each photograph, the participant's average brightness setting across the ten adjustment trials was applied to the respective standard or HDR photograph. Participants viewed the final, adjusted photographs in full-screen mode on the same laptop computer. They then completed a questionnaire that asked them to compare the overall scene, as well as a subset of objects in the scene, which were depicted in each of the two photographs (Table 1), to the actual scene before them. Specifically, participants appraised each photograph's ability to accurately represent their perception of each object in the scene. They used a five-point Likert scale to rate each photographed object's fidelity, ranging from Poor (1) to Excellent (5). If they could not see the object in either the photograph or actual scene, they were instructed to report *N/A*. If a given object received different ratings between the two photographs, participants were encouraged to describe the relevant visual attributes that differed between the two photographs (e.g., color, brightness, amount of visible detail, legibility).

***Table 1. Objects listed in participant questionnaire.***

| | |
|---|---|
| 1 | Contrast chart |
| 2 | Toddler |
| 3 | SUV headlights |
| 4 | Pavement in front of SUV headlights |
| 5 | Truck taillights |
| 6 | Larger diamond-shaped sign at end of street |
| 7 | Smaller diamond-shaped sign at end of street |
| 8 | Sky |
| 9 | Trees |
| 10 | Power lines at end of street |
| 11 | Overall scene |

# ANALYSIS

There is an on-going debate about whether parametric or non-parametric methods should be used to analyze data collected using Likert scores, with some advocating the use of non-parametric analyses and others arguing the two methods provide similar findings [5, 6, 7, 8]. Because the distribution of scores did not appear to consistently follow a normal distribution across all questions, we adopted a conservative approach and report findings from non-parametric analyses [5]. However, supporting others' arguments, the findings are qualitatively the same when analyzed using a parametric approach (paired *t*-test) [6].

Participants' evaluations of each standard- and HDR-photographed object to the actual object were directly contrasted in order to test for reliable and quantitative differences between the fidelity of standard and HDR photographs' representations of low-illumination scenes. Because each participant provided a single measure for each object for each type of photograph, a Wilcoxon matched-pairs signed-ranks test was employed. This non-parametric test evaluates whether the median of the participants' difference scores deviates significantly from zero [9].

# RESULTS

There were six N/A ratings. Two participants marked the power lines (Object 10) to be N/A in both the standard and HDR photographs. One of these participants also marked the sky (Object 8) as N/A in both the standard and HDR

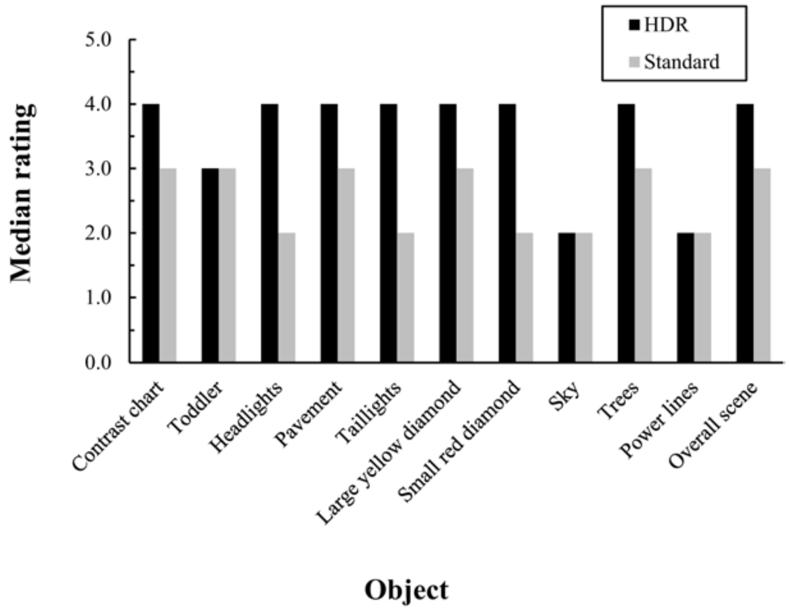


***Figure 2. Median rating of how accurately each object in an HDR or standard photograph represents the same object in the real scene. Ratings ranged from 1 ("poor") to 5 ("excellent"). Ratings of N/A are not represented in these data.***

photographs. These N/As were not included in the subsequent analyses.

To better understand the group-level ratings for each object, Figure 2 shows the median ratings for HDR and standard photographs. Because the Wilcoxon test evaluates the median difference score between two categories, Figure 3 provides the median differences for each rating category.

Preference for one type of photography method over another was not unanimous across all objects. Pairwise comparisons revealed significantly higher ratings of fidelity for the HDR photograph compared to the standard photograph for objects that either reflected light (large yellow diamond, $V = 45$, $p < 0.01$; small red diamond, $V = 50$, $p = 0.02$) or light sources that shone in the direction of the observer (SUV headlights, $V = 64.5$, $p < 0.01$; truck taillights, $V = 59$, $p = 0.02$). Qualitatively, the toddler was rated as more accurately represented in the standard photograph (Fig. 3; median difference score = −1.0; $V = 20$, $p = 0.44$). This non-significant effect reflected differences in individual subjects' ratings between the two photographs: The median group rating was "3" for both HDR and standard photographs (Fig. 2). Ratings of all other objects, including the contrast chart, were not reliably different between standard and HDR photographs ($p$s > 0.05). A test of each photograph's overall ability to accurately represent the overall scene revealed a strong preference for the HDR photograph ($V = 41$, $p = 0.02$).

# DISCUSSION

Relative to standard photography, HDR photography provided a measurably superior and accurate representation of elements within the nighttime scene we evaluated. The benefit of HDR representations is evident when there is a greater luminance range in a scene, e.g., perceiving details in a nighttime scene in the vicinity of an oncoming vehicle's headlights. In contrast, there is unlikely to be a distinct benefit of using HDR photography where there is a relatively small dynamic range of luminance, e.g., perceiving black power lines against a nighttime sky. Thus, the viewer's preference for the relative fidelity of HDR over standard photography can be expected to depend upon the photographed subject matter.

We found no reliable evidence for any tested object being preferred under standard-photographed conditions. This makes sense given that HDR photography will not significantly affect the appearance of a scene in which the dynamic range is small. If a standard photograph is judged to be superior to an HDR photograph, this may reflect exaggerated or questionable adjustments during tone mapping. It could also reflect a poor selection of photographs used to create the composite HDR photograph, e.g., there may be ghosting incurred from camera movement across photographs. As such, the photographer must be attentive and avoid introducing undesired artifacts [2]. In preparing the HDR photograph for this study, care was taken to avoid unnecessary adjustments to the tone-mapped photograph, which preserved the realism of the HDR photograph.

When participants were instructed to adjust the photograph's brightness to match that of the overall scene, they were told that if they were to prioritize a region, it should be in the vicinity of the SUV's headlights and truck's taillights. This area included the chart with contrast gradients and the toddler

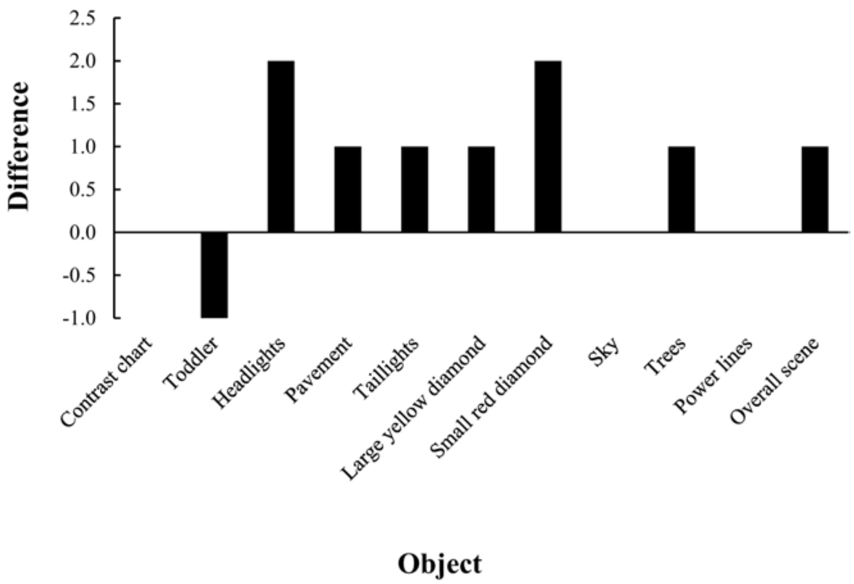


***Figure 3. Median difference scores used in analysis. Scores were calculated by taking the median of the difference between each pair of HDR and standard photograph ratings for a given object. Positive scores mean the HDR photograph was rated as being more accurate than the standard photograph. Ratings of N/A are not represented in these data.***

mannequin. The instruction to focus on this region might be reflected by the null difference in the representation of the contrast chart and toddler in the two photograph conditions (Fig. 3). An alternative explanation is that these objects' representations are overly insensitive to the tested dynamic ranges differences. While this study cannot address this question, these null effects are important because they demonstrate that even when the representation of some objects within the scene is congruent (e.g., mannequin, contrast gradient), there can be appreciable differences in other regions of potential interest (e.g., signage, lighting).

Participants' voluntary reports of why they rated one photograph better/worse than the other provide some insight into why HDR photographs are preferred over standard photographs when attempting to create accurate representations of low-illumination scenes. Overall, participants indicated that the *colors* of the two diamond signs were more accurate in the HDR photograph. Many also commented that the *brightness* of the headlights and taillights appeared to be more accurate in the HDR photograph. Compared to standard photography, these assessments reflect HDR photography's ability to more accurately represent luminance changes across a scene. This is especially true in generally low-illuminance scenes, such as the one that was photographed for this study. The larger of the two signs contained the word “End,” which participants noted as being more legible in the HDR photograph. A general preference for the HDR photograph was supported by comments such as it being “crisper,” “more in focus,” and having more “detail” and better colors than the standard photograph.

An important issue associated with the use of HDR photography under low illumination is that of glare. In some situations, the multi-exposure HDR method used here may be limited by issues of veiling glare in the camera, i.e., the uncontrolled spread of light. Veiling glare from light sources (e.g., vehicle headlamps directed at the camera) can mask areas by saturating the respective pixels in the photograph, thereby preventing the photograph from accurately representing the scene [10]. The multi-exposure technique of HDR photography can control for some glare. In contrast, standard photography cannot do this, unless the brightness of the overall photograph is significantly reduced, in which case potentially important, darker regions of the photograph will be underexposed and not representative of the actual scene. This will affect small objects, such as text on a distant road sign being illuminated by a vehicle's headlamps. It will also be an issue for photographs in which there is a low level of contrast between a target object and its background. In situations in which glare cannot be controlled or reduced from a desired vantage point (e.g., photographing a scene with a vehicle shining its high beam lights directly at the viewer), there are algorithms being developed that attempt to minimize the effects of glare (e.g., [11]). While these algorithms may be beneficial, additional care must be taken to guarantee that both tone-mapping *and* glare are modeled accurately.

The ability of HDR photography to control glare can be seen in the vicinity of the SUV's headlights (Fig. 1). Interestingly, this capacity appears to have adversely affected participants' rating of the HDR photograph. While there was visibly less glare in the HDR photograph, participants gave the standard photograph a greater rating of representation accuracy for the toddler (Fig. 3). Related, several participants commented that the toddler was difficult to see in the HDR photograph because of glare and general brightness from the SUV's headlights. Importantly, the standard photograph's toddler rating was not reliably different from that of the HDR photograph, so caution must be made when interpreting the qualitative findings. Similar comments were also made about the visibility of the contrast chart, but unlike the toddler, there was no qualitatively higher rating of the standard photograph for the contrast chart (Fig. 3). Thus, while glare may hinder both photography methods to accurately represent a scene, the current study did not find reliable evidence supporting one method over the other in their ability to control glare.

There is an important caveat to the idea that HDR photography provides a more accurate representation of a scene. There are conditions where a standard photograph will be better than an HDR photograph under low illumination. For example, uncontrollable motion from a camera or an object (e.g., a human, moving vehicle, etc.) will limit the use of long shutter speeds, which would otherwise be necessary to capture details in shadows for use in creating an HDR photograph. Similarly, HDR photography limits one's ability to photograph a transient event or a non-stationary object, owing to the object of interest failing to maintain a constant position for a long enough period to photograph across multiple EVs. Thus, while HDR photographs provide some benefits over standard photographs in low illumination, it is not practical for all conditions.

## CONCLUSION

Using HDR photography under conditions of low illumination and adjusting the photograph brightness using psychophysical methods can result in more qualitatively accurate representations of potential areas of interest, relative to the same scene photographed using standard photography. This is particularly true for photographic representations of luminous elements of the scene such as street lights or retroreflective street signs.

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The Engineering Meetings Board has approved this paper for publication. It has successfully completed SAE's peer review process under the supervision of the session organizer. This process requires a minimum of three (3) reviews by industry experts.





ISSN 0148-7191

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**Reprinted from: Accident Reconstruction: Technology and Animation VI (SP-1150)**

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0348

**ISSN** 0148-7191


Printed in USA **96-0049**

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## ABSTRACT

A new low light video recording system is described which can be used to document visibility conditions at nighttime accident scenes. The system includes a means for calibrating the recording and playback equipment for the prevailing illumination conditions while on location at an accident scene. Use of a hand-held grey scale chart facilitates calibration of the equipment and provides a visual check during playback. The characteristics, use and adaptability of the system for a variety of accident reconstruction activities is described.

## INTRODUCTION

Making a realistic record of the night visibility conditions at an accident scene using video equipment has been difficult in the past. A recent development provides the means for overcoming the majority of these difficulties. A video system and calibration procedure is described which enables the reconstructionist to record the low illumination visibility conditions at an accident site.

## VIDEO SYSTEM DESCRIPTION

HISTORICAL SOLUTIONS - In the past, many investigators have tried to use color camcorders or still photography for recording low illumination visibility conditions at an accident site. With color camcorders, the results were, at times, less than satisfactory due to their relatively high luminance requirements (typically 1 to 4 lux) and their tendency to over-correct in low light conditions.

Still photography has enjoyed greater acceptance as a medium of choice for recording low light conditions. However, some investigators have experienced problems with the use of still photography for night scene documentation. Potential problems include reliance on subjective memory, the need for multiple trips to an accident scene, and variations in photographic procedural techniques and print densities [1].

Experience with the limitations of these alternate documentation methods led to the development of a new low light video recording system. The new system as described below addresses the problems encountered with the other methods and introduces many features that should prove useful to the accident reconstructionist.

NIGHTTIME VISIBILITY LEVELS - An apparent functional lower limit for the ability of the human eye to resolve detail in low light conditions occurs at a luminance level of 0.05 lux. Visibility cutoff occurs at this level for objects of significance in visual environments and event sequences common to low light accident scenes [2]. This luminance level can be described as the approximate luminance needed to resolve a 15.2 cm (6 inch) diameter object, such as a denim-clad leg, that is reflecting light at a level of 0.05 lux under low illumination conditions, with a dark asphalt background reflecting light at about 0.01 lux, when the object is about 50 m (165 feet) from the observer [2,3]. Under certain ideal static acuity states, the human eye may be able to exceed this level of performance. However, for the most part, those conditions are not found to be common to nighttime low light accident scenarios [2,3,4].

THE NEW LOW LIGHT RECORDING SYSTEM - The new system makes use of a black-and-white video camera that is able to record visual images down to an average scene luminance of about 0.01 lux. This is of particular interest in view of the 0.05 lux human eye functional visibility limit discussed above. The low lux level of the new camera is enough below the human visibility limit to allow the video recording and playback equipment to be calibrated to the prevailing accident scene visibility conditions. Since the final check on calibration, recording, and playback fidelity is the eye of the investigator, the necessary verifications can be completed in real time while the investigator is at the accident scene. This is an obvious advantage for the new system.

The calibration devices provided in the new video recording system include numerically graduated potentiometers and a numbered grey scale chart. A potentiometer on the low light camera lens allows the operator to adjust the reference aperture of the lens to a setting consistent with the accident location. A potentiometer on the playback monitor, working in conjunction with the potentiometer on the camera lens, allows the operator to set the scene ambient darkness level displayed on the monitor to that observed at the scene.

The use of the hand-held grey scale chart during calibration at the accident scene provides an additional visual check on the equipment set-up both at the accident scene and during subsequent video playback.

The three panel foldout grey scale chart, shown in Figure 1, has overall dimensions of 0.4 m (15 inches) by 1.5 m (60 inches). The chart contains 0.1 m (4 inches) high numerals one through six, and 0.23 m (9 inches) diameter solid circles colored in shades of grey from off-white to very dark grey on a black background. The 0.23 m diameter solid grey circles were selected to give a visual range of approximately 60 to 80 m (200 to 260 feet) at a visual acuity range of 0.08 to 0.1 with luminance levels of 0.01 to 0.05 lux. [5] The chart in this form has been found to facilitate equipment calibration for a variety of accident scene lighting conditions.

The system includes a standard 8mm color video camcorder for daylight and intermediate luminance level recording. **A** switch is provided that allows the operator to easily switch from color to low **light** black-and-white recording. Figure 2 shows a view of the camera system.

Electrical supply can be provided from a portable 12 volt battery power pack, or from a vehicle cigarette lighter plug-in. This feature makes the recording system completely portable for hand-held accident scene walk-throughs or for vehicle mounted drive-throughs. The connections may be hardwired for permanent mounting inside a vehicle.

Mounting brackets for the camera system are available for mounting on the hood or for dash mounting inside a vehicle. The magnetic hood mounting bracket provides for convenient and rapid system setup and operation on a variety of vehicles. This bracket can also be used for mounting on a vehicle roof or on other relatively horizontal sheet metal surfaces. Figure **3** shows a view of the camera system mounted on the hood of a vehicle in front of the driver at approximate driver eye height. Figures 4 and 5 show the system mounted inside a vehicle.

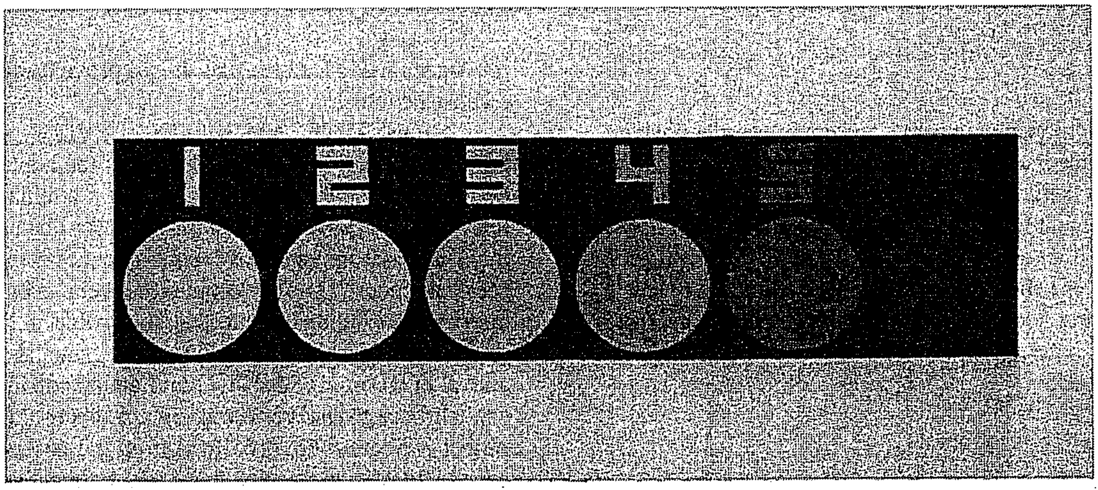


**Figure 1:** Grey Scale Calibration Chart

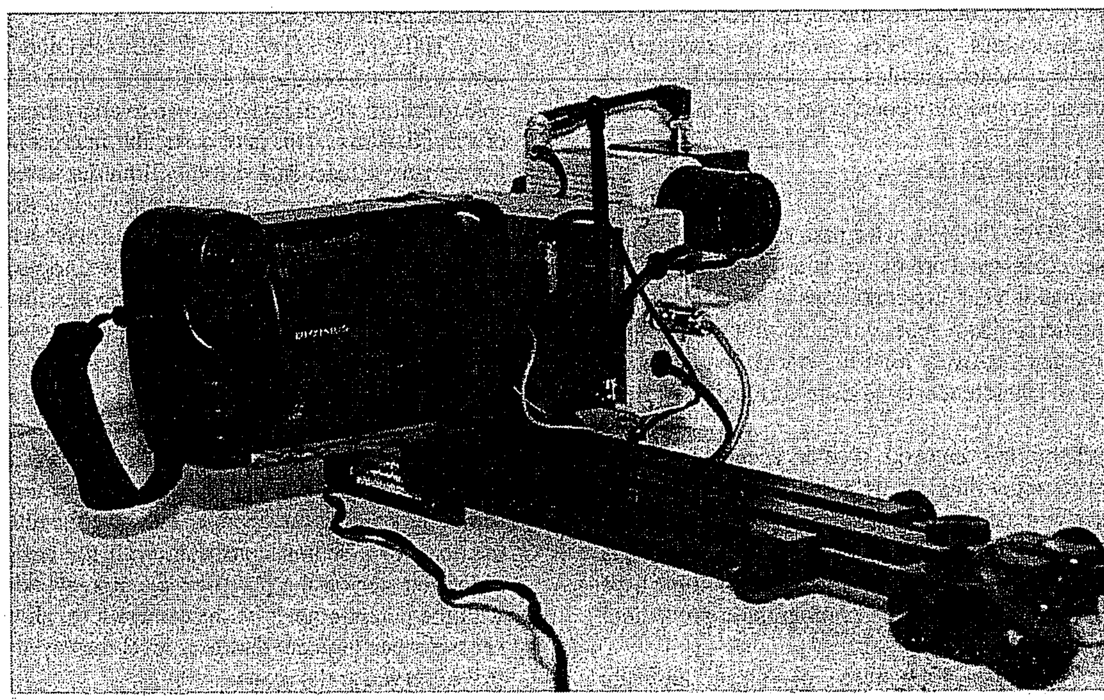

**Figure 2:** The camera system with low light camera lens potentiometer and dash mount shown

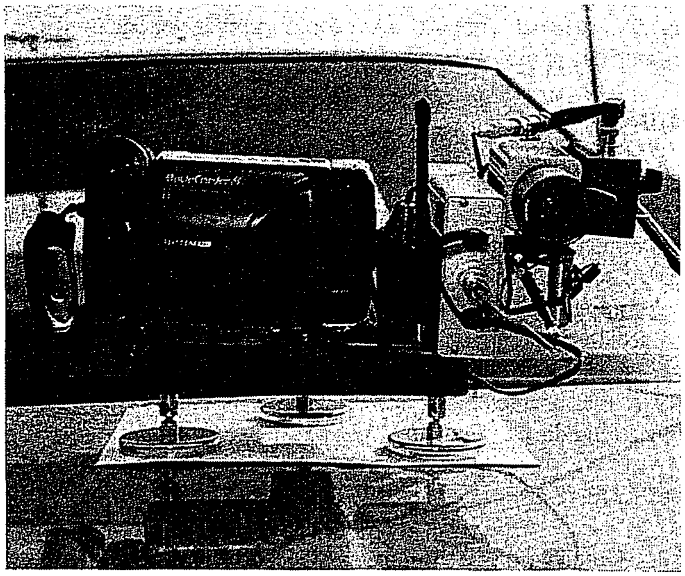

**Figure 3:** Camera system shown mounted on vehicle hood

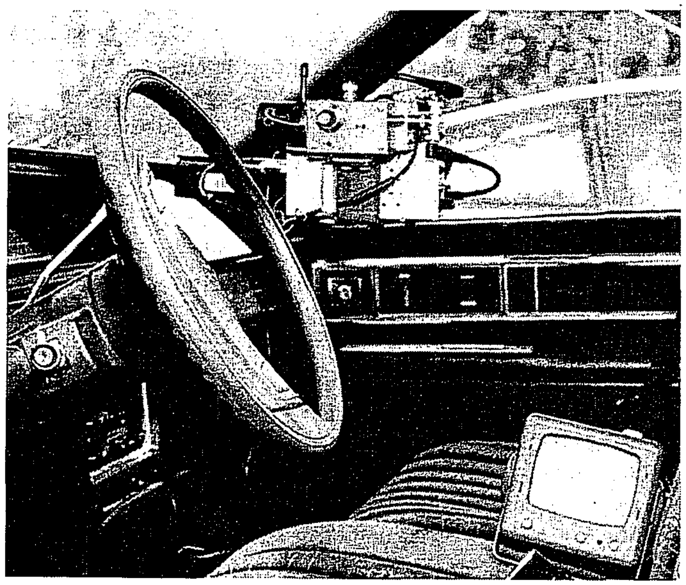

**Figure 4:** Camera system shown mounted inside a vehicle and the playback monitor with calibration potentiometer

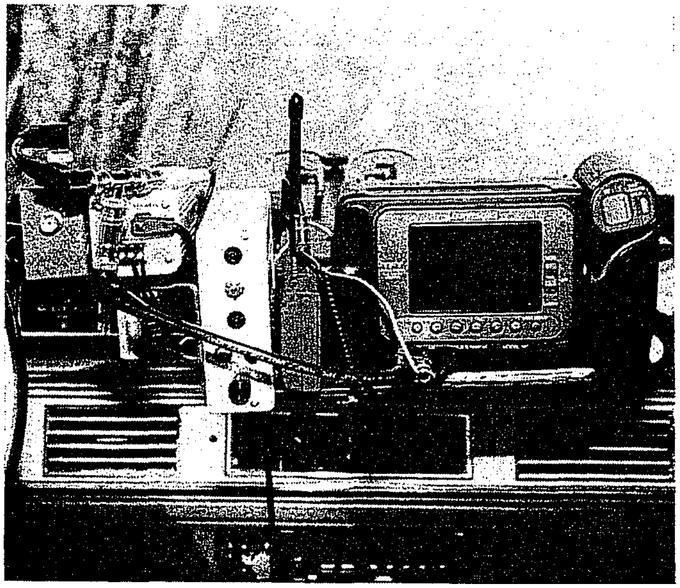

**Figure 5:** Camera system shown mounted inside a vehicle

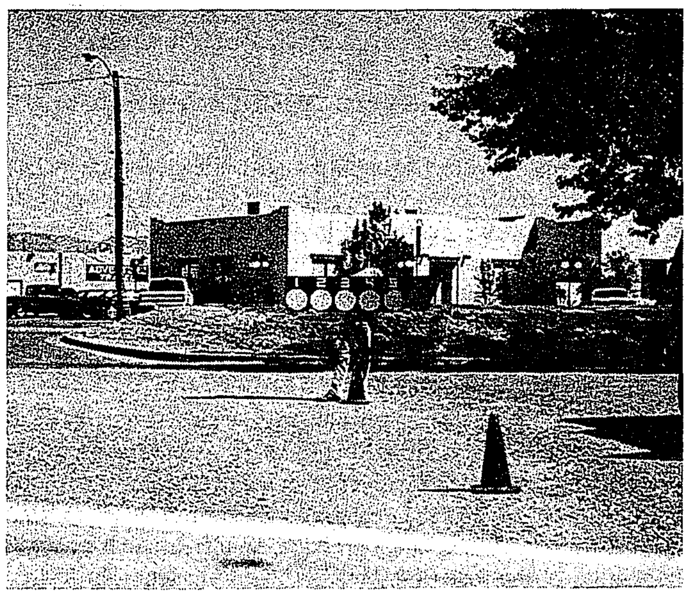

**Figure 6:** Grey scale chart using daylight reenactment

SYSTEM CALIBRATION PROCEDURE - To begin a calibration of the system for low light conditions, the camera operator should verify that the lighting conditions are as they were at the time of the accident. Next, with the camera system mounted or hand-held, turn the camera on and aim it in the direction of interest (i.e. driver, pedestrian, or witness viewpoint). The camera operator should position the black-and-white video monitor for convenient observation. An assistant should stand facing the camera at or near the accident location while holding the unfolded grey scale chart. The dial potentiometer on the video monitor should be adjusted until the ambient scene presentation on the monitor is consistent with the camera operator's observation. The potentiometer on the low light camera lens should be adjusted to give a consistent presentation of detail features in the scene, including the grey scale chart. The calibration potentiometers should also be adjusted to provide an optimal presentation of the scene details as shown on the monitor screen. The camera operator should then record the camera and grey scale chart positions, the dial settings on the camera lens and video monitor potentiometers, and the resolvable grey scale chart number for this location. Next, the camera operator should push the camera record button to record this calibration position.

The assistant should then move the grey scale chart to alternate positions nearer to or farther from the camera in such a way that the scene area of interest is spanned by the calibration positions. This is often facilitated by placing traffic cones at equally spaced calibration positions prior to starting the calibration sequence. Spacings of 7.6, 15.2, or 30.5m (25, 50, or 100 feet) have been found appropriate depending on illumination conditions within the accident scene area of interest. At each of the selected positions, repeat the calibration procedure. Figure 6 shows a view of grey scale chart calibration use during a daylight reenactment.

The calibration procedure is concluded by selecting optimum dial settings for the camera lens and video monitor potentiometer based on the results obtained during the calibration sequence at alternate positions. This selection is facilitated by reviewing the recorded calibration dial settings for the accident sequence under investigation. Record additional video footage for these settings.

At this point the camera system is ready for documenting the low light visibility conditions for the accident scene. The reconstructionist can now begin scene drive-throughs or walk-throughs consistent with case requirements.

## ADDITIONAL SYSTEM FEATURES

The new camera system features a wireless lapel microphone which enables the system to record sound along with either black-and-white or color video. This feature is convenient for audio recording of calibration data and other significant observations by the investigator during the accident scene inspection.

The new system also features proprietary electronic circuitry that maintains constant voltage input, regardless of battery level or power source voltage fluctuations to the cameras and the video monitor. This feature ensures consistent system performance throughout calibration, recording, and playback functions.

## ADDITIONAL FUNCTIONAL CONSIDERATIONS

The lens of the low light black-and-white video camera has an automatic iris function which responds to light in the accident scene similar to the actions of the human eye. The system's potentiometer calibration procedure, for instance, biases or adapts the automatic iris of the lens to a mid-range consistent with the average ambient luminance level for the accident scene area. Conceptually, this is similar to the luminance level adaptation of the human eye [4].

Additionally, the automatic iris, which increases and decreases about the calibrated mid-range, is analogous to the human eye iris in controlling the size of the opening in front of the lens and the amount of light entering the camera [4]. Glare from approaching vehicle headlamps produces an increase in the overall brightness of the video presentation and a reduction in feature resolution in the recorded image similar to the glare veiling luminance of the human eye [3].

These features combined with the lens response time and system recording speed have resulted in video recording presentations which are found to be consistent with observer experience for a variety of accident scene phenomena and accident reconstruction reenactments.

SYSTEM PERFORMANCE - The new system has been extremely useful for recording low light accident scenes in a manner consistent with viewer observations. Although there is no widely accepted test procedure for quantifying minimum video system illumination capabilities, the developers of the new system at Wendell Hull & Associates are working toward establishing procedures to allow quantifiable illumination comparisons to be made between different cameras. Once these procedures are developed, the capability of the camera can be more readily compared to the resolution capability of the human eye.

OTHER USES - The multiple attributes of the new video recording system make it readily adaptable to uses such as crime scene documentation and law enforcement surveillance. An additional use, the one which led to the system's development, is as foundational support data for computer-generated video animations of nighttime accident scenes.

## CONCLUSIONS

A new video recording system that recently became commercially available has been described which has the combined attributes of high and low illumination recording, alternate location mountings, full portability, and a means for calibration. These attributes make the system useful for a variety of accident reconstruction documentation tasks. Future plans include the development of test methods and analytical procedures for further characterizing performance criterion for this type of video recording equipment.

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Dr. Hull's firm currently offers a variety of engineering consulting services including forensic analysis, accident reconstruction, hazards analysis for oxygen equipment, fire and explosion analysis, equipment and materials testing and computer animation services.

*Safety Engineering and Risk Analysis 1996*, SERA-Vol. 6, American Society of Mechanical Engineers

# Psychophysical Validation of Photographic Representations

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## ABSTRACT

In order to represent how a scene would appear to a typical observer, a photographic print can be calibrated based on careful observation. A psychophysical validation procedure is described, involving the use of visual stimulus charts. The scientific rationale and basis for this procedure is reviewed, and additional applications are discussed.

## INTRODUCTION

In the course of investigating an accident or evaluating the safety of illumination at a given site, it is common to take photographs showing the scene from the position of an observer, such as the view of a pedestrian for an approaching driver under specific illumination conditions or the view of a darkened stairwell for a person descending. Photographs offer the promise of showing directly how visible various features are, so that decisions and evaluations can be made without trying to interpret the results of often complex analyses of luminance, glare, and visual factors. A central requirement for using a photographic print in this way is to have a means of validating the print, establishing that it faithfully represents some aspect of the visual experience that an observer would have at the actual scene.

Considerable research has been devoted to studying the role of visibility problems in accidents and to predicting the visibility of critical features, especially under marginal illumination (e.g., Adrian, 1987; Ayres et al., 1995; Olson, 1987; Schmidt-Clausen & Damasky, 1994). Analytical tools have been developed to predict visibility in scenes that cannot be recreated (e.g., Adrian, 1989; Burgett & Villalba, 1985; Phillips et al., 1990) or to evaluate candidate headlight systems (e.g., Burgett et al., 1989; Farber, 1988; Farber & Matle, 1989; Olson et al., 1990; Owens et al., 1989; Hans-Joachim & Schmidt-Clausen, 1982).

Very little attention, however, has been paid to accurate representation of low-visibility conditions in photographic prints. Most books on photography or on accident reconstruction do not discuss the problems of portraying night visibility conditions when photography is discussed (e.g., Brown & Obenski, 1989), or else note that a low-light photograph can be exposed and printed to yield an arbitrarily dark or light print (e.g., Duckworth, 1983).

The key is to base evaluation of the print on observations made at the scene. Baker & Fricke (1986) briefly describe a procedure in which a test target or pattern, such as grey numbers on a black background, are slowly moved from a dark area to a lighted area to find the point at which the numbers are just barely readable at the observer's position; then the viewing conditions for the picture are to be adjusted so that the numbers are just barely readable. This is the essence of a psychophysical or subjective validation procedure. If a print containing such a test pattern can be validated, then a print of a photograph that is identical in all respects (e.g., circumstances, lighting, camera settings, developing and exposure settings) but with the test pattern removed can be presented as a validated representation of scene appearance.

This approach was further developed and tested by Holohan et al. (1989), using grey alphanumeric characters of varying reflectances on a black background. An observer notes the visibility threshold, or the darkest character that can be accurately recognized when placed in the scene of interest and viewed from the viewing position of interest under specified lighting conditions. Then a photograph is taken, and prints are made at a series of densities (or print exposures). The observer selects a print density that yields the same visibility threshold, or in which the same character is just barely visible as was the case at the scene. Tests with a series of observers established that this method produces a photographic print that, to a reasonable approximation, portrays the appearance of the scene with respect to visibility of objects.

An important feature of this approach is its conceptual simplicity. Given the complexity of photography - characteristics of cameras and lenses and films, the chemistry of the developing process, the nonlinearities of printing - it is very difficult to place confidence in the visibility represented by a photographic print based solely on good photographic technique. Instead, if the visibility of some aspect of a print reproduces the visibility recorded at the scene, then the details of the photographic process do not need to be considered.

The work described by Holohan et al. (1989) was largely atheoretical, with no justification offered for the grey characters used. Similarly, a recent extension to calibrating night video recordings (Hull et al., 1996) does not deal with the rationale for designing stimuli. In the next section of this paper, relevant literature on human vision and visual performance testing will be reviewed. This provides a basis for development of visual stimulus charts, as described in the third section of the paper. The final section describes uses for these charts.

## VISUAL TESTING

Detection of a visual stimulus can depend on a multitude of factors related to the static and dynamic aspects of the stimulus and background, the characteristics and condition of the observer, and the lighting. For many practical matters, such as the detectability of an object in the roadway or the adequacy of corrective lenses, many factors can be held constant as a first step. It is typical to begin by determining the detectability of a static stimulus as a function of its luminance contrast by a static alert observer fixating on the stimulus location.

The most common visual tests are those designed to assess visual acuity, or the ability to resolve fine detail. These tests, used routinely in clinical optometry, determine the smallest stimulus that can be detected (or recognized and identified), or the smallest separation of points or lines that can be resolved, generally using well-illuminated high-contrast stimuli such as black lines or letters on a white background (Davidson, 1991) or bright lines on a dark background (e.g., Ayres, 1995). Despite their usefulness for studying refractive errors, and their face validity for predicting ability to read high-contrast sign lettering at a distance, acuity tests actually address only a very limited aspect of normal vision, specifically discrimination of fine detail (Boyce, 1981).

Research over the last 30 years has shown that visual processing can be characterized as performing a spatial frequency analysis, based on the output of filters tuned to a series of different spatial frequencies; that is, any visual scene is analyzed into contrast changes at various spacings across the visual field, from widely-spaced or low-frequency changes to finely-spaced or high-frequency changes (Campbell & Robson, 1968; Wilson, 1991). Spatial frequency is measured in cycles per degree (c/d) of visual angle. Evidence for this conception of visual processing comes from electrophysiological studies of neuronal response at various locations in the visual system, as well as from a variety of behavioral studies and subjective phenomena (Ginsburg, 1986; Laming, 1991a, b; Olzak & Thomas, 1986).

Consequently, in order to assess ability to detect and discriminate visual information, visual capability must be tested at a series of spatial frequencies, typically using sinusoidally-modulated luminance gratings (luminance varies across a spatial dimension, appearing as alternating light and dark bars with gradual transitions). The *spatial modulation transfer function* (or the *spatial contrast sensitivity function*) is determined by measuring the minimum contrast that a person can just barely detect at each of a succession of spatial frequencies. Forced-choice testing, in which the observer must select one of several possible affirmative responses (where or when or what the stimulus is, rather than whether or not the stimulus is detectable) is ideal for avoiding problems related to variability in the observer's criterion or bias (Higgins et al., 1984); the method of increasing contrast (raising the contrast until it is just barely detectable), however, has been found to provide reasonably stable and useful results (Ginsburg et al., 1983; Ginsburg & Evans, 1984). Spatial contrast sensitivity testing is being used increasingly in clinical research and practice (Nadler et al., 1990; Patorgis, 1991). The contrast threshold for high-frequency gratings provides roughly the same information as a visual acuity test (which can be interpreted as the highest spatial frequency or smallest spacing at which a high-contrast stimulus can be discriminated).

Spatial contrast sensitivity measurements have been shown to predict real-world visual task performance better than traditional acuity testing, including field target detection by pilots, age differences in highway sign discrimination (Ginsburg, 1987), speed of detecting a target against a complex natural background (Shinar & Gilead, 1987), and identification of faces and common objects (Owsley & Sloane, 1987). The ability of a driver to safely operate a vehicle and avoid obstacles and pedestrians, for example, at times requires identification of large objects and areas, often under conditions of low illumination and contrast. High spatial frequency or visual acuity testing is more suited to predicting legibility of high-contrast signs at a great distance.

Based on considerable research, it appears that central vision is served by a set of pathways tuned to different spatial frequencies for a given orientation, with at least six different spatial frequency pathways needed to encompass the range of human spatial frequency sensitivity (Olzak & Thomas, 1986; Wolfe, 1990). The Vistech test charts designed by Ginsburg and his colleagues originally presented six spatial frequencies (1, 2, 4, 8, 16, and 24 c/d) at 8 contrast levels, but later versions use only five frequencies (1.5, 3, 6, 12, and 18 c/d). Even five spatial frequencies, however, may be more than are needed for most practical purposes.

A typical spatial contrast sensitivity function is an inverted-U, with a single peak (greatest sensitivity) at a spatial frequency somewhere between about 2 and 10 c/d (depending on mean luminance, temporal characteristics of the stimulus, and other factors). Ginsburg et al. (1983) found that pilots' identification of approaching aircraft was best predicted by contrast sensitivity at 8 c/d and above. Owsley and Sloane (1987) found that results at 6 c/d were the best predictors for detection and identification of objects, signs, and faces (except for face detection, with best prediction at 0.5 and 3 c/d). Regan (1991) and Pelli et al. (1988) suggest that, for clinical diagnostic purposes, only two frequencies need to be tested: a mid-range frequency to determine contrast sensitivity at or near its peak (for which they provide series of letters at different grey-on-white contrasts), and a high frequency (which can be measured with a standard acuity chart).

The stimulus of choice for research is a sinusoidal luminance grating, in order to isolate the response of the visual system to a single frequency and a single mean luminance level. At frequencies near and above the peak-sensitivity frequency, however, a square-wave grating (simple alternating dark and light bars, with no gradual transitions) yields the same pattern of results (after appropriate correction; Lamson, 1991b). Results for sinusoidal and square-wave stimuli diverge only at very low spatial frequencies, well below 1 c/d, for which some of the upper harmonics of a square wave fall into a spatial frequency region of high contrast sensitivity; the spectrum of a square wave consists of the odd-numbered harmonics in geometrically decreasing power. Given this observation, and given that mid-range and high spatial frequencies are apparently most suitable for predicting task performance, it follows that a simple but useful test procedure might assess contrast sensitivity with square-wave stimuli at a mid-range spatial frequency (3-8 c/d) and a high spatial frequency (20 c/d or above).

## TEST CHARTS

The design of a suitable visual test chart for use in photographic validation is constrained in several potentially conflicting ways.

- A single chart should be used (if possible), rather than a series of charts for different frequencies or other characteristics, so that only one print needs to be validated.
- The chart should be small enough that it does not occupy a large portion of the camera field, obscuring areas of interest and also making it more difficult to achieve reasonably uniform illumination across the chart.
- A wide range of contrast levels should be used to avoid having all of the stimuli be too easy or too hard to detect under the scene lighting conditions.
- Contrast needs to vary in small steps so the chart will be sensitive to changes in viewing conditions.
- The chart should present appropriate spatial frequencies when viewed at the distance of interest.
- Testing should be quick in order to complete observations and photography during changing illumination conditions.

There may be no single best solution to these multiple constraints, and in any case it is necessary to have different charts available depending on the conditions to be studied. For example, a 2 x 2.5 inch chart has been used to examine visual conditions at an indoor stairway, whereas 30 x 40 inch charts have been used in connection with several motor vehicle accident investigations. It is feasible to present a large number of spatial frequencies and contrast levels on a single chart, varying the two dimensions continuously -- e.g., using a multi-panel chart measuring nearly 7 x 8 feet, erected on a portable framework -- but restriction to a smaller set of frequencies allows the use of smaller charts.

Figure 1 shows a full-size reproduction of a 2.5 inch chart using simple square-wave stimuli of two spatial frequencies and six contrast levels. The mean reflectance of each stimulus is approximately equal to the reflectance of the background grey area. From a viewing distance of 100 inches, the larger circles correspond to a spatial frequency of approximately 2.5 c/d and the smaller circles to approximately 10 c/d. Contrast (calculated as $(L_{max}-L_{min})/(L_{max}+L_{min})$) varies in the original chart from 0.9 down to 0.1. As in the visual test charts used by Ginsburg, the circles are presented at three different possible orientations, so that the observer's task is to choose the lowest contrast circle at each frequency that just barely allows identification of orientation.

The basic stimulus used in this test chart - one light bar and portions of two flanking dark bars - is not a true square wave grating. Fourier analysis of the stimulus reveals a spectrum with frequency components that do not follow a simple harmonic series. Nevertheless, the strongest frequency component is the fundamental, corresponding to the reciprocal of the wavelength (in this case, twice the width of the lighter bar). Therefore this chart can be used to assess contrast sensitivity for the two spatial frequencies indicated.

Figure 2 shows a chart in which the circular stimulus areas have been replaced by rectangles in order to increase the portion of the total area used by the square-wave stimuli, while incorporating eight contrast levels for each spatial frequency. Viewed from 100 inches, a 2.5 inch chart of this design would yield stimuli corresponding to approximately 1.9 and 7.6 c/d (for the main spatial frequency

Figure 1. Visual test chart designed to present six contrast levels at each of two spatial frequencies.

components of the larger and smaller rectangles, respectively). Such economy of space is not critical for a small chart to be used at short viewing distances, but may facilitate investigations involving viewing at hundreds of feet away.

Maintaining constant mean reflectance across the chart, as in the Ginsburg test charts and those shown here, has the advantage of measuring contrast sensitivity at a single frequency and mean luminance under the given viewing conditions. Grey-on-white charts, such as the letter charts developed for clinical testing by Regan (1991) and Pelli et al. (1988), as well as grey-on-black charts, such as those developed by Holohan et al. (1989), necessarily confound contrast and luminance. For photographic validation, such confounding is not an important issue, and may increase the sensitivity of the validation procedure, although it complicates the discussion of visibility under the conditions studied.

The usage of one of these charts for validating a photographic print is straightforward:

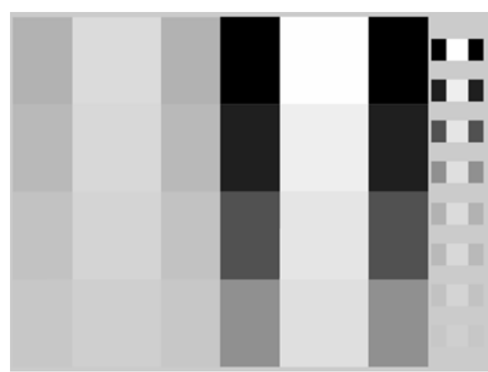

Figure 2. Visual test chart designed to present eight contrast levels at each of two spatial frequencies.

1. The visual conditions of interest are recreated (e.g., lighting, time of day, position of observer); the chart is placed in the scene at the position of interest.
2. The observer records contrast sensitivity thresholds based on observation of the chart.
3. A photograph is taken of the scene with the chart. (In practice, a variety of exposure settings is used to bracket the presumably best exposure and ensure a negative with adequate contrast resolution.)

4. A photograph is taken with identical camera settings after the chart is removed.
5. The negative of the scene with the chart is printed at a series of closely-spaced densities.
6. The observer selects the print that yields the same minimum detectable contrast level for the chart (when the print is viewed at a distance that recreates the visual angle that the chart subtended at the scene).
7. An identical print is made of the negative of the scene without the chart.

Several caveats need to be kept in mind when presenting such a validated print. First, the illumination of the print when shown to others needs to approximate the illumination under which the print was selected (although contrast sensitivity is not highly sensitive to small changes in overall illumination). Second, a scene feature that is visible or detectable when attended to, whether in a print or at the scene itself, is not necessarily salient, especially if not looked at directly with central (foveal) vision. Third, the validation print represents what the investigating observer could see; any important differences between that person's vision and the vision of other viewers of interest (e.g., a driver involved in an accident, or the observers who will view the print) need to be considered.

As a final caveat, it is essential to note that a validated print does not necessarily show the scene as it appeared to the investigating observer. The validation procedure is tied to accurately representing featural detectability, since it is based on psychophysical contrast thresholds. In principle, it should be possible to use other psychophysical procedures to document the subjective magnitude of detectable aspects of the scene, such as the apparent brightness of objects or the apparent contrast between adjacent features (see, e.g., Biondini & de Mattiello, 1985; Ginsburg & Cannon, 1980; Quinn, 1985); the observer would then attempt to generate a photographic print with the same subjective characteristics. Such an extension is beyond the scope of the present work.

## ADDITIONAL APPLICATIONS

In addition to its role in photographic print validation, a visual test chart can facilitate scene investigation in several other ways. One important application is for quantifying the perceptual conditions. For example, under ideal laboratory conditions, contrasts as low as 0.2% can be detected by an observer with good vision who attends to a stimulus (Laming, 1991a). Under field illumination conditions, however, observation of a visual test chart will yield minimum detectable contrasts that are many times higher. Thus, testing an observer's vision at a scene can avoid the error of trying to apply ideal laboratory data to scene conditions.

This approach can be extended to permit valid conclusions about the detectability of specific contrasts at the scene. A photographic negative or print depicting the scene with a visual test chart can be scanned (digitized). Scene features then can be quantitatively matched to regions of the chart with similar luminance, using appropriate software. For reasonably large targets (i.e., where target width corresponds to a spatial frequency near or below that of peak contrast sensitivity), contrast detectability for portions of the test chart can be extrapolated to contrast detectability for the corresponding scene features, such as a target against its background. In order to make use of such matching, it is necessary to assume two things about the photographic process: that the process yields reasonably uniform response across the central area of the image, and that any chromatic differences between scene features and the test chart do not jeopardize the luminance matches. Furthermore, the photograph should have adequate resolution of contrasts (e.g., in a highly over- or under-exposed print, it would not be possible to tell the difference between successive luminance levels in the chart).

A further logical extension allows determination of luminance estimates for scene features. If luminance measures are made at the scene of various areas in the visual test chart, then the luminance readings can be applied to scene features by matching with the chart: a scene feature such as an object in the roadway would have yielded approximately the same luminance reading as a region of the chart that matches the measured brightness (or photographic density) of that feature in the photograph.

Finally, a visual test chart captured in a photograph can be used in the same way as a standard photographic chart grey scale or color chart. During printing, the density and color mix can be adjusted to achieve a reasonable apparent match of the photographic print to the chart. This can be difficult if the chart occupies only a very small area of the print, as would be appropriate for the psychophysical validation work described here, but may be used as a first approximation to a representative print, prior to printing multiple densities and using chart observations to select the best version.

## ACKNOWLEDGEMENTS

Erich Phillips played an important role in this work, especially in the development of sinusoidal luminance grating charts. John Meyer performed the FFT analysis and provided valuable comments on a draft of this paper. The Visual Communication Group at Failure Analysis Associates provides invaluable technical support and expertise for designing test charts as well as processing and printing photographic images.

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# Faithful presentation of luminance contrast: Evaluation of photographic and computational display methods

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## ABSTRACT

Representations necessarily lose some of the visual information available in corresponding real-world scenes. This paper will discuss evaluations of the extent to which luminance contrast and visibility is preserved with three different methods for representing real-world scenes. Method one involves using psychophysical data from contrast charts to select the best print from among a density-varied series of photographic prints. The second and third methods involve extending the dynamic range of the representation by using High Dynamic Range Image (HDRI) techniques. HDRI's can be created by combining multiple overlapping exposures of a scene, or via computer simulation. In method two, algorithms are used to compress the luminance information in the HDRI into the luminance range available in the display, while preserving visible contrast as much as possible. The third method uses a wide-field, high-dynamic-range viewer to present an image with a much wider dynamic range than is available in a photographic print or a CRT display. Each method represents an improvement over simple photographic representation. In conjunction with appropriate instructions on how to interpret the images and the extent to which the images can be regarded as faithful, methods such as these can support practical decisions in visual design and reconstruction.
**Keywords:** High Dynamic Range, Luminance Contrast, HDRI, Visibility, Tone Mapping, Radiance, Display Methods

## 1. INRODUCTION

Compared to the human visual system, the technology commonly used for capturing and displaying visual information is rudimentary and limited. In the natural world, we can make use of scene information on barely moonlit nights as well as on bright sunny days, with illumination (and reflected luminance) varying by over $10^6$; at any given moment, luminance can vary by over $10^4$ between scene features and still allow effective visual processing. Most camera lenses, films, and digital image processors are unable to capture information accurately over such a wide luminance range, and most display methods (e.g., photographic prints, projected images, and CRT displays) provide luminance ranges that are much smaller than natural scenes.

Generally, the limited luminance range for image capture and display is not a serious problem, as long as some care is taken. Photographs provide apparently satisfying depictions of sights and faces, and movies show apparently realistic night as well as daytime scenes, whether viewed as projections in theaters or on home television screens. Such apparent realism, however, is illusory, based on perceptual mechanisms such as brightness and color constancies that let the very limited luminance ranges presented stand in for the actual conditions they are meant to depict. Faithful representation of luminance contrast is more crucial than presentation of absolute luminance levels.

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For certain applications, however, the limitations of typical capture and display technologies can be problematic. Judgments about the acceptability of a lighting scheme may be influenced by absolute as well as relative luminances; e.g., a proposed set of luminaires may appear reasonable in a computerized rendering but turn out to be too bright or leave shadows that are too harsh when constructed in reality. Decisions about the visibility of scene features can also depend heavily on absolute luminance levels, since human contrast sensitivity varies with luminance. Therefore, numerous efforts have been made to increase the fidelity of image displays and to assess the perceptual similarity between displays and actual scenes.

The rise in the use of digital processing has created a new demand for dealing with the luminance-range problem. For example, a series of exposures of a single scene can be combined into a single high dynamic range image (HDRI), covering a wider luminance range than can readily be displayed in common technology (e.g., Debevec & Malik, 1997). Similarly, HDRI's can be produced by software simulations of real or hypothetical scenes (e.g., Ward Larson & Shakespeare, 1997).

There are two principal strategies for dealing with the limited luminance range of available displays. One approach is to compress the luminance range of the original captured or computed image information so that it fits within the display range. The other approach is to develop display technology for wider luminance ranges. With either approach, it is essential to assess the perceptual fidelity of the displayed scene according to reasonable criteria such as visibility or discriminability of key features or affective reactions to the scene, with the criteria defined and tied to the purpose for which displayed image is intended.

This paper describes work on three related projects to improve and assess the perceptual fidelity of displays. The first involves utilizing the luminance range compression afforded by standard photographic film, combined with psychophysical technique for selecting a photographic representation that conveys luminance contrast over a range of interest. The second involves the use of algorithms to compress a wider range of digitally-captured luminance data into a range that can be displayed, while attempting to preserve luminance contrast. The third project involves development of a high dynamic range viewer so that the luminance range of a digitally-captured or computer-rendered image will not need to be reduced as much as with standard displays.

## 2. PSYCHOPHYSICAL VALIDATION OF PHOTOGRAPHIC REPRESENTATIONS

Any photographic negative film is useful over only a limited exposure or luminance range, the film is completely washed out (black area in negative) if the exposure is too high, and completely unaffected (clear area in negative) if the exposure is too low. Between the extremes, the response of the film is non-linear, with greater compression at high and low exposures than over the mid range. Photographers often attempt to limit the luminance range of the scene to be photographed (e.g., by selection of lighting, or by filters) so that much of the scene luminance will fall within a range that can be captured by the film.

In order to produce a photographic representation (e.g., a print or projected slide) that accurately portrays some aspect of the original scene, a technique is needed to establish relevant perceptual correspondence between the scene and the representation. Building on prior work with test patterns (e.g., Baker & Fricke, 1986; Holohan et al., 1989; Hull et al., 1996) as well as research on visual perception (e.g., Campbell & Robson, 1968; Ginsburg, 1986), Ayres (1996) described a method using a contrast sensitivity test chart. The test chart, placed in the scene to be photographed, allows an observer to estimate her contrast sensitivity threshold for stimuli near the peak of the human spatial contrast sensitivity function (2-10 cycles/degree) and a higher spatial frequency. Such a test chart is shown in Figure 1. Later, the observer selects a photographic representation (e.g., from a series of prints varying in density) which yields the same contrast sensitivity thresholds when viewed at an appropriate distance and under specified lighting conditions (i.e., she can see the chart just as well in the representation as she could at the scene).

This psychophysical validation procedure is limited by the characteristics of the photographic process. There is no assurance that luminance contrast will be preserved for luminances substantially greater or less than those presented by the test chart. The procedure provides an objective means for matching certain perceptual aspects of a scene to those of a representation, as long as the luminance range limitation is considered.

Figure 1. Contrast chart developed by Ayres (1996) and used for matching visibility in conventional photographs.

### 3. ALGORITHMIC LUMINANCE RANGE COMPRESSION

Recent years have seen a great deal of interest in improving computer graphics displays. A variety of tone-mapping operators have been proposed and developed to optimize the translation of information from HDRI's to available displays. Algorithms based on knowledge of the human visual system help preserve local luminance contrast and thereby improve the perceptual fidelity of the display despite the overall loss of information caused by range compression. McNamara et al (2000) demonstrated the value of tone-mapping with subject experiments that built on the first serious development of tone-mapping for computer graphics by Tumblin and Rushmeier (1993). Another early tone operator that attempted to match display visibility to visibility in real scenes was the contrast-based scalefactor of Ward (1994), which applied a simple correspondence formula based on the visual sensitivity studies of Blackwell (CIE 1981). This idea was extended and combined with simple models of time adaptation and color sensitivity in the operator of Ferwerda et al of Cornell University (Ferwerda 1996). The Cornell model was further developed into a complete (though static) model of human visual response, including color, contrast, and spatial frequency response in medium to high dynamic range scenes (Pattanaik et al 1998).

The algorithm developed by Ward Larson et al. (1997) is simpler than the Cornell model and accounts for aspects of vision such as the effects of glare and changes in color and contrast sensitivity and acuity in high dynamic range scenes. In a recent evaluation (Ledda et al., 2003), 40 subjects viewed a modified version of the Ayres (1996) test chart (with the small targets 50% as large as the larger targets); they also viewed a photographic representation of the scene on a CRT display (from an HDRI based on the Ward Larson et al. algorithm). It was found that contrast sensitivity for larger targets (1 cycle/degree) was nearly as good with the CRT display as with the actual charts; however, if human visual effects such as glare were not included in the tone-mapping algorithm, the CRT-displayed representations were too good (i.e., too many low-contrast targets could be seen). Similar results were obtained in a study reported by Ward (2002). Thus, the use of the tone-mapping algorithm with human vision factors incorporated led to CRT representations with moderately reduced perceptual fidelity regarding luminance contrast. Further work is needed to ensure luminance contrast closer to the real scene, especially for smaller targets (i.e., higher spatial frequency information).

## 4. HIGH DYNAMIC RANGE VIEWER

Photographic prints, project images, and CRT displays offer only limited luminance ranges, necessitating the use of significant compression in order to accommodate DRI's. High dynamic range displays, on the other hand, permit greater preservation of luminance contrast. Ward (2002) describes a prototype stereographic viewer using a bright, uniform backlight and LEEP ARV-1 optics to yield a $10^4$ luminance range with two layered transparencies. This HDR viewer presents a maximum luminance of 10,000 cd/m$^2$ with a viewing field that is 120° side-to-side. This viewer is shown in Figure 2. Transparencies may be generated using computer graphics lighting simulation and rendering techniques, or HDRI photography.

Ledda et al. (2003) found that contrast visibility for an HDRI of a scene containing a test chart was closer to real-scene viewing performance using this high dynamic range viewer relative to a CRT display. In fact, their study determined that there was no statistical difference between the contrast chart's visibility on the HDR viewer versus the real scene. Because the scene contained bright sources directed at the subjects, adjacent to a dimly lit chart, disability glare had a significant effect on real scene visibility. Their test scene is shown in Figure 3. Their experiment seemed to demonstrate that the HDR display method has sufficient range and fidelity to reproduce this important effect in a representation. In subjective evaluations, the participants reported that the scene displayed in the viewer was much closer than the CRT to the appearance of the real scene.

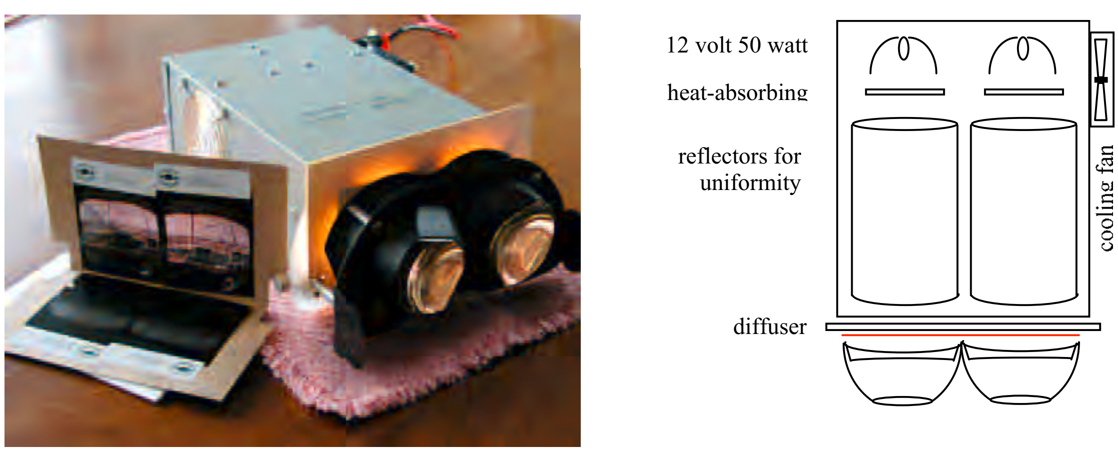


Figure 2. A high dynamic-range stereoscopic viewer using two transparency layers to achieve minimum to maximum luminance of 1 to 10,000 cd/m$^2$.

Figure 3. The test scene used by Ledda et al (2003) to validate the high dynamic range viewer.

## 5. CONCLUSIONS

Every representation or display of a visual scene involves some degree of compromise, since it is not yet possible to recreate the full range of spectral, spatial, and luminous detail that is encountered by the human visual system in normal experience of scenes. Practical decisions based on visual displays can benefit from improved displays as well as from understanding the limitations of displays. A photographic print that has been selected to match certain perceptual characteristics of the corresponding scene (e.g., luminance contrast sensitivity at several spatial frequencies, as described in this paper) can support reasonable judgments about the original scene as long as restrictions such as those related to luminance range and static representations are made clear. Tone-mapping algorithms can provide a means for compressing a wider luminance range of an HDRI into the limited range available with a print or a CRT screen, with fairly good preservation of local luminance contrast, although some display formats (e.g. CRTs) cannot reproduce high spatial frequency information faithfully. The recent development of a stereoscopic high dynamic range viewer permits a closer approximation to normal visual experience for static scenes, as is borne out by test results and subjective evaluations to date.

Each of these method represents an improvement over simple (unvalidated) photographic representation. Given an understanding of the limitations of each approach, methods such as these can support practical decisions in visual design and reconstruction.

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# Nighttime Photography — Show It Like It Is

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ABSTRACT

A technique is presented to produce a photograph that accurately illustrates the limits of perception for an observer's view of objects under night lighting. This may be used to show others the results of an investigation of visibility problems associated with a nighttime collision. The method, which involves the observer viewing signs of varying shades of grey at the site under appropriate conditions, and the production of a range of photographic prints from which the correct density level is selected, is described. Findings from validation testing are discussed including the expected accuracy and possible difficulties.

PHOTOGRAPHY OF A COLLISION SITE is a frequently-used and widely-accepted means of illustrating circumstances observed by a person investigating or reconstructing a collision. Few persons have difficulty recognizing features that may appear in a daytime photograph, such as trees and signs that may obstruct a driver's vision, and it is relatively easy for even an amateur photographer to produce a colour photograph acceptable at face value as representing the appearance of the scene.

It is far more difficult to illustrate what a driver or other observer may have seen during darkness or under conditions of low illumination, since there is no straightforward procedure for exposing and printing film, that will produce a print that accurately represents the observer's view, Even in low lighting such as that commonly provided by a vehicle's headlamps, it is not difficult to produce a photograph that shows the scene well into the distance almost as clearly as by daylight; and another print could be produced showing inky blackness.

An obvious method that has been used involves suitable photographs being taken at the scene and printed at a variety of densities. An observer then returns to the scene under identical conditions and selects that photograph corresponding most closely to its appearance. This can be cumbersome (requiring two site attendances under correct conditions), and is subject to substantial difficulties in comparing the poorly-lit scene with the photographs, which must be viewed at a higher level of illumination. The process is limited by the required dark adaptation of the human eye. A further disadvantage, from an engineering point of view, is that it relies upon the observer's judgement with no standard by which its accuracy can be judged. This is a particular problem in the case of a potentially biased observer or an observer not familiar with procedures of this nature.

Previous efforts involved placing a series of signs comprising black numerals on a white background, at set intervals from the foreground to the background past the items of interest. The limit of visibility was taken to be the most remote sign for which the number could be recognized. This, or a quite similar, method has been used or advocated by others (1,2)*.

Placing signs between the foreground and the background can be helpful in establishing a representative photograph in some circumstances, but often presents three major disadvantages. The procedure is not: feasible in locations where the signs cannot be positioned in a clear line of sight suitably ahead of, or beyond, the objects of interest. In situations involving artificial lighting, the sign at the limit of visibility may be under significantly different illumination than the objects of interest, which may result in a disproportionate relative prominence in the reproduction. The procedure does not readily accommodate a means to minimize possible bias on the part of the observer.

* Numbers in parentheses designate references at end of paper.

In view of these difficulties, a systematic method was developed through a number of iterations to allow the production of a photograph that, subject to limitations discussed below, can be demonstrably equivalent to the view of a particular observer in night visibility. During its development, characteristics and limitations of the method have been examined.

VISION AND PHOTOGRAPHY

A person with an interest in recording an observer's nightime view is usually concerned with the limits of perception, in investigating conditions under which an object, such as a pedestrian, a parked automobile or a road obstruction, may just be visible. This involves consideration of the effect of illumination, background contrast, object size and other factors. The work reported here is directed only to the problem of providing suitable illustrative photographs, after determination of the visibility conditions.

A search of the literature identified little other work that specifically addressed techniques to produce photographs corresponding to an observer's nighttime perception. The subject involves several inter-related areas of specialization, including the physiology of the eye, psychological aspects of perception, low-illumination sensing, and photography.

The human eye/brain sensory and perceptual systems are complex, but extensively studied (e.g. 3,4). It is well known that the eye has two types of sensors, called rods and cones, The cones are particularly dense around the fovea, at the back of the retina, and, under "daytime" light levels in excess of about one millilambert, they provide what is known as photopic vision with high-resolution colour detai. At lower light levels the cones become progressively less effective; the contribution by the rods becomes relatively greater; and resolution decreases. Scotopic or night vision is pure rod vision below about 0.0 1 millilambert down to the lowest threshold of vision. Night driving encompasses a wide range of luminance levels, largely within the intermediate range known as mesopic vision (5).

While cones are sensitive to colour, rods are not; further, rods and cones have differing overall spectral sensitivities whereby the maximum sensivity of the rods is at a lower wavelength than that of the cones. Colour is not solely a property of objects, but results from an interaction between radiant energy and the visual system. The psychophysical relationships are complex (6), and there apparently is not an established method for predicting the relative contrast of items of differing illumination, reflectance, and spectral content in the mesopic range of vision.

Vision is the primary sense required for driving, and has been examined in this respect by many researchers (e.g. 5,7). Visual aspects of night driving have attracted particular attention due to the increased hazards (8,9). There have been many experimental studies of the limits of night driving vision (10, 1 1) and empirical-theoretical investigations have attempted to predict visibility from motor vehicles at night (12,13), that together illustrate many of the difficulties and uncertainties inherent to this subject.

What a driver may see is also affected by the night adaptation of his eyes, whereby their sensitivity increases asymptotically over a period of many minutes, but then decreases very rapidly on exposure to bright light (3). The eye's sensitivity is determined by adaptation to an overall level of illumination; since the driver's visual field includes areas of widely varying luminance that change dynamically as the vehicle proceeds along the road, contrast sensitivity also varies over time.

Most efforts at the presentation and recording of night images have concentrated on obtaining the brightest, clearest or in some sense "best" image, whether for surveillance (14), commercial photography (15) or art photography (16), with very little consideration of its correspondence to an observer's perceptions of the scene.

It is difficult in the extreme to produce a photograph from the driver's seat that accurately illustrates both the well-lit foreground and the almost-unlit areas of the field of view. A photographic print cannot provide the same range of luminance as the eye can accommodate. The problem is accentuated by point light sources such as background streetlights, or the headlight glare of a facing vehicle.

Light entering a camera is converted into a colour print image by chemically altering three layers on the film, and then on the paper, of differing spectral sensitivity. This is analogous, but not identical, to the process involving three types of colour-sensitive cones recognized in the eye. Colour distortion in a night photograph, relative to the perceived scene, also may be anticipated: the colour sensitivity in film does not diminish at low light levels in the manner that it does in vision; the film cannot easily be balanced for the ambient lighting characteristics; and the different colour emulsions will be affected to differing extents by use of the film beyond its linear response range. Established photographic calibration methods (17,18) cannot be used because an observer's perceptions at night differ from those in the good lighting conditions under which the print is to be assessed.

This brief discussion of the wide-ranging, although far from comprehensive, literature review indicates that no photograph can purport to be a totally accurate replica of an observer's perception under night conditions. However, the extensive use of charts, such as the Snellen eye test chart, and photographic resolution test: targets (19) indicate that the use of a suitably designed target in the field of view can be used to produce a faithful representation of that target, and it may be hypothesized that the object of interest will then appear in the image as an acceptable representation of the observer's perception.

## PRODUCING A PHOTOGRAPHIC REPLICA

A series of signs is used in the part of the scene of interest to establish the threshold of visibility of the "observer", the person viewing the scene for this purpose, under pertinent lighting conditions. The signs have a black background and ten different symbols each having a distinct reflectance. A photograph of the area, including the chosen signs, is printed at a variety of densities. The print in which the signs signifying the limit of visibility are barely recognizable, corresponds best to the actual overall view of the scene.

THE METHOD -- The use of symbols of varying reflectance on a matte black background allows the signs to be positioned at the objects of interest and thus, to have the same illumination. Differing symbols randomly displayed permits any potential for observer bias to be minimized.

Ten reflectance levels for the symbols were established at nearly equal density intervals between white and almost black, with reference to a Kodak grey scale and by a little experimentation adding black paint to a white base. At given ambient illumination, the symbol luminance depends on its reflectance. As reflectance is reduced (corresponding to increasingly dark tones of grey) the symbol is progressively more difficult to see until, at a certain contrast relative to the background, the eye can no longer distinguish it sufficiently well to identify it. Under the pertinent lighting conditions, this grey tone defines the threshold contrast. Each grey tone is taken to have a "contrast number" having an integer value between 1 and 10 from lightest to darkest. Findings obtained in using signs from two different sets in pairs, indicate that a finer division of the grey scale would not produce a better photograph.

Five alphanumeric characters and their reverse images, having apparent similar complexity involving six or five bars in the seven-bar rectangular format, were selected as the set of symbols (Figure 1). Two of the reverse images are identifiable as other characters. The symbol set is comparable with characters used by others as targets for resolution tests (19). Dissimilar recognizability of the symbols has not been a significant factor in findings obtained using the signs. After very little practise, observers were able to recognize the reverse symbols as readily as the more common characters.

The symbols have a stroke width of 90 millimetres, a height of 540 millimetres and a width of 360 millimetres, and are on a 600 by 400 millimetre background. The height and width were selected relative to the stroke width, with

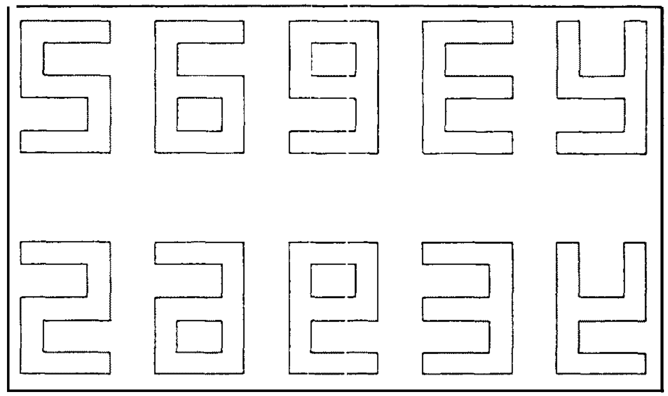

Figure 1: The set of symbols

consideration of aesthetically preferable proportions. The stroke width was chosen with consideration of the normal visual acuity of one minute taken for well-lit, high-contrast Snellen-type eye charts. An equivalent viewing distance of 300 metres in moderate illumination was assumed. The reduction in resolution in night scenes estimated from findings by others (5,20) has been proven to have been accurate, in that the signs have been found to be useful for observations at distances of more than 100 metres to as close as 30 metres from the objects of interest.

The signs were made from three millimetre thick fibreboard. They are coded for the contrast number along the grey scale, the symbol identification and the sign set. They are stored in sequence, in a case that includes a slot at the front for display of the selected unit. The case also includes a pair of half-width, hinged doors on the front for control of the display time. use of the signs under the same conditions, except with viewing periods of roughly one half second and ten seconds, revealed very little difference in the ability of an observer to recognize the symbols.

The signs can be employed in a simple fashion by displaying a number of them together or in sequence, for the observer to select the one which signifies the limit of visibility. This might be useful for a careful, independent observer but the substantial potential of a biased result is obvious. A major benefit is realized by display of the signs, one at a time in no recognizable sequence, for attempted identification by an observer who was involved in a specific incident under investigation. In this situation, two sign sets are used, each including the ten symbols (Figure 2) in no particular sequence with regard to the contrast numbers but not having any symbol at the same contrast number as that of the same symbol in the other set. The use of signs displayed randomly from two sets minimizes the possibility of the observer being influenced by

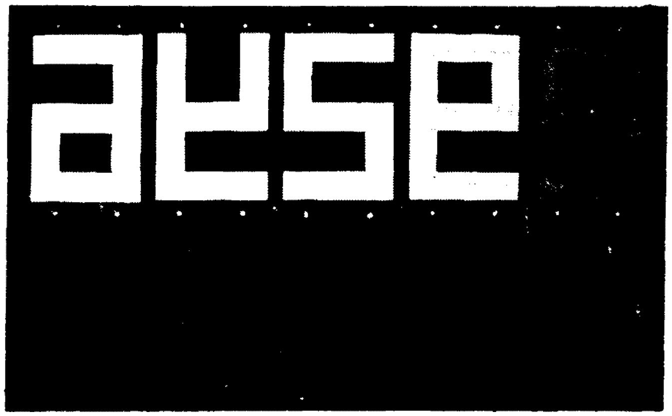

Figure 2: One set of signs

an expectation from an easily-remembered sequence.

The display cases are positioned at the appropriate elevation as close as is practical to the objects of interest. A sign is selected from either set, not necessarily alternately, and is placed in either case in an irregular sequence while the view of the observer is masked. The sign is exposed to the observer for the appropriate period. The determination by the observer and an assessment of certainty are recorded in a tabular listing and a graphical format by which the trend of the sequential observations is apparent. The process is repeated until the results define the signs, one from each set, that signify the threshold of visibility for the observer. A prepared form is helpful for this purpose (e.g. Figure 3).

For the first phase of the method, any controllable artificial lighting is adjusted to the correct location, intensity and direction; and the observer is positioned in the relevant setting until the end of a period for eye adaptation to the low-level illumination. The objects of interest do not have to be present. It may be desirable to have them absent if the observer was a party in the incident and there is a possibility that the testing might affect the recollection of the matter. Otherwise, it is preferable to have the objects in place for viewing with the signs, to accommodate a secondary assessment of the photograph selected later, as desired. The recording of specific details about the conspicuity of the objects is helpful in this respect, as well as being useful for a simple description of the extent of visibility.

One person records and monitors the observations, selects the signs for display, and decides when sufficient sign; have been displayed to determine the limits of visibility. One person communicates the observations to the area of the signs by radio. This can be the observer but, preferably, is an intermediary who also can assist in the control of the view of observer as necessary. At least one assistant in the area of the signs is quite helpful.

For the second phase, any involved artificial lighting remains at the correct location, intensity and direction; the signs signifying the threshold of visibility, are placed in the correct positions; and the observer is rep aced by a camera. A 35 millimetre camera and' 400 ASA colour film can be suitable but a larger negative format and professional film may be preferable. The lens focal length is that which, in conjunction with the print size to be obtained, will produce a print that, at the preferred viewing distance, would be an overlay of the scene. An incident light reading is obtained at the area to be photographed and the camera exposure is set accordingly, to obtain the best resolution in the film. Photographs also are taken at one f-stop increments for two greater and two lesser exposures. If the signs will be a significant distraction in the illustration of the scene to others, the photography is repeated with the signs removed. Encoding of the negative frames by a camera data back is desirable, particularly for photography in various set-ups. Professional photography may be beneficial.

In the third phase, the film is developed and printed with no adjustment in the print density. The negative with the best resolution is determined from examination of the prints. That negative then is printed at a selection of density levels in a sequence that suitably brackets borderline legibility of the symbols. If the objects of interest were photographed with the signs absent, the corresponding negative is printed similarly in the same processing. The print density increments are not precisely linearly comparable to film exposure increments but there is a similarity in general. Prints at density levels approximating half f-stop film exposure increments are likely to be suitable but will exhibit distinctly discernible differences such that a finer division may be desirable.

The final phase of the method involves selection of the photographic print in which the signs that signify the threshold of visibility for the observer, are barely discernible when viewed at the correct distance under appropriate lighting (print image shadow detail will vary significantly even between different "normal" lighting conditions). This phase can be done by the investigator without the observer if that person might be inclined to make a biased selection, perhaps because of involvement in the incident.

CONDITIONS AND CONCERNS AT THE SCENE -- While the first phase of testing is underway, the investigator usually also assesses the limits of useful perception of an object of interest by the observer. Considerable care is necessary in undertaking such assessments, and is essential if the observations and photographs are to be related to an earlier incident. Some of the circumstances to be considered are listed:

# NIGHTTIME PERCEPTION OBSERVATIONS FOR PHOTOGRAPHY

| FILE: | DATE: | PAGE: |
|---|---|---|
| OBSERVER: | START: | **FINISH:** |

| | **LEFT SIGN (as seen by observer)** | | | | **RIGHT SIGN (as seen by observer)** | | | |
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| **#** | **SIGN** | **OBS.** | **?** | **COMMENTS** | **SIGN** | **OBS.** | **?** | **COMMENTS** |
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| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
| 14 | | | | | | | | |
| 15 | | | | | | | | |
| 16 | | | | | | | | |
| 17 | | | | | | | | |
| 18 | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***LEFT SIGN GRAPH*** | | | | | | | | | | | ***RIGHT SIGN GRAPH*** | | | | | | | | | | |
| | ✓ | | | | | | | | | | | ✓ | | | | | | | | | | |
| | ✗ | | | | | | | | | | | ✗ | | | | | | | | | | |
| **CONTRAST** | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

DEGREE OF CERTAINTY: At ?, enter "D" for definite, "P" for probable, "M" for maybe, or "X" for no selection.

CONTRAST GRAPH:

| ----CORRECT (✓)----- | | ------------INCORRECT (✗)------------ | | |
|---|---|---|---|---|
| D or P | M | 1 of 2 signs correct | 6 of 7 bars correct | Others |

Figure 3: Form for recording sign observations at a site

- the safety of the observer, occupants in passing vehicles and the test personnel;
- the position and orientation of the object to be viewed and photographed;
- the state of the object, including the cleanliness of any reflector on it;
- the suitability of the foreground and background to the object of interest;
- ambient illumination, including that from the moon, streetlights, building lights and reflected glow from urban areas;
- snow, rain and fog that might affect the relative contrast of the object in the scene;
- for lighting by a vehicle, the vehicle type and loading, and the age, cleanliness, aim, setting and operating voltage of the headlights;
- for the view from a vehicle, the condition of the windshield;
- shielding the observer from the scene during changes, and from glare from passing traffic.

The headlights of a vehicle facing the observer's position may be an important part of the scene. The relatively very bright lights cause veiling glare for an observer, due to light scatter within the eyes, that reduces the visibility of the remainder of the scene. To a different extent, they also affect a photograph by flare and local over-exposure. In preliminary testing that has been undertaken with and without headlight glare using a short symbol viewing time, the symbols were less recognizable with glare, resulting in the selection of a darker illustrative photograph which was in agreement with the observer's comments about the scene. Further investigation is needed to determine the usefulness of the method in such conditions.

FILM EXPOSURE AND PRINT DENSITY -- Early experimentation revealed considerable problems in producing a usable range of photographic prints by varying the exposure of the film between frames. The width of the range that could be obtained was limited and there was substantial loss of resolution in the prints toward the ends of the range. A, darker print obtained by substantially under-exposing the film provides an unsatisfactory result, as very short exposures result in reciprocity failure, involving nonlinear chemical response of the emulsion layers, by which lighter and darker areas reduce in brightness at differing rates.

A properly-exposed negative of a fixed scene under low lighting conditions, is capable of holding more information than is visible to the human eye by virtue of its ability to accumulate the incident light over a lengthy period (exceeding the latency of the rods and cones) and so a print may be created that is clearer than is seen by an observer, often without burning out the brighter parts of the scene. A good result is obtained by printing a correctly-exposed negative at greater density by reduced exposure of the print paper. Various density levels may be obtained commercially, and an appropriate range and density level step size may be selected to encompass test requirements.

VALIDATION

While the described method of producing a representative illustration of a night scene has obvious face validity in general, consideration is given to the effect: of possible variation among observers.

OBJECTIVES --- An experiment was devised to test the method using a number of subjects. Each person was required to view a scene on two occasions. During the first, the subjects acted as observers and the sign contrast numbers signifying the threshold of visibility, were established. On the second occasion, each subject chose the photograph that best illustrated the scene just viewed, from prints not showing the symbols. The density of the chosen print was compared to that of a photograph in which the symbols of threshold contrast were barely recognizable.

The experiment was used for investigation of the significance of a number of variables:

* the extent to which the density of the chosen photograph could be predicted from the threshold sign contrast number;
* the variability among viewers in the selection of a photograph in which a particular symbol is just recognizable;
* the degree of uncertainty in identification of an observer's "threshold contrast number" (threshold of visibility) in the signs;
* the scatter in the threshold contrast numbers, among observers;
* the variation in density level of photographs chosen by an observer after first and second viewings of the scene;
* the scatter in density of photographs chosen as best illustrating the scene, among observers;
* differences between the relative prominence of dissimilar objects as viewed at the scene and in the photographs.

THE VALIDATION PROCEDURE -- Eleven "subjects" (unpaid volunteers), comprising six males and five females between 16 and 58 years old were tested (Table 1), although only nine of these were available for the second part, and ten for a third part, of the experiment. Subject C had earlier involvement with the method, acting as an assistant, and helped set up the experimental scene. The other subjects, being friends and relatives of the authors, had some peripheral knowledge of the method from earlier casual discussion.

A hockey arena from which the ice had been removed from the concrete pad in the playing area, provided a suitably controllable environment. All extraneous light was excluded and the pertinent part of the white boards and background were covered. The scene was in the middle part of one end of the playing area. In the first part of the experiment, it involved only the two sets of signs against the background. In the second part, it comprised the sign cases unmoved but with their black doors closed, and a number of objects resting on the concrete pad and suspended from the end glass and boards:

- a board covered with rectangles of low lustre paper of various colours,
- a warning sign with strips of orange reflective tape on a white background,
- a mock-up of an adult, with a grey jacket, black pants and white shoes,
- a blue bicycle,
- two reflective warning triangles,
- one red, and one blue, plastic milk crate,
- two small traffic pylons.

The scene was photographed with the objects present and with a. pair of symbols exposed (Figure 4). Illumination was provided by four photo-floodlights positioned out of the observers' view. These were energized through dimmer switches that were adjusted to produce a suitable intensity of lighting. A chair for the observer was placed midway across the playing area, 40 metres from the scene.

TABLE 1

The Subjects in the Validation Experiments

| Sub | Age | Sex | Eye Correction | Involvement |
|---|---|---|---|---|
| A | 16 | M | None | Parts 1, 2 & 3 |
| B | 22 | F | None | Parts 1 & 3 |
| C | 25 | M | None | Parts 1 & 2 |
| D | 26 | M | None* | Parts 1, 2 & 3 |
| E | 27 | F | None | Parts 1, 2 & 3 |
| F | 33 | F | None | Parts 1, 2 & 3 |
| G | 39 | F | Contact Lenses | Parts 1, 2 & 3 |
| H | 42 | F | Con tact Lenses | Parts 1, 2 & 3 |
| I | | | | |
| J | 50 54 | MM | Glasses Glasses** | Parts Parts 1, 1 & 2 3 & 3 |
| K | 58 | M | Glasses | Parts 1, 2 & 3 |

* Contact lens worn sometimes but not during the experiment.

** For distance only; not used for viewing the photographs.

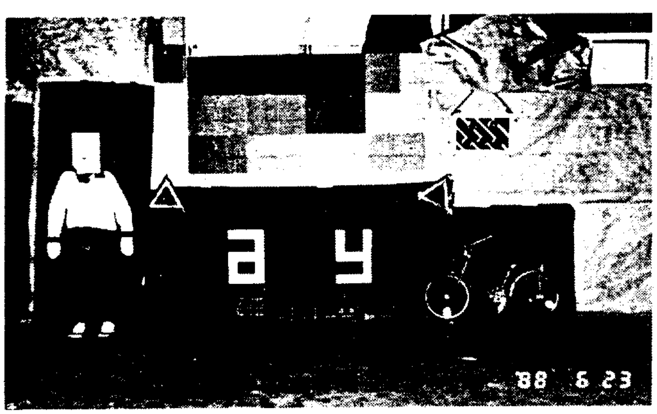



Figure 4: Objects in the test scene

Before the subjects arrived at the arena for the first part of the experiment, they received a sheet showing and naming the symbols that they would be asked to identify, and briefly describing the process in which they would be involved. When they arrived, they waited for not less than 15 minutes in an area that was darker than the viewing area. During this time, the symbols and the first part of the process were described to them by one of the experimenters.

After the eye adaptation period, the subjects were guided, in turn, to the observation position. Each waited not less than three minutes in the chair in the viewing area before the first sign was exposed for attempted identification. The process continued by the described method, with an exposure of each sign for about ten seconds, until the contrast number signifying the threshold of sign visibility was considered to have been adequately determinable.

Upon completion of part one of the experiment by the last subject, the various objects were added to the scene. The pair of signs nearest the threshold contrast for each subject were displayed in the cases and the photography was undertaken by the described method. The film was developed and prints were obtained for each pair of signs. A local photo processing centre was able to provide prints at ten density levels at regular intervals, which suitably encompassed the range of interest. These were designated from 0 to 9 in order of increasing density. Corresponding photographs of the scene with the signs hidden were prepared also.

The sheet provided to the subjects before they first attended the arena, also presented a list of the objects that would be in the scene on the second occasion, and a brief description of the second part of the efforts in which they would be involved. Upon their return to the arena, they again waited for not less than 15 minutes in the darkened holding area. During this time, the objects and the further efforts were described to them by one of the experimenters. After the eye adaptation period, each subject viewed the scene for at least eight minutes, during which one of the experimenters drew attention to each of the objects and to particular aspects of the objects.

After observing the scene, each subject, in turn, was quickly guided to a well-lighted room where the photographs of the scene with the signs hidden, were displayed. The subject chose the photograph with that density which represented the best overall illustration of the scene just viewed. Each subject also chose the photographs that best showed each of the objects considered alone. Comments by the subjects about similarities and differences between the chosen photographs and their observations of the scene, were obtained. Each subject then examined a set of photographs displaying all of the different pairs of signs of threshold contrast number at the same print density as that of the photograph chosen by that person as being the best overall illustration of the scene. The subject identified the signs that were at their limit of recognizability. The subjects repeated part two of the experiment once.

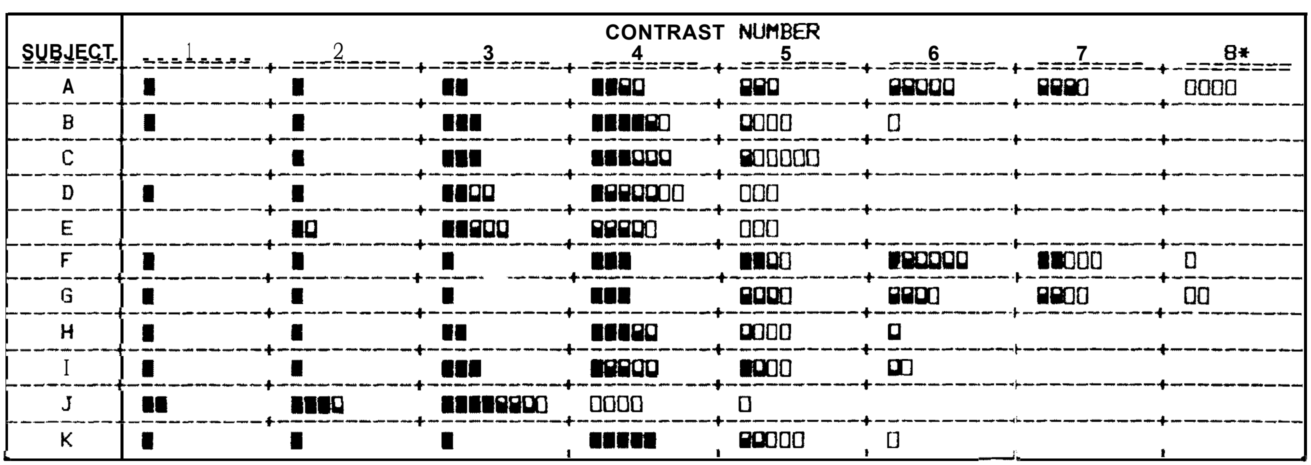
In the third part of the experiment, the photograph in which the sign at each contrast number was barely discernible, was chosen from the associated set of various density prints. This was done by the experimenters in good lighting soon after the efforts at the arena. About four months later, a similar procedure was undertaken by the ten subjects who were available.

THE THRESHOLD SIGN CONTRAST NUMBER -- The indication by the observers in viewing the signs in the first part of the experiment were charted (Figure 5). Each observer had viewed, once or more, every sign in the range of contrast numbers from that at which identification always was correct to that at which it never was correct. The narrowest possible range of contrast numbers would have been one if, for two signs in sequence, the observer had been always correct for one and always wrong for the other. Since the range of contrast numbers was more than one for every observer (Table 2), further assessment was needed to ascertain the contrast number that signified the threshold of visibility for each person.

The threshold contrast number for each observer was taken to be that at which the probability of correct identification was 50 percent. The discrete set of sign contrast numbers produced non-integral derived threshold contrast numbers (Table 3). A probability weighting was assigned for every determination by each observer and the average at each contrast number was calculated. The value was 1.0 for a correct identification made with confidence, and nil when there was no significant recognition of the symbol. Intermediate values were applied for a correct identification made with appreciable uncertainty, responses suggesting two symbols of which one was correct, and responses in which six of the seven bars of the symbol were correct. Appreciable changes in the intermediate values had little effect. The threshold contrast numbers derived by this procedure compared closely to those perceived in overviews of the charts plotted during the testing. The variation in threshold contrast number among the subjects was somewhat less than three.

VARIATIONS IN THE CHOSEN PHOTOGRAPHS -- Perceptible, although not immediately obvious, differences were apparent in prints at adjacent density levels when compared side by side. Distinct differences in prints separated by two density levels were readily discernible. (Figure 6, showing prints of the same symbols at five adjacent density levels, provides an impression of these circumstances, as limited by the further reproduction necessary for this paper.)

In choosing a photograph from prints at the ten density levels, shortly after viewing the scene, the subjects generally were quite consistent between the two tests (Table 4). Five of them chose the same photograph; only one chose photographs separated by more than two density levels. The range in density levels among the subjects was four after the first, and three after the second, viewing of the scene.




* No symbol at level 9 or 10 was used.
■ = correct, with confidence.
▣ = correct, with uncertainty.
◘ = one of alternate choices correct, or six of the seven symbol bars correct.
□ = unidentified or incorrect.

Figure 5: Graphical display of the determinations during testing of all observers (as recorded initially on the lower part of the form shown in Figure 3.)

TABLE 2

The Distribution of Subjects Among the Ranges of Contrast Numbers for Signs Always, to Signs Never, Correctly Identified

| Range of Contrast Numbers | Number of Subjects |
|---|---|
| 1 | 0 |
| 2 | 2 |
| 3 | 5 |
| 4 | 3 |
| 5 | 1 |
| 6 | 0 |

TABLE 3

The Threshold Sign Contrast Numbers

| Subject | Number of Tests | Threshold Contrast Number |
|---|---|---|
| A | 24 | 5.8 |
| B | 16 | 4.4 |
| C | 16 | 4.3 |
| D | 16 | 3.6 |
| E | 15 | 3.3 |
| F | 22 | 5.9 |
| G | 20 | 5.6 |
| H | 14 | 4.6 |
| | 16 | 4.5 |
| J | 19 | 3.0 |
| K | 14 | 4.7 |

TABLE 4

The Photographs Chosen as Best Overall

| Subject | Density Levels Chosen | |
|---|---|---|
| | First Trial | Second Trial |
| A | 6 | 4 |
| C | 6 | 6 |
| D | 7 | 7 |
| E | 9 | 5 |
| F | 5 | 4 |
| G | 5 | 5 |
| H | 5 | 5 |
| J | 9 | 7 |
| K | 6 | 6 |

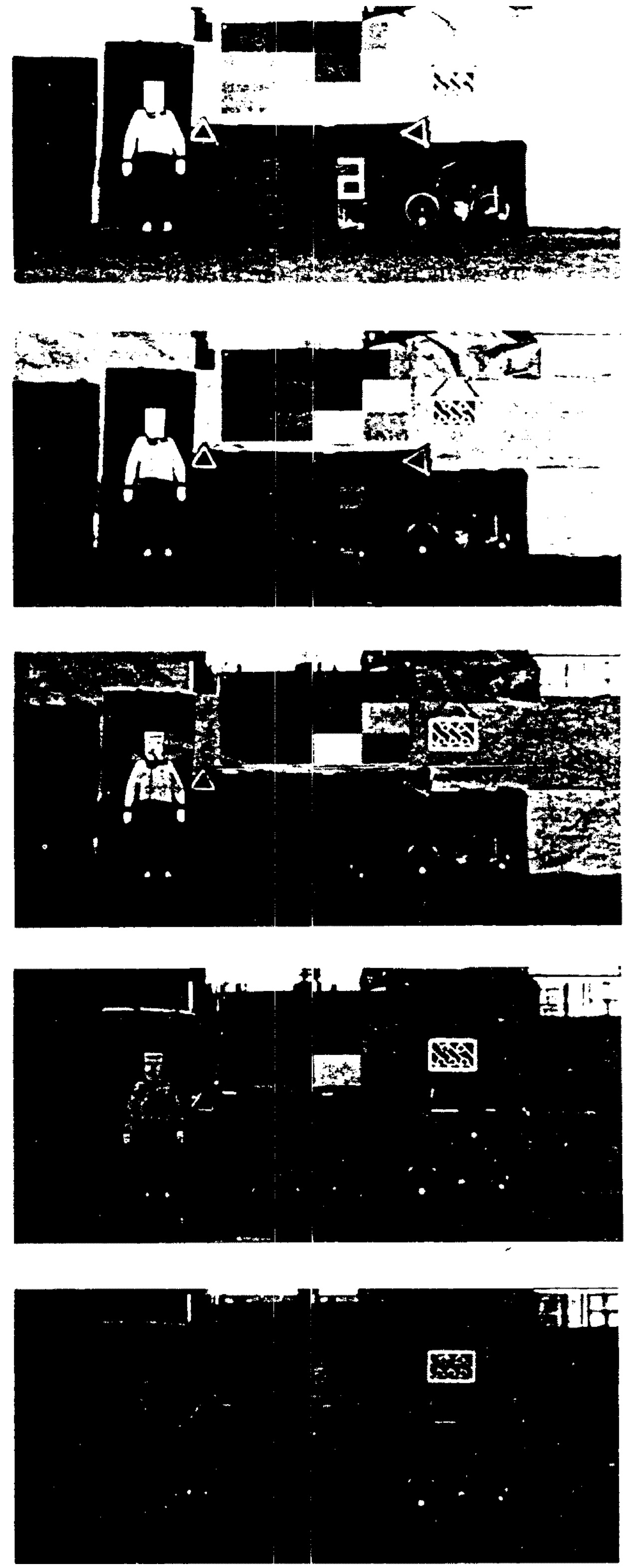


Figure 6: A photograph of the test scene, printed at five adjacent density levels

Subjects uniformly reported easily observable differences in relative appearance among the objects as viewed in the scene and as shown in the photographs. All subjects recognized that the red crate was considerably more visible in the photographs than at the scene, relative to the blue crate, and that the triangular reflectors, the warning sign and the facial features (black markings on brown paper) of the adult mock-up were far more prominent in the photographs than in the scene. In choosing the overall best photographs, the subjects tended to base their assessments principally on the relative appearance of the multi-colour board, the bicycle, the outline of the adult mock-up, and the background.

The resolution of the human eye degrades rapidly as light intensity diminishes. To obtain a photograph, additional exposure time can often be used to compensate for the dimness of lighting in a night scene. Such a photograph can show more detail than is apparent to a person viewing the night scene, even when the overall contrast of the object and background are appropriate. This may well account for the inability of the observers to perceive small details, such as the facial features on the adult mock-up, in the dim lighting, while recognizing them easily in the photographs. The highly reflective red objects, in particular, were relatively more prominent in the photographs (possibly due to the change in the eye's spectral sensitivity in dim light:), suggesting that, for such objects, use of a blue filter may allow better colour matching.

THE PHOTOGRAPH PER THE THRESHOLD CONTRAST -- The three experimenters individually viewed photographs at all density levels for signs at contrast numbers between 3 and 6, and selected, for each contrast number, their best estimate of the density level at which the symbol was at the threshold of recognizability (Figure 7). As the contrast number increases (and the contrast between the symbol and the black background in the sign decreases) the density level decreases, as is to be expected. The relationship is approximately linear, with a change of one contrast number requiring a change of about two density levels.

With reference to the: threshold contrast number derived for each subject (Table 3), and the mean of the experimenters' estimations of the limit density level for each contrast number (Figure 7), the"predicted density level" was established for each subject. This density level is that which the described method selects as corresponding best to that person's view of the scene.

Ideally, the predicted density level would equal the subject-selected density level in each case. Good agreement was obtained (Figure 8); the greatest difference was 1.3, and the mean difference was only 0.8, density levels. There was no obvious bias towards predicting density levels higher or lower than those chosen by the subjects.

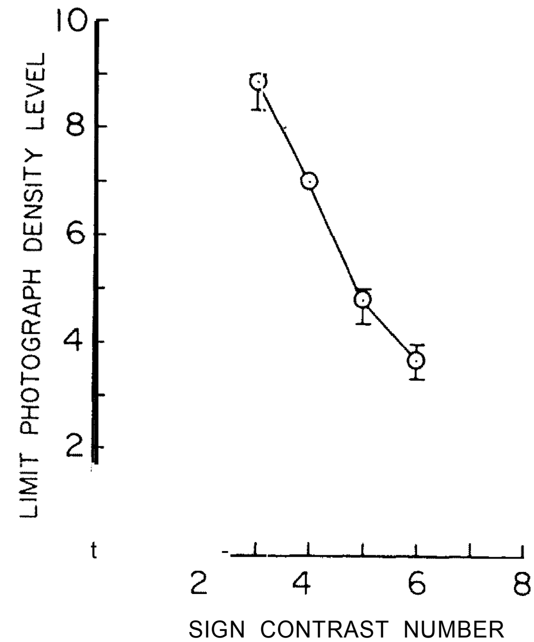



Figure 7: Photograph density level at the limit of legibility, of signs of different contrast numbers, as determined by three experimenters.

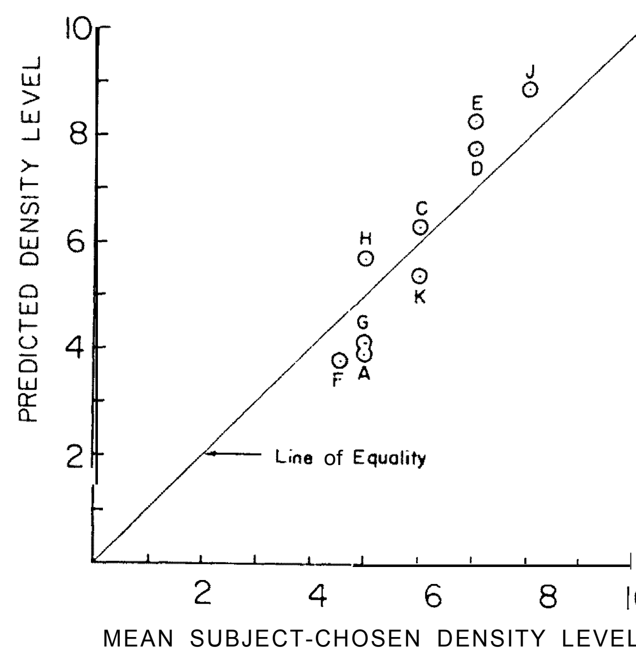



Figure 8: Comparison of the photograph density level predicted by the experimenters for, and the mean density level chosen by, each subject as best representing the scene.

Eight of the nine subjects who completed all prior testing, were available and selected the limit density level for photographs including pertinent signs. There was more variability between subjects than between experimenters, possibly due to the limited experience of the subjects in assessing such photographs and to some experimental difficulties. A separate set of predicted density levels was similarly derived from these observations and compared with the subject-selected density levels (Figure 9). The largest difference was still only two density levels, which in view of the test procedure indicates a reasonable correspondence. However for seven of the eight subjects, these predicted photographs were brighter than the mean densities of the photographs chosen after viewing the scene.

These findings indicate a need for care, not only in the observations at the site, but in the subsequent selection of the photograph. Lighting and viewing distance should correspond to those in which the photograph is to be used for demonstration.

The important conclusion to be drawn from the validation tests is that the method will usually produce a photograph that is a reasonable representation of a dependable person's view of an object in a night scene. Close consideration of the results during attempted identification of the symbols displayed at the scene, should allow an accurate assessment of the reliability of the person's observations.

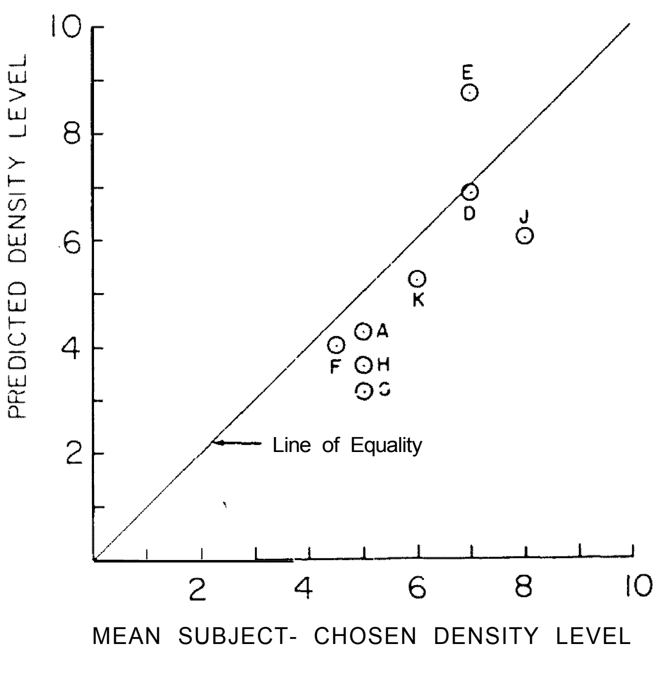



Figure 9: Comparison of the photograph density level indicated by the selections of each subject with reference *to* the signs shown in the photographs, and the mean **density** level chosen by that subject as best representing the scene.

DISCUSSION

The testing demonstrated that there is variation among observers, so that any undertaking of this nature should carefully consider the vision of the person whose view is under consideration. It is obviously best to use that observer, if at all possible. Since such a subject is potentially biased, the use of the sign sets make it much easier to complete objective perception observations, as well as to produce matching photographs.

The testing indicated areas of variability that render a perfect match impossible. The determination of the threshold sign contrast number is open to some judgment as there is not a clear transition from perfect visibility of one sign to perfect invisibility of the next. There is uncertainty in the identification by some subjects of the density level for the photograph best representing the scene. There is substantial variation in the relative prominence of different objects viewed directly and in a photograph. This dictates a need for close attention by the investigator to minimize deviations and to recognize the possible extent of those that may remain. The photograph that is provided for illustrative purposes must be explained accordingly.

Careful use of the method produces a photograph that has a substantial likelihood of being within one density level of the choice that would be made by the observer if it were possible to view the photograph and the scene simultaneously for comparison. An observer other than the person who was involved in the incident, necessitates an assessment of the extent to which the observer's vision is "representative" or comparable to the involved person. Even with such other observer, the method can produce a photograph that is demonstrably similar, in general terms, to a subject's static night view of a scene.

Further verification of a photograph produced in this manner may be obtained by recording specific comments from the observer about the relative visibility of various objects. Caution is necessary regarding small objects or details (as photograph resolution exceeds that of the human eye at low light levels) and objects with colours that are likely to have a substantial effect on their relative prominence in the view of the scene and the photograph.

DYNAMIC VERSUS STATIC OBSERVATIONS -- Static perception conditions do not necessarily correspond to the view of a driver in a vehicle moving at highway speeds, since the continually changing field of view limits the driver's ability to recognize unusual obstructions. An investigator has the problem of selecting the position at which the subject can see an object sufficiently clearly to recognize it as a hazard. The method has been used for only very limited investigations in this regard. During one investigation with a single subject, it was found that there was no significant difference in visibility of signs at various contrast numbers between viewing times of about one half second and ten seconds. In another instance, a driver moving at a moderate speed toward an object, following extensive sign contrast observations, was able to respond to the object by braking before reaching the statically-determined point of threshold visibility. It is suspected that this may have resulted from increased visibility distance due to road roughness and headlight bounce, but further investigation remains to be done.

A further, important, consideration is the difference between the perception of an unalerted driver of a vehicle approaching an object at a substantial speed, and that of the same person in a stationary vehicle, viewing the same object after knowing it is there, The literature contains a considerable number of investigations of dynamic driver perception, although very scattered results are reported that appear at least partially attributable to the method of determining perception. A permanent record of a driver's dynamic view is difficult to imagine, after consideration of these efforts to record his static view.

SUMMARY

A method has been developed that provides a means of preparing a photographic print that, to a reasonable degree, objectively illustrates the appearance of a night scene to an observer. Such a photograph may be desired to show others the results of an investigation of problems associated with a nightime collision. Much of the subjective assessment usually required has been removed by the use of a variety of signs of differing shades of grey.

Limited validation studies have identified significant differences in perception between observers, but have demonstrated that these are appropriately recognized by the method. While the testing did not encompass a statistically representative number of subjects, it was able to predict an appropriate photograph for each, that closely matched the subject's judgement. Difficulties were identified, including imbalance between objects of differing luminance and colour (which may be reduced by professional photography).

The results to date are sufficiently good, and sufficiently better than the existing alternatives, that the method may usefully be applied when the need for such illustration arises.

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# Visibility Study - Methodologies and Reconstruction

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## ABSTRACT

Often as part of accident reconstruction the question of visibility arises. Examples range from a simple daytime obstruction to the more complex case of nighttime human perception. With these cases, it is often necessary to analyze the visibility aspects of the accident situation and determine if a reasonably alert person would have been able to detect certain objects associated with the accident. In order to analyze the accident situation, a method for studying various visibility aspects is needed.

The purpose of this paper is to present a methodology to study visibility aspects of an accident. It will present field reconstructions of both daytime and nighttime accidents, and unique examples illustrating target detection factors and how they can lead to an increase in visibility at night. The methodologies will include still photography, video and motion pictures. While daytime visibility studies will be addressed, the main portion of this paper will concentrate on the nighttime visibility studies.

## INTRODUCTION

In accident reconstruction, the leading or contributing factors to an accident experience can usually be categorized as one of the following:

- Human factors - The driver and his interaction between the vehicle and the surroundings.
- Environmental factors - The highway, it's surface, weather conditions, etc.
- Vehicle factors - Performance or mechanical failures.

When considering visibility issues in accident reconstruction, the primary factors are human and environmental. These two factors are the foundations from which all of your study, research and analysis of that issue should originate. There has been extensive research dedicated to analyzing the human and environmental factors and how they relate to visibility issues.* It is extremely important that the details of each factor be researched as a part of the preparation for a study and/or analysis.

In certain accident situations, it is important to determine if adequate visibility was present for one or both of the vehicle operators. For example consider the following:

- Two vehicles approaching an uncontrolled, perpendicular intersection in the desert during the daytime. Can each of the drivers see the other? How about at nighttime?
- A disabled truck parked partially on the roadway is clearly visible at noon on a sunny day, yet how discernible is it at night in the rain?
- A tractor/trailer is in a turning maneuver as an approaching vehicle runs into it. How well can it be seen at night? What factors determine its conspicousity? How about under rainy conditions at night?

In order to answer these types of questions and others, a systematic method must be followed to study these situations and then present the findings in a reliable manner. The media used most frequently to convey visibility of an accident site

* Please see list of references for examples.

is photography. In order to study the accident, it is important to be able to reproduce the conditions that the driver saw. This paper will discuss and illustrate the use of a control for this purpose. A detailed description of the proposed methodology for daytime, nighttime and special situations will be introduced.* This will be followed by illustrative examples of case studies and finally a discussion of the proposed systematic method will conclude.

## GENERAL PREPARATION

In order to perform a daytime or nighttime visibility study, some general preparations need to be made with regard to the accident scene, vehicle(s), and/or pedestrian(s). The accident scene needs to be substantially similar to what it actually was at the time of the accident. This includes all of the environmental factors that may effect the visibility in the study. Examples include buildings/structures, trees, utility poles, extra vehicles (parked or moving), and/or signing fixtures (warning, directional, informational, etc.). If the scene at present does not contain the same facilities that were present at the time of the accident, then the items necessary to make it substantially similar should be added or removed. If the preparation is for a visibility study at nighttime or in a special situation, then the artificial lighting facilities should be made substantially similar as well. Finally, in both daytime and nighttime visibility studies, arrangement for traffic control may be a necessity.

Now that the scene is essentially similar to that of the time of the accident, exemplar vehicles and/or pedestrians exhibiting similar characteristics as the subject vehicles and/or pedestrians need to obtained. It is very important that the car, truck, motorcycle, bicycle, etc. and/or pedestrian utilized as the object of the visibility, exhibit similar color, size, shape and general reflectivity of the subject vehicle and/or pedestrian. Generally, vehicles should be the same make and model, as well as similar size, shape and color characteristics. If the preparation is for a visibility study at night or in a special situation then the headlights on all of the vehicles will need to be state certified or adjusted to the accident setting (if known). With pedestrians, a mannequin or an exemplar person may be utilized, however it will be necessary to assure that the gender, size and color of clothing are substantially similar to that of the subject pedestrian. It is imperative that the source of visibility exhibit proper viewing height whether it be a exemplar vehicle or the known eye height of the subject pedestrian.

Lastly, time positions can be obtained by performing a preliminary reconstruction (speeds and distances) prior to the execution of the visibility study. Should perception/reaction enter as one of the issues of the study, pre-determined times and positions can lead to a straightforward study.

## THE USE OF A CONTROL

Often in scientific research, large amounts of data are collected for the purpose of analysis. This data is not necessarily meaningful unless it is compared against data that does have meaning. For example, 300 pounds is an amount that does not have a lot of meaning until related to a forty-year-old male who, by comparison to the weight of a 50$^{th}$ percentile forty-year-old male, is overweight.

This comparison concept is the basis of the methodology described in this paper. The human eye has an extraordinary capacity for seeing very small details, faint amounts of light, and minute variations between objects. However, it is very poor at estimating absolute values. For example, under ideal conditions the eye can see a difference in the brightness of two areas that differ by as little as one percent. But even an experienced photographer has great difficulty estimating the

* Special situations include dawn/dusk, fog, and rain.

actual finite amount of light in a room within 100 percent of its true value[23].

We can take advantage of the eye's outstanding ability to discriminate detail in recording the scene as it actually appears. In a nighttime visibility study, the photographer has no need to know the absolute value of the light if a Polaroid photograph is taken and used as a **control**. Likewise, in a daytime visibility study the photographer has no need to know the values of the colors if a photograph is taken of the subject with a color card in view; in which case the card becomes the **control**. This **control** will stay constant from beginning to end of the visibility study. Using a **control** provides a reliable means of attaining full control over the entire chain of photographic variables. Figure 1 is a flowchart demonstrating this chain and the purpose of the **control**.

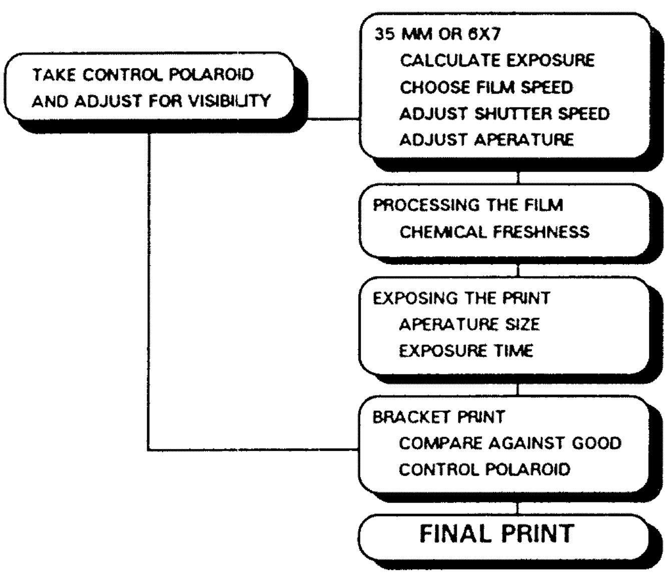



FIGURE 1

The other advantage of this method is the reduction of potential errors. The photographer can immediately make a <u>direct</u> comparison of the primary object in its natural background to the **control** polaroid and modulate the exposure accordingly *while at the scene*. This eliminates light meter errors, adjustments in film processing, and/or return trips. It also eliminates variations due to weather changes such as cloud cover, rain, fog, etc. if two or more trips are needed to complete the task. The use of this **control** polaroid is essential to maintain the chain of continuity between the accident scene and the final photograph as demonstrated in Figure 1.

## <u>DAYTIME VISIBILITY</u>

Daytime visibility studies are usually relatively simple. Most often, the limitations of visibility during the day have to do with obstructions. Human perception, as it relates to the detection of colors and contrast is a factor; however the most important factor is the environment. After the general preparations have been made, the execution of the study should be prepared. A point of reference has to be assigned. For example, the point of impact (if known) is one good reference. Times and distances from a point of impact are values that are easy to understand by any person analyzing the study.

When preparing the photography, video acquisition, and/or motion picture equipment, it is important to note that the selection of the equipment is not as important in a daytime visibility study as it is in a nighttime visibility study. For a daytime situation, depending on the extent of the study, the following equipment will be needed.

First, an instant camera with variable aperture and shutter speed, such as a Polaroid 195 or a Konica Instant-Press, will be needed for location documentation. Color polaroids are recommended for daytime use because of the factors involved with color detection.

Next, the still photography equipment needs to be prepared. An SLR camera that is equipped with a 50mm lens, will be needed. Typically, 50mm lenses are utilized for visibility studies because of their ability to closely represent the optics of the human eye at normal viewing distances.

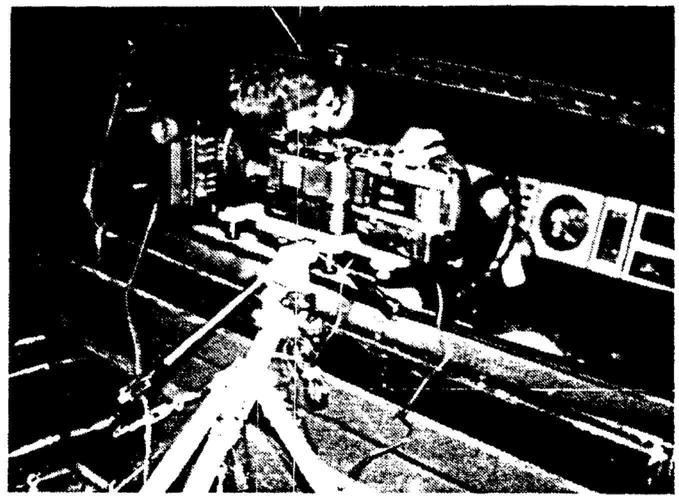
If the study warrants video or motion picture documentation for presentations such as a stop motion animation, then it is suggested that research into the preparation of such presentations should be pursued. As far as the scope of this paper is concerned, high quality consumer or commercial grade video equipment should suitably perform the necessary functions of replicating daytime visibility.

## NIGHTTIME VISIBILITY

Nighttime visibility studies can be very complex. In addition to the general visibility study preparation, a few additional items need to be considered as well. A future date and time with similar natural lighting conditions should be selected. This is done by obtaining the tide tables for the time of the accident and for the present. Then a correlation of the lunar data is constructed between the time of the accident and a future date and time. If done correctly, this new date and time will exhibit similar lighting conditions to the time of the accident. If the accident involved a question of visibility of a sign then the actual sign in question or a comparably worn sign, if available, needs to placed in the same position as at the time of the accident.

The equipment for the nighttime visibility situation should be chosen carefully. It should be noted that due to exposure times and other photographic necessities, a tripod will have to be placed at the proper height in the vehicles to support the photographic, video and/or motion picture equipment. All of this equipment can be placed on the same tripod by means of a multi-mount.

Color photographs are produced by exposing a three layer film inside a camera. Lens aperture and camera shutter speed determine the amount of light that will reach the film. If too much light reaches the film, the negative will be overexposed. If too little light reaches the film, the negative will be underexposed. What is preferable is just enough light to reach the film to produce the best exposure. One note however, caution needs to be exercised when the exposure times begin to exceed approximately 1 second. The reason for this is that the linear relationship between exposure time and film speed often diminishes in this longer exposure period as the reciprocity effect appears. Compensating for this effect often results in longer than otherwise normal exposures to produce accurate photographs.



MULTI-MOUNT WITH PHOTOGRAPHIC EQUIPMENT

As discussed earlier, in order to obtain a photograph which accurately corresponds to the conditions observed at the accident site by the driver/rider and by the investigator, there are several variables in the photographic procedure that must be controlled either individually or collectively.

During the taking of the photograph - Film speed, aperture size, shutter speed.

During the film processing - Chemical freshness.

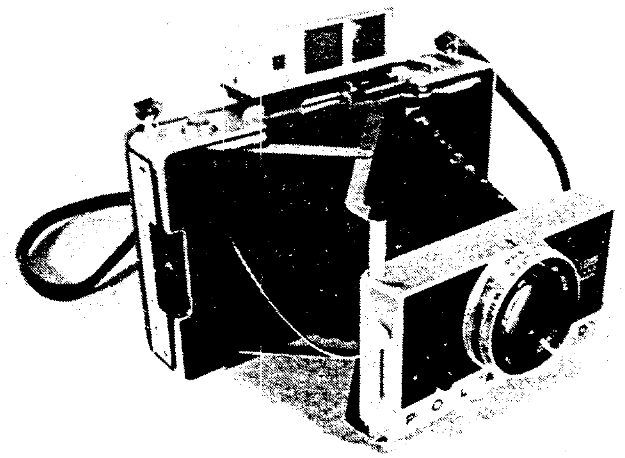
During the printing of the negatives - Paper type, enlarging lens/aperture size, and exposure duration.

It is extremely important that the final photograph depict the objects viewed as they are seen under the actual available illumination level and type. For example, headlight color differs from those of sodium lamps, and high pressure sodium lamps differ from metal halide lamps and mercury lamps. As the color rendition of light sources differ, the perception of objects viewed may also vary depending on the color of the primary object, its background, and the nature of the visual noise. Documenting this quality of discrimination can be achieved by a careful comparison of the reconstructed scene with a polaroid photograph of the same scene developed at the site. Black and white polaroids are ideal for that purpose due to (1) the high speed of the film (3000 ASA), (2) its good grain construction, and (3) its high contrast quality. If color rendition is important, a color polaroid can be taken as an additional control.

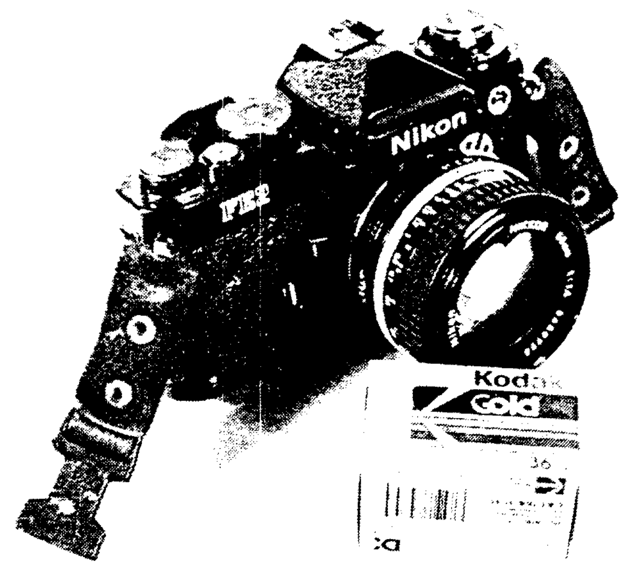
An instant camera with variable aperture and speed, such as the Polaroid 195 or Konica Instant-Press, will be used to produce the control polaroid. A good control polaroid is obtained by comparing the objects of visibility in the polaroid under a flashlight to the reconstructed scene. It is important that the objects of visibility are utilized in making the comparison. Additionally, a flashlight is utilized to avoid dark adaptation while examining the polaroid. Once a good control polaroid has been achieved then it is necessary to record the speed and aperture on the reverse side of the polaroid since this correct exposure and data will remain constant throughout this process.

35mm / 6x7 FORMATS

In the still photography preparation there are two different formats that may utilized; (1) 35mm and (2) 6x7 format. The 35mm format is the most common. This format is the most popular because it provides the widest range of various speed films and the widest aperture in the lens selection. A 35mm SLR camera with a 1:1.4 50mm lens, such as the Nikon FE2 pictured, will be needed for this preparation.



POLAROID MODEL 195 INSTANT CAMERA




NIKON FE2 WITH 50mm 1:1.4 LENS

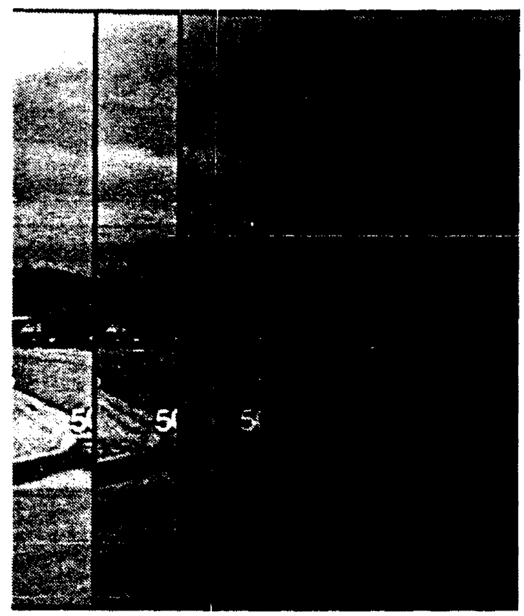
In the film selection there is a compromise between the desirable shorter exposures and the need for good grain content. In consideration of both print and slide film, 400 ASA Kodak print film was found to be a good choice. This film needs approximately three times more light than the polaroid film. For example, if a good control polaroid is arrived at with a 1/2 second exposure time for an aperture setting of f4 for 3000 ASA film; then a corresponding settings for 400 ASA film would be an aperture of f1.4 for 1/2 second. In other words, a three stop increase in the aperture was performed to accommodate the extra light needed to properly expose the film.

The second format that may be utilized is a 6x7 format. Using a 6 x 7 format camera allows a larger size negative to be obtained. A larger negative is desirable because it renders better picture definition. Greater depth of field, and reduced flaring of light sources are achieved by the available lens selection. A SMC Pentax 6x7 camera with a 45 mm F4 lens and Kodak Vericolor 400 print film is a good choice.


SMC PENTAX 6X7 WITH 45mm 1:4 LENS

Under certain conditions, photographs with superior quality can be produced using the 6x7 format cameras and lenses. However, these photographs require special attention. Due to the lens type and slower film speed, longer exposures are often required that can range between 15 to 30 seconds depending upon conditions and prevailing illumination. Also, excessive traffic may have a negative effect on background illumination under certain conditions.

In both formats, after the negatives have been properly exposed and then developed, a bracketed print needs to be constructed. A bracketed print is produced by exposing sequential lighting levels across the print. This print is then compared to your good control polaroid and the exposure time which best corresponds to the polaroid is selected. The print that results from this selection should best correspond to the conditions the night of the test. Therefore the picture will be an accurate representation of the visibility available during the study and consequently the visibility during the accident.



(longer ------------------------------shorter)
exposure time

EXAMPLE OF A BRACKETED PRINT

MOTION PICTURES / VIDEO

Often a dynamic representation of a visibility study is desired. Motion pictures and video are the media used for this purpose. For motion picture preparation a 16mm motion picture camera, such as the Beaulieu R16 with a roll of high speed (ASA 320) 16mm film pictured below, is utilized. It is extremely important that high speed film is obtained for this type of dynamic representation. The method for exposing the motion picture film is very similar to that of still photography. Once a good control polaroid is obtained, the frame rate is calculated by adjusting the exposure time for the lower film speed and using this equation:*

$$\text{Frame Rate} \approx \frac{0.4}{\text{Exposure Time}}$$

Depending on the conditions the calculated frame rate may need to be adjusted. A frame rate under approximately 6 frames per second is usually not desirable because of the dynamics involved. When the proper exposure is calculated to be under 6 frames per second then reduce the exposure time in the equation by one, two or three stops, whichever is necessary to produce a reasonable frame rate. When the film is developed have the processor "push" develop the film the amount of stops that it was reduced by. It should be noted that "pushing" in excess of three stops is not recommended due to the adverse effect on the grain size.

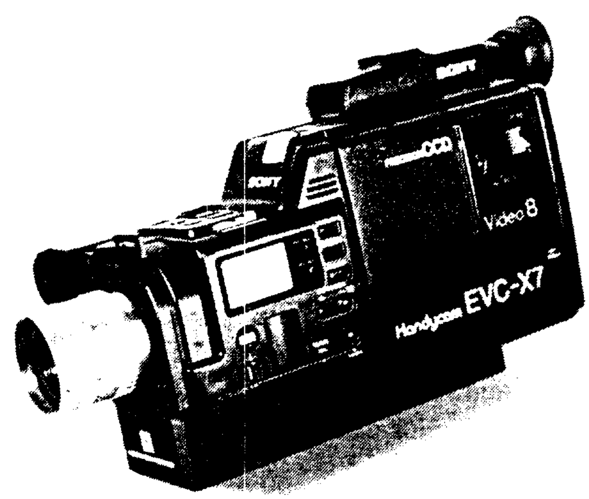
BEAULIEU R16 WITH EASTMAN 7292 FILM

* Please consult the owners manual of the motion picture camera utilized to obtain the proper relationship.

After the proper negative is obtained a positive film needs to be produced. This is done by utilizing a Hazeltin machine together with the good control polaroid and obtaining printing values for exposure and color settings. The finished product will be a film that can be viewed using a 16mm projector.

Video technology can also be utilized as well. For this preparation a special low light, C-mount video camera, such as the Sony EVC-X7 with 1:0.95 C-mount lens, is recommended. To achieve the proper exposure under low light levels, the aperture will usually need to be adjusted fully open. However, compare the good control polaroid to the viewfinder of the video camera to ensure proper exposure. The recorded videotape is then viewed on a monitor. The monitor is compared against the good control polaroid and adjusted to achieve a good match.

As mentioned earlier, motion pictures and video can also be utilized in a stop motion animation presentation of nighttime visibility. If desired, research into such presentations is suggested.




SONY EVC-X7 LOW LIGHT CAMERA

## SPECIAL SITUATIONS

In addition to daytime and nighttime situations there are some situations that require some different preparation and execution. These situations include dawn, dusk, fog and rain.

## DAWN / DUSK

For dawn and dusk visibility studies some additional general preparation needs to be done. The sunrise and sunset times from the tide tables for the date of the accident and the present need to be obtained. With dusk/dawn situations it is very important that the similar time with respect to the sunrise or sunset be selected for the study. It must be noted that the natural lighting changes very quickly in these particular types of studies, so proper preparation and quick execution is essential.

Similar to nighttime visibility studies, a good control polaroid needs to be taken of the object. If the object of visibility is in the foreground of the sun then adjust the control polaroid to meet the visibility. In other words, if the observer can see certain details of the object then adjust the control polaroid to reflect those same details. This is performed by decreasing the aperture and exposing the negative properly for the object.

Once the good control polaroid has been obtained then follow the procedures outlined in the nighttime visibility section to attain a good representation of the visibility of the dawn/dusk situation.

## FOG

Research on visibility studies in fog is limited. However, fog visibility tests have been conducted to determine visibility distances in various forms of fog. For example, two fog density scales were developed in Italy and West Germany and are illustrated in figure 2[18].

Performing visibility studies in the fog require preparation that is currently unavailable. With a fog induced accident it is difficult at best to ascertain the identical conditions that were present at the time of the actual accident. In addition, adding the complexity of a nighttime situation to the fog and attempting to perform a visibility study is not only very involved but also could be very dangerous. It is suggested that more research be performed in establishing safe and reliable methodologies for studying visibility in fog environments.

| | ITALY VISIBILITY DISTANCE (m) | | GERMANY STANDARD VISUAL RANGE (m) | |
|---|---|---|---|---|
| TYPES OF FOG | MAX | MIN | MAX | MIN |
| MIST | 1000 | 330 | | |
| THIN FOG | 330 | 150 | 1000 | 500 |
| MODERATE FOG | 150 | 50 | 500 | 200 |
| THICK FOG | 50 | 20 | 200 | 100 |
| VERY THICK FOG | 20 | 10 | 100 | 50 |
| FOG WALL | 10 | 0 | 50 | 0 |

FIGURE 2

## RAIN

In preparation for a rain visibility study, some additional preparation needs to be made. The precipitation records for the date and time of the accident need to be obtained. After the general preparation has been arranged, future dates need to be monitored for rainfall activity.

In this type of situation, it is important that all the preparation has been made well in advance and all equipment and personnel needed for the study are ready at a moments notice. Care should be taken with any equipment exposed to the elements.

Similar to the dawn/dusk situation, the rainfall activity may change very quickly, so proper preparation and quick execution is essential. Again, once the good control polaroid has been obtained, then follow the procedures outlined in the night visibility section to obtain a good representation of the visibility of the accident scene in the rain.

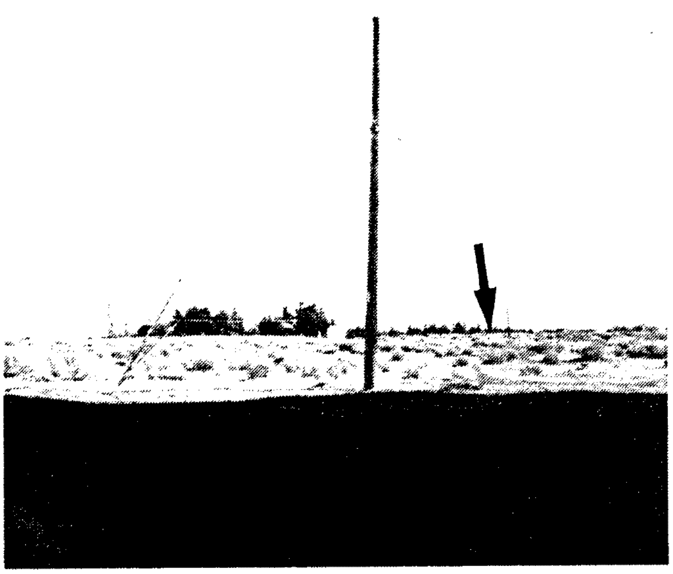
## CASE STUDIES

CASE #1

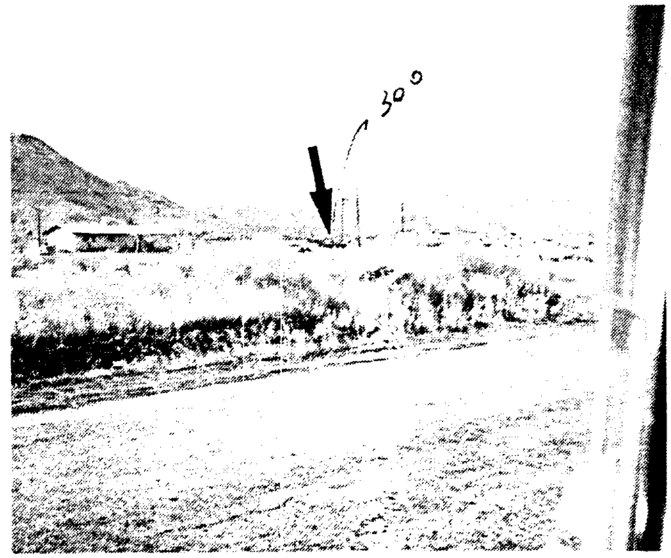
A typical daytime visibility situation occured when two vehicles approaching an intersection, in a rural desert setting, collided in the middle of the intersection. The issue was whether the drivers could see each other in time to avoid the collision. For these type of situations the following factors are of extreme importance: the nature and degree of obstruction, size, color of the vehicles, and the contrast of the vehicles to their surroundings. In this particular situation color control becomes significant.

An accident reconstruction was performed to obtain speeds and distances. The exemplar vehicles were placed at specific distances away from the intersection, corresponding to their reconstructed speeds. Then photographs depicting each of the driver's viewpoints were taken at these placements.

The following two photographs depict each of the driver's views at 91 meters (300 feet) from the intersection. The first photograph shows the white Volkswagen's approach and the second photograph depicts the brown sedan's approach.



VIEW FROM BROWN SEDAN



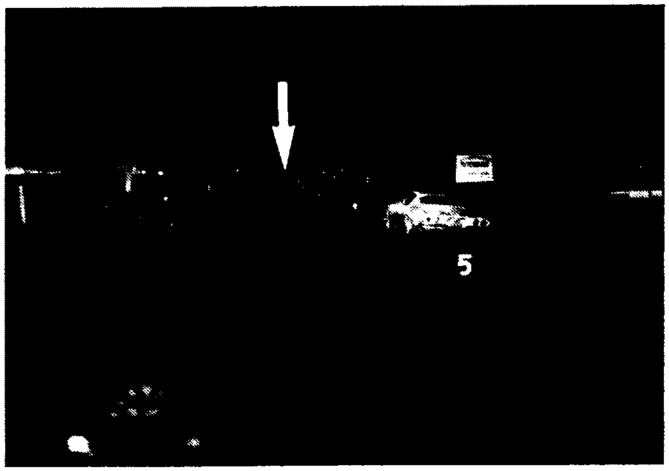
VIEW FROM VOLKSWAGEN

It was shown that even though the desert background had some veiling characteristics, the vehicles were discernable approximately 91 meters (300 feet) from the intersection. It was also shown that the veiling charateristics of the desert background were further reduced when the vehicles were placed in motion. Therefore the target detection factor was enhanced in this study.

CASE #2

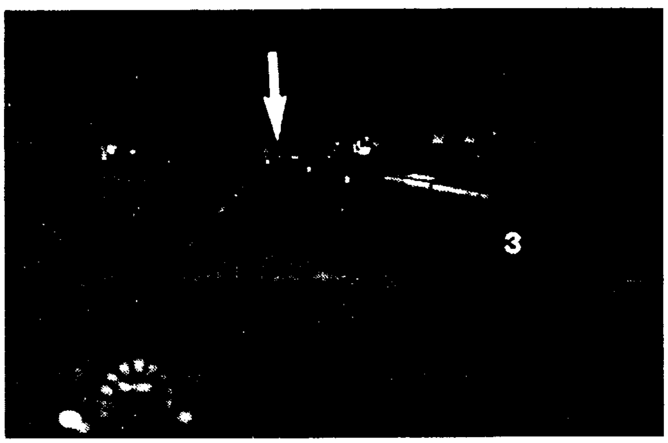
A milk truck turning left on a two lane highway was struck by an oncoming motor vehicle. A visibility study was performed using identical vehicles under similar conditions that existed on the night of the accident. On the night of the accident, the truck's wheels were white. The test truck had blue wheels so its trailer's rear wheels (location of impact) were painted white to match. The wheels of the adjacent axle were left blue for comparison and research purposes. An oncoming vehicle was positioned behind the turning truck similar to the actual accident.

Numbers in increments of hundreds of feet were placed on the right to identify the distance from the truck. Photographs were taken using the described control methods. The car was tested using both its high beams and low beams.




VIEW AT 152 METERS (500 FEET)

Pictured above at 152 meters (500 feet) with high beams, the tanker reflects back sufficiently to identify it as an object that is across the lane of travel. Additionally, the side marker lights are clearly visible.




VIEW AT 91 METERS (300 FEET)

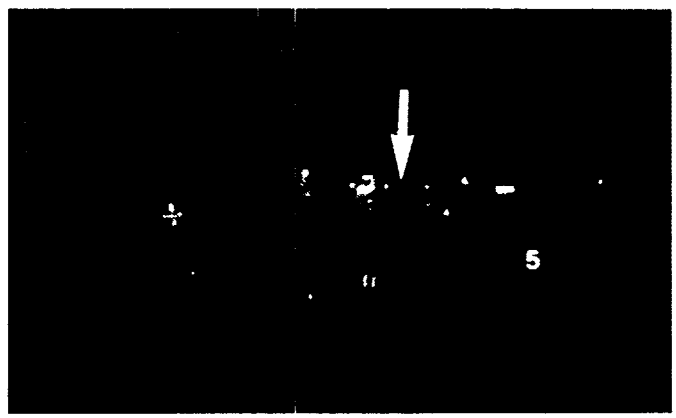
At 91 meters (300 feet) with high beams the white tractor can be detected. In addition, the white rim on the trailer is clearly visible. The same rim is also discernible from this distance with low beams. From closer distances, previously seen details become increasingly pronounced and all of the other truck and trailer features can be easily detected.

The appearance of the blue and white rims were of special interest. The white rim was able to be seen from a substantially greater distance than the blue one. This illustrates the various reflective characteristics of the different colors.

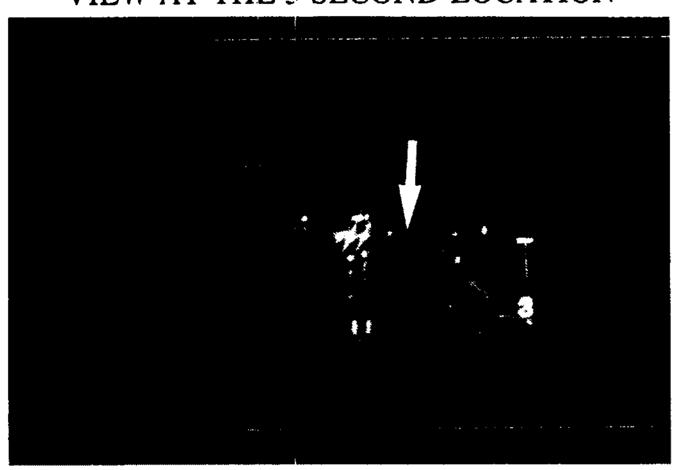
CASE #3

A tractor trailer combination was in the process of parking in a private drive on a rainy night. As the driver maneuvered his truck into the parking space, an approaching vehicle with functioning headlights collided with the trailer. All of the tractor and trailer's lights were functioning as well.

A detailed reconstruction to determine the speed of the approaching car was performed prior to this study. The speed was used to determine the location of the car and the time, at that location, along the approach, prior to impact. During the study, numbered placards were placed to the right to represent the time, in seconds, prior to impact. It was raining just prior to the test and light rain was falling during it.




VIEW AT THE 5 SECOND LOCATION



VIEW AT THE 3 SECOND LOCATION

This study indicated that the details of the tractor/trailer, particularly lights and reflectors, could be detected and associated with the actual vehicle from about the 5 second location at 64.4 km/h (40 mph) under wet conditions. The rims of the tractor are discernible at the 5 second location and the definition of the trailer is seen by the 3 second location.

CASE #4

This case involved an analysis of a reflectorized roadway fixture to evaluate its performance. A stop sign which was claimed to be positioned beyond the driver's horizontal visual field parameter of 10 degrees was evaluated.

The scene was modified to duplicate the same conditions that were present at the time of the accident. The recently installed reflectorized pavement markers were eliminated, lights were reduced to the previous levels, and an identical exemplar vehicle with state certified headlights was used.

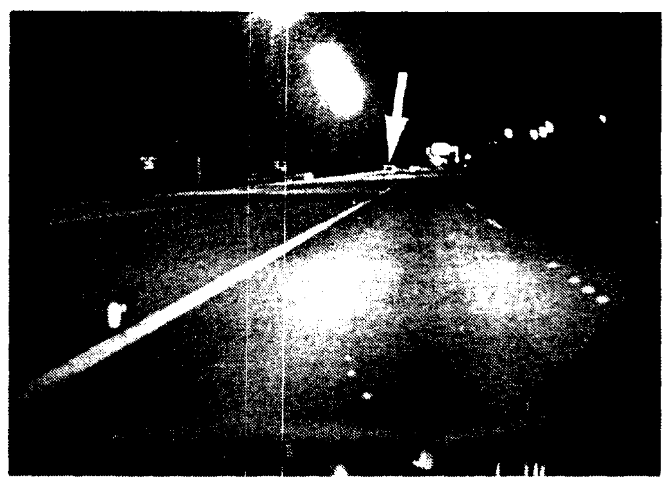
VIEW FROM 91 METERS (300 FEET)

The research was conducted and it was determined that even though the reflectorized sign was placed beyond the distance recommended in the published literature, the sign attracted sufficient attention for easy detection, recognition, and identification. The subject stop sign was detectable from close proximity up to approximately 274 meters (900 feet) away. Additionally, the octagonal shape of the back side of the stop sign for the opposite direction was clearly identifiable from a distance of 300 feet away. This would be an additional indication to an approaching driver that the intersection is stop controlled. Given the above considerations, it is difficult to explain why a driver would not be able to perceive the stop sign, due to sign placement.

CASE #5

Hi Mast illumination is being used on freeway interchanges with greater frequency. Typically, high mounted metal halide light sources are utilized to provide superior light distribution and uniformity ratios. This particular case involved the visibility of a light-colored Volkswagen with only sixty percent of the luminaries functioning in the Hi Mast fixture.

In preparation for the visibility study, the illumination of the accident scene was decreased to 60 percent efficiency. An exemplar vehicle was positioned at the impact location with it's lights on. Calibrated photographs were taken at particular distances approaching this location to depict the visibility of a oncoming driver.



VIEW FROM 136 METERS (445 FEET)

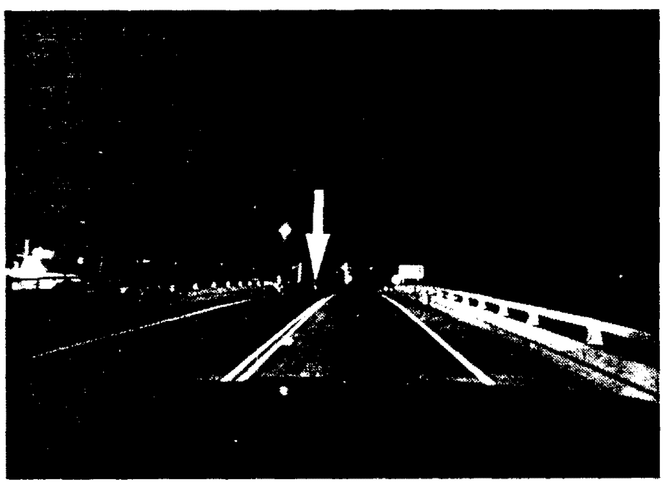
This study revealed that even with only 60% of the luminaries functioning, the vehicle could be detected from approximately 183 meters (600 feet).

CASE #6

A pedestrian was crossing a highway at night near an expressway overpass and was hit by an approaching pickup truck. The geometry of the expressway overpass formed a vertical curve and the pedestrian was crossing under a luminary which was functional at the time of the accident.

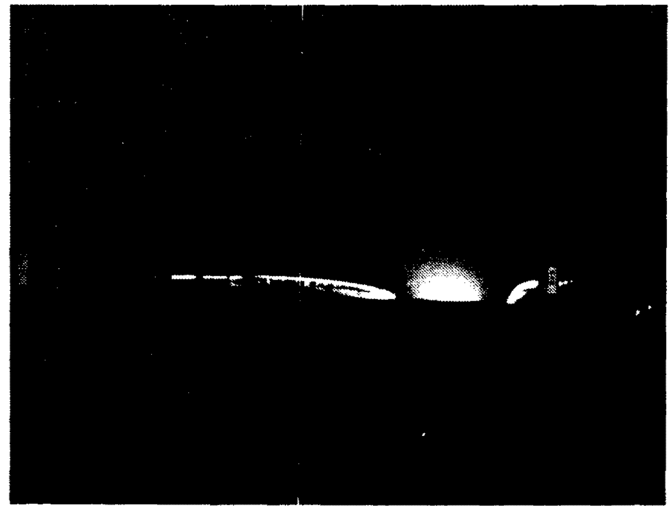
A full scale study using the prescribed methods was set up to evaluate both the geometric and nighttime sight limitations, if any, from both the pickup driver's and the pedestrian's point of view.

The results indicated that in this instance, the pedestrian had an advantage over the truck driver in terms of visibility. Once the pickup driver had proceeded to the point where the overpass is no longer an impairment on visibility then the ability to detect, identify and recognize the presence of the pedestrian on the opposite side of the road became available.



DRIVER VIEW AT APPROXIMATELY 72 METERS (235 FEET)

Although during the daytime the pedestrian would have little or no indication of an approaching pickup truck behind the overpass until it had crest the hill, at night time the conditions are different. The *headlights* of the approaching truck are visible from quite a distance. In addition, the reflection of the headlights off of the bridge railings and guardrails further announced the presence of the truck.



PEDESTRIAN VIEW BEFORE TRUCK CRESTS HILL

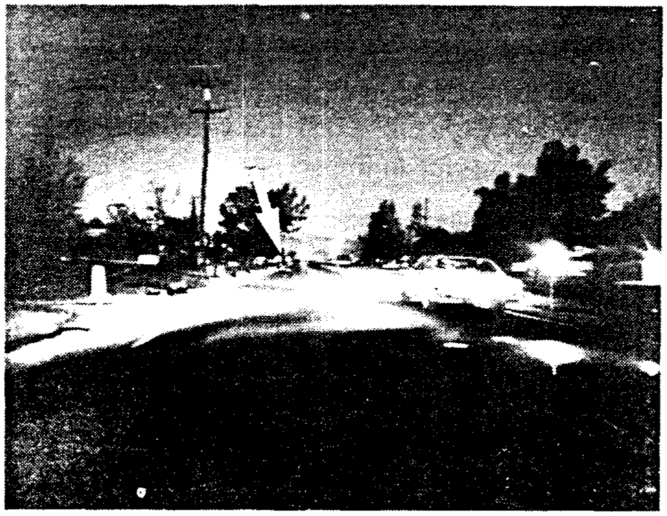
With these additional target detection factors present only during the nighttime, the pedestrian's visual perception of the approaching pickup truck is actually significantly greater than the driver's view of the pedestrian. In essence, the pedestrian's sight distance for the detection of the truck is *improved* at night.

CASE #7

Auto-pedestrian collisions have been studied under various conditions. In this particular case, two pedestrians were walking on a two lane rural highway at night against the flow of traffic. Both were dressed in blue jeans and white T-shirts. The accident occurred when two vehicles, with low beams on, were approaching the pedestrians from the rear and one vehicle was passing another. When the passing vehicle moved into the opposing lane of traffic, it struck the pedestrians.

A study was set up to evaluate the visibility of the driver in the passing vehicle. Identical vehicles and exemplar pedestrians wearing similar clothing were utilized. Placards were placed on the side of the road indicating the distance from the zero reference. Additionally, any glare from oncoming vehicle's headlights was not disturbed.

Calibrated photographs were taken at various distances away from the pedestrians to determine at what point full and partial visibility was attainable. The photograph below depicts the view at approximately 91 meters (300 feet) from the zero reference and 76 meters (250 feet) from the pedestrians.



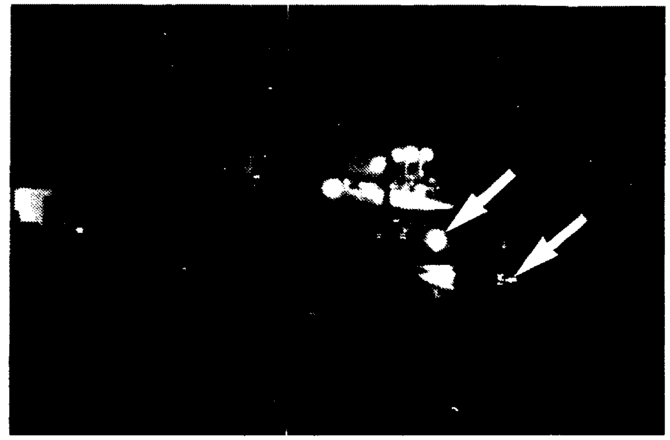
VIEW AT 91 METERS (300 FEET)

The results of the study indicated that the pedestrians could be detected and identified from a distance of approximately 122 meters (400 feet) or less with partial detection from slightly greater distances. Partial detection was attributable to the white T-shirts worn by the exemplar pedestrians.

CASE #8

A passenger vehicle was in the process of making a left turn from a local street, which had a stop control, onto a major arterial, having two lanes in each direction. A motorcycle was approaching from the left of the passenger car and the two collided. A utility pole was located in the quadrant between the two vehicles.

A study was setup to determine the effect the utility pole had on the visibility of the motorcycle during the night of the accident. An exemplar motorcycle with a state certified headlight was utilized. The motorcycle was placed at various locations along its approach and calibrated photographs were taken.



VIEW OF THE MOTORCYCLE APPROACH

The results of the study indicated that prior to the headlight moving behind the utility pole, the beam of the motorcycle headlight was reflecting off the roadway surface in front of the pole. Additionally, the beam of the motorcycle headlight created a "halo" effect when it moved behind the utility pole. In other words, light was visible on both sides of the utility pole.

CASE #9

Construction-zone accidents are of special interest. In these type of situations, equipment, traffic routing, signing and the construction zone itself must be carefully addressed. In this particular case, a vehicle traveling into a construction-zone at night, drove through warning signs and barricades and collided with a piece of construction equipment.

A study was performed to evaluate the visibility of the barricades, reflectorized pylons, and a road construction sign that was used past its rated life span. An exemplar vehicle with state certified headlights was utilized in providing the driver's visibility perspective. The subject sign and the other construction facilities were placed at the same locations that they were at the time of the accident.

The results of the study indicated that the construction-zone had more than adequate warning sign facilities. Moreover, a careful evaluation of the road construction sign revealed that although it was utilized beyond its rated life span, it still maintained useful reflective properties and provided acceptable levels of warning.

VIEW OF THE SUBJECT SIGN

VIEW OF ADDITIONAL BARRICADES

CASE #10

A bicyclist riding a small BMX bicycle at dusk was struck as he turned right at an intersection by an approaching Cadillac. The bicyclist had a posted stop sign for his approach and yet failed to stop despite the approaching Cadillac which had the right of way.

A visibility study was set up to evaluate the visibility considerations of both the Cadillac driver and the bicyclist. The subject Cadillac and an exemplar bicycle that was not equipped with headlights, reflectors, nor functional brakes were utilized. The vehicle and bicycle were placed at locations based on a reconstruction of the accident. Calibrated photographs and video using the prescribed methods were then taken from each of the operator's viewpoints. The photograph below depicts the driver's view at approximately 1 second prior to impact.

DRIVER VIEW 1 SECOND PRIOR TO IMPACT

The results of this study related that under the conditions of the subject accident, it was nearly impossible to discern the non-illuminated bicycle that had no reflectors on it, in comparison to detecting the approaching Cadillac with its headlights. The Cadillac was much more conspicuous and detectable than the small and fast moving bicycle, particularly at the correlated dusk period.

## DISCUSSION

As illustrated through the case studies the task of detection depends greatly on a number of different factors. Generally categorized, those factors are human and environmental.

The environmental factors consider items such as the expressway overpass (CASE #6) and utility poles (CASE #8), as well as the typical line of sight, daytime visibility situations. In these considerations, the geometry of the scene is of great significance in evaluating the visibility. This underlines the importance of fully reconstructing the accident scene to what it was at the time of the accident, prior to performing the visibility study.

The human factors are more complex by nature. These factors encompass elements relevant for detection such as acuity, contrast, form perception, color, etc. As mentioned earlier, extensive research has been performed in these areas for specific situations. The significance of the prescribed methodology is that it *condenses* these factors into a single yet precise comparison concept. In essence, this concept directly evaluates the target value and conspicuity of the subject.

Target value is the capability of the subject to be visible against its background and to provide early recognition and discrimination[40]. To evaluate the target value, a visibility assessment of the object against its background needs to be made and then reproduced, using the described methodology, for later analysis.

Target values can be increased or decreased by a number of different factors. For example, in certain situations rain can actually improve the task of detection (CASE #3). When water builds up on the roadway surface the reflectivity of the surface increases. Another example of improved detection is a condition called silhouette lighting. A dark object against a brighter background is readily detectable, particularly if the object is in motion. Items such as a glaring sun or headlights from a oncoming vehicle may cause discomfort or disability glare, thereby reducing the detection threshold of an object. It is factors such as these or similar factors that can adversely affect the target value.

Conspicuity is the property of a peripherally located object that is likely to lead to the object's detection and subseqent foveal fixation (and identification) by reason of its size, luminance, constrast, or other physical properties[36]. This idea is noted in a number of the case studies and is for the most part a common property. An example is the stop sign in CASE #4 positioned to the right beyond the recommended range. Due to the reflectorization and it's color, shape and size, the stop sign dominated the accident scene ahead. This property of the sign would lead to a reasonable detection distance by any approaching vehicle.

As noted earlier, the eye has a remarkable capacity for seeing minute variations between things. In evaluating the target value and conspicuity, the prescribed methodology produces a control, such as a polaroid, and makes a comparison against the actual scene. An important point of the methodology, is that the object of visibility is utilized for the comparitive purposes.

## CONCLUSION

A method has been presented by which the reconstruction, documentation, and presentation of the visibility at an accident scene is controlled and reproduced with remarkable accuracy.

The concept of a control was introduced as the basis for this accurate reproduction. It relies on the human eye's unique capability to discern minute differences in brightness when used on a comparatory basis. It was shown that this method can be successfully used both in day and night situations, and may be used to control the reproduction of the accident scene onto still photography, motion pictures, and video.

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## EDUCATION

### University Degrees

| | |
|---|---|
| • M.E. Bioengineering | University of Utah 2001 |
| • M.S. Physics | University of Utah 1986 |
| • B.S. Mechanical Engineering | University of Utah 1983 |

### Continuing Education

| | | | |
|---|---|---|---|
| • Computer Aided Multivariable Control System Design | (40 hours) | MIT | 1990 |
| • Injuries, Anatomy, Biomechanics & Fed. Regulation | (24 hours) | SAE | 1997 |
| • Special Problems in Accident Reconstruction | (40 hours) | IPTM | 1997 |
| • Biomechanics for Collision Reconstruction | (40 hours) | Texas A&M | 1998 |
| • 2001 Summer Bioengineering Conference | (24 hours) | ASME | 2001 |
| • ARC – CSI Crash Conference | (21 CEU's) | ARC – CSI | 2003 |
| • PC-Crash training | (16 hours) | MEA | 2008 |
| • Mathematica training | (16 hours) | Wolfram | 2008 |
| • Human Factors in Traffic Crashes | (40 hours) | N. West. U. | 2012 |
| • Heavy Vehicle Crash Reconstruction | (40 hours) | N. West. U. | 2013 |

### Continuing Education and Experience in the Following Areas:

- Biomechanics, biomaterials, and the effect of dynamic loads and vibration on human tissue
- Failure analysis of human structures, mechanical, electro-mechanical, and electronic devices
- Accident reconstruction
- Anatomy / physiology
- Multibody dynamics
- Vehicle dynamics
- Human perception systems, physics, modeling, and physiology
- Mathematical modeling of dynamical systems
- Physics of imaging systems including use and applications
- Design and implementation of electronic hardware and firmware
- General electronics and electrical engineering principles

## TEACHING EXPERIENCE

| | |
|---|---|
| • Lecture instructor: Physics of the Human Body | University of Utah |
| • Lecture instructor: Modeling and Control of Dynamical Systems | Evans & Sutherland |
| • Lab instructor: Ionizing Radiation Transducers | University of Utah |

- Lab instructor: Physics of Photography — University of Utah
- Teaching Assistant: Statics — University of Utah
- Various presentations in the areas of accident reconstruction, investigation, and biomechanics

**<u>PROFESSIONAL EXPERIENCE</u>**

**PHYSICIST**
**MECHANICAL / BIOMECHANICAL ENGINEER**
**ACCIDENT RECONSTRUCTIONIST — CF & E, Inc. — 1993 – Present**

- Evaluate injury claims, determine and analyze mechanisms of trauma from direct impact, vibration, and inertial forces.
- Reconstruct and investigate accidents, determine impact forces, accelerations, changes in velocity, and occupant dynamics.
- General product failure analysis and engineering consulting including automobile systems and other systems and products such as:
    - Investigate, analyze, and determine the failure mode(s) of various vehicle components such as airbags, tires, etc.
    - Investigate, analyze, and determine the failure mode(s) of various human structures.
    - Investigate, analyze, and determine the failure mode(s) of other mechanical and electronic devices such as: coffee makers, electric blankets, garage door openers, and other electric and mechanical devices
- Analyze, interpret, and report data from impact and vibration testing.
- Create 3D animated demonstrations for courtroom use.

**ENGINEER — Evans & Sutherland — 1986 – 1993**

- Developed multi-body mathematical models of automobiles and tractor semi-trailer vehicles.
- Programmed these models into a computer for use in training and engineering simulator systems.
- Developed mathematical models of other dynamical systems.
- Developed software to allow communication between a vehicle simulator and an Alliant FX-80 mini super computer allowing an interactive link between the driver in the simulator, the vehicle dynamics model, and the 3D visualization system.
- Designed, developed, and implemented the instrumentation in a vehicle simulator to effect an interactive link between a driver in the vehicle simulator, the vehicle dynamics, and the real-time 3D visual display.
- Co-authored a proposal, feasibility study, and preliminary budget for a complete truck driver training simulator system.
- Co-developed, designed, and implemented a complete “proof of concept” vehicle simulator system to prove the feasibility our proposal. This simulator included a vehicle cab with full interactive controls and instruments, a vehicle dynamics model, and real-

time 3D visual system.

- Developed and programmed software for a head tracking projection system.
- Developed and programmed mathematical models of a human perception system, including the vestibular and propreoceptive systems for research and control of a full motion simulator system.
- Developed and programmed software for an X-Windows based 3D modeling and rendering software.

**ENGINEER** **Hercules Aerospace 1983 – 1986**

- Designed and developed software, electronic hardware, and mechanical tooling to perform dynamic impact testing of carbon composite Space Shuttle rocket motors. The testing determined the effects of impact loads on the carbon composite material and if the damage threatened the integrity of the rocket motor’s structure and measured penetration, acceleration, and vibration.
- Developed and supervised various non-destructive test procedures for empty and loaded rocket motors and other missile components in order to determine failure mode(s) and structural integrity.
- Analyzed the data, and reported the results.
- Designed and implemented the electronic hardware, software, data acquisition systems, mechanical tooling, and documentation for these tests.
- Principle development engineer for the flight instrumentation for the Peacekeeper (MX) missile third stage rocket motor.
- Interpreted the acquired data from static testing of the Peacekeeper third stage to determine performance and structural response of the rocket motor.
- Extensive work regarding testing and analyzing the general integrity of the missile components built by Hercules Aerospace.

**ENGINEER** **Terra Tek Research 1981 – 1983**

- Supervised the Computer Controlled Testing area.
- Designed and programmed software to dynamically control the testing of re-constituted soil samples for the Defense Nuclear Agency. I compiled, interpreted, analyzed, and reported all the test results to the client.
- Designed and implemented the interface between the computer, servo system, and instrumentation.
- Compiled, interpreted, analyzed, and reported the results of other tests.
- Extensive work regarding mechanical failure analysis

## OTHER EXPERIENCE

- Independent testing investigating occupant and vehicle dynamics during low speed rear end collisions.
- Testing investigating occupant and vehicle dynamics during high speed collisions.
- Read, write, and speak the french language.

## PAPERS

- Co-author "Notes on Real-Time Vehicle Simulation," a text book which accompanied a course taught at the 1989 SIGGRAPH conference.

## PROFESSIONAL ORGANIZATION MEMBERSHIPS

- The Society of Automotive Engineers (SAE)
- The National Association of Professional Accident Reconstruction Specialists (NAPARS)
- International Society of Biomechanics (ISB)
- American Society for Testing and Materials (ASTM)
    - Committee Member of:
        - E07 on Nondestructive Testing
        - E08 on Fatigue and Fracture
        - E28 on Mechanical Testing
        - E30 on Forensic Sciences
        - E48 on Biotechnology
        - E58 on Forensic Engineering
        - F09 on Tires
        - F13 on Pedestrian/Walkway Safety and Footwear
        - F24 on Amusement Rides and Devices
- American Society of Mechanical Engineers (ASME)

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# July 1, 2014

RE: ***Rates for David Ingebretsen, M.S., M.E. as of July 1, 2014***

The following rates apply for cases filed in the state of Nevada for David M. Ingebretsen

**Hourly rates:**

- All consulting, travel including air travel time, preparation time, etc. except as noted below: $275.00 per hour
- Time at trial, arbitration, etc.: $325.00 per hour + expenses
- Deposition* when held out of state: $325.00 per hour
- Deposition* when held at my office: $325.00 per hour
- Deposition* when held in Salt Lake at an alternate location: $325.00 per hour plus travel
- Expenses: As incurred
- A refundable $2500.00 retainer may be required before work begins.
- **Costs to be paid by noticing attorney for a deposition must be paid in advance.**
- A refundable negotiable retainer and airfare expenses must be paid in advance of all trials
- A 2 (two) hour cancellation fee, plus non-refundable expenses, plus preparation time will be assessed for canceled/changed trials, depositions, arbitrations, inspections, etc. when the notice of cancellation/change is not received a minimum of 48 hours (2 working days) in advance of the scheduled appearance to the party who cancels the event.
- Consulting pro-rated in 0.1 hour increments. Testimony pro-rated in 1.0 hour increments.

**EXCEPTIONS:**
At this time, travel *time* from Salt Lake City to and from Las Vegas and Reno is not assessed.
For testimony:

- Airfare and transportation costs are not waived. Where possible, travel expenses will be split between cases.
- Billing time for inspections includes travel time to and from an airport virtual office to the work location, and time at the work location. That is, what would be normally billed if the CF&E office were physically located at the airport.
- Preparation time, etc. for the inspection is billed normally as outlined above.

*These rates and policies are subject to change without notice.*

**Travel expenses are billed to the noticing attorney per Discovery Commissioner ruling. Costs to be paid by noticing attorney for a deposition must be paid in advance.*

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| State | Client/Case Name | Case# | Hired By | Date of Loss | Attorney/Agent | Deposed | Testified |
|---|---|---|---|---|---|---|---|
| UT | Abbott v. City of St. George, et al. | 090501859 | Defense | 7/6/2008 | Linette Hutton | | 8/31/2012 |
| CA | Acoba, et al. v. State of California Department of Transportation, et al. | CIVSS 817887 | Defense | 12/19/2007 | K.C. Ward | 11/13/2013 | 1/15/14, 1/16/14, 1/23/14 |
| NV | Alfaro & Reyes v. Bailey | A-10-627597 | Plaintiff | 7/17/2010 | Peter Christiansen | 5/23/2012 | |
| NV | Alvares, et al. v. McMullin, et al. | 2:13-cv-GMN-CWH | Plaintiff | 5/17/2012 | Jacqueline Bretell | 10/31/2014 | |
| NV | Alvarez v. Mulgado-Oliva, et al. | A-13-678755 | Defense | 6/5/2012 | Jason Fowler | 2/2/2015 | |
| NV | Angel v. Tennis | A605846 | Defense | 6/6/2008 | Phillip Emerson | 8/30/2013 | |
| NV | Angulo v. Williams, et al. | A-12-658606-C | Plaintiff | 11/18/2011 | Todd Terry | 10/16/2014 | |
| NV | Annesley v. Ellman, et al. | A522182 | Defense | 7/26/2005 | Michael Nunez | 4/24/2009 | |
| NV | Artuz v. Northern Pipeline | A590069 | Plaintiff | 7/31/2007 | Brad Mainor | 2/16/2011 | |
| NV | Bacon & Paunessa-Bacon v. Lair, et al., Veolia Transportation Inc., et al. | A572449 | Defense | 3/14/2009 | George Ranalli | For Defense 3/21/2013 | |
| NV | Bacon & Paunessa-Bacon v. Lair, et al., Veolia Transportation Inc., et al. | A572449 | Plaintiff | 3/14/2009 | Robert Vannah | | For Plaintiff 5/8/2014 |
| UT | Barrientos, Nelson & Carpenter v. Jones, Burnett & Ogden City et al. | Civil No. 060905807 WD | Plaintiff | 12/13/2005 | Robert Sykes | 7/1/2008 | 11/5/2009 & 11/6/2009 |
| UT | Beale v. Marriott Vacation Club Int'l, Inc. dba Marriott Ownership Resorts, Inc. | Civil No. 2:10cv00456 | Defense | 1/1/2008 | Joe Minnock | 6/22/2011 & 8/19/2011 | |
| NV | Beckstead v. Martin, Jr. | A581968 | Plaintiff | 7/19/2008 | Matthew Hoffman | 3/29/2011 | |
| UT | Berry v. Chuck-A-Rama Buffet, Inc. | Civil No. 070401784 | Plaintiff | 11/23/2006 | Dan Oswald | 10/15/2010 | |
| NV | Baggett v. Reed and Washington Group International | A498798 | Plaintiff | 11/14/2003 | Valerie Macris | 8/28/2006 | 8/12/2009 |
| NV | Barrera v. Western United Insurance Company, et al. | 2:09-cv-02289-ECR-PAL | Defense | 4/21/2008 | George Ranalli | 3/14/2011 | |
| NV | Blevins v. Chapman Las Vegas Dodge | A567573 | Defense | 7/18/2006 | Gary Ashman | 3/30/2012 | |
| NV | Boehm v. Casablanca Resorts LLC | A525718 | Plaintiff | 8/3/2004 | Carol Hay | 7/7/2009 | |
| NV | Boudreau v. Opbiz LLC | A590511 | Defense | 11/10/2008 | Adrianne Duncan | 8/18/2010 | |
| NV | Brown v. Cheyenne | District Court 573721 | Plaintiff | 10/18/2006 | Benjamin Cloward | 4/26/2010 | |
| UT | Bryner v. Salt Lake County, Miller, Potter & Romero et al. | 2:06cv00377 TC | Defense | 5/9/2004 | Valerie Wilde | | 8/5/2009 |
| NV | Calhoon v. United States Bowling Congress, et al. | A-11-635644-C | Plaintiff | 2/22/2009 | Bill Palmer | 9/6/2013 | |
| NV | Carlson v. Smith, et al. | 08-TRT00118 1B | Defense | 12/19/2006 | David Zaniel | 8/25/2010 | 1/6/2011 |
| NV | Carmosino v. Union Pacific Railroad Company | A-636732 | Plaintiff | 5/8/2009 | George Bochanis | 6/25/2013 | |
| CA | Carter v. Kone, Inc. | RG08366269 | Defense | 1/19/2006 | Nandor Krause | | 2/14/2012 |
| UT | Casalaspro v. Griffin | 128000315 | Defense | 6/5/2011 | Anna Nelson | | 7/20/2012 |
| CA | Castillo v. Allen & Benedict Exchange, Inc., Lodgeworks, L.P., E. Kent Halverson, Inc. et al. | Superior Court 26-55150 | Defense | 1/22/2009 | Allan Isbell | 11/14/2012 | |
| CA | Castro v. Segue Construction, Inc., et al. | SCV 249483 | Defense | 10/20/2010 | Allan Isbell | 7/22/2013 | |
| NV | Cavosie & Stevens v. ICON Health & Fitness; Boulder Palm, LLC, et al. | A490303 | Plaintiff | 7/22/2004 | John DaCorsi | | 7/15/2009 |
| UT | Christensen v. Werner Co., Inc., Lowe's H.I.W., et al. | Civil No. 120902533 | Plaintiff | 6/7/2010 | Kristina Otterstrom | 3/25/2013 | 4/15/2014 |
| UT | Christiansen v. Bryan Trucking, Watterson | Civil No.: 1:09-cv-61 | Plaintiff | 12/21/2007 | Bob Sykes | 2/14/2011 | |
| NV | Christman v. Bergstein, Santor, Argus Protection Services LLC d/b/a US Protect, et al. | A596861 | Defense | 8/9/2007 | Lori Siderman | 7/23/2012 | |
| NV | Cooper v. Ransome, McKenna and California Hotel and Casino | A09-590099-C | Defense | 3/28/2009 | Tom Dillard | 1/26/2011 | |
| UT | Cox v. Lutu | Civil No. 090400916 | Defense | 8/16/2007 | Lynn Davies | | 11/8/2011 |
| NV | Crosslin v. Sammy's Woodfired Pizza, et al. | A564879 | Plaintiff | 6/25/2006 | Afshin Tadayon | 5/7/2010 | |
| UT | Cunningham v. Toner | 070907253 | Plaintiff | 1/26/2007 | Stephen Kelsen | | 3/23/2010 |
| NV | Cutler v. Drabant | A528527 | Plaintiff | 11/15/2004 | Paul Powell | 12/4/2008 | |
| NV | Del Quadro v. BPM Senior Living Company | A592668 | Defense | 2/6/2008 | Maria Toto | 11/22/2010 | |
| NV | Dorsey v. Weisner, et al. | A-13-686290-C | Defense | 8/7/2011 | Jason Fowler | 12/12/2014 | |
| NV | Ealy v. Regional Transportation Commission of Southern Nevada, et al. | A-10-615208-C | Plaintiff | 10/3/2008 | Jonathan Hicks | 10/17/2011 | 9/18/2012 |
| NV | Eastep v. Flores; Dale Tile Services | A504928 | Plaintiff | 4/23/2004 | Robert Eglet | 10/22/2010 | |
| NV | Ebarb v. Jamison | A505497 | Defense | 1/30/2005 | Jim Olson | 7/16/2009 | |
| UT | Eldredge v. State Farm Mutual Automobile Insurance Company | 2:12CV900DAK | Plaintiff | 6/7/2011 | Joseph Jardine | | 11/17/2014 & 11/18/2014 |
| NV | Esoldi v. Farrell | A629477 | Defense | 12/14/2008 | George Ranalli | 7/25/2012 | |
| UT | Flaming Gorge Corporation v. McGregor | Civil No. 070800009 | Defense | 7/21/2007 | James Watts | | 10/15/2009 |
| NV | Francis v. Hales | A-13-675468-C | Defense | 8/31/2011 | Stacey Upson | | 2/17/2015 |
| NV | Friedman & Lamb v. Malfa & Baize, et al. | A-13-693033-C | Defense | 4/19/2013 | Michael Nixon | 2/26/2015 | |
| UT | Friel v. Ewoniuk | Civil No. 070917104 | Plaintiff | 11/29/2005 | George Waddoups | 1/16/2011 | |
| NV | Fryman & Hayes v. Master Toddy, Inc., et al. | A552329 | Plaintiff | 11/28/2005 | Robert Eglet | 7/14/2009 | |
| NV | Garboski v. CLS Nevada, LLC et al. | A09602903C | Plaintiff | 3/11/2009 | Daniel Foley | 6/20/2011 | |
| NV | Garcia v. Brown, et al. | A673675 | Plaintiff | 6/27/2011 | Kimball Jones | 10/10/2014 | |
| CA | Garcia, Ork & Johnson v. Cornejo, et al. | HG07 322923 | Defense | 4/7/2005 | Judy Anderson | 1/25/2010 | 6/10/2010 |
| NV | Gill, et al. v. United Parcel Service, Inc., et al. | A-12-670742-C | Plaintiff | 11/8/2011 | Mark Henness | 8/25/2014 & 11/10/2014 | |
| UT | Golden v. Salt Lake City Corp. | 110415345 | Plaintiff | 2/4/2010 | Trevor Bradford | 1/31/2014 | |
| NV | Gonzales v. Cafferty, et al. | A-12-673390-C | Plaintiff | 12/16/2011 | Pete Christiansen | 11/21/2014 | |
| NV | Gonzalez v. Cashman Equipment Company, Araiza-Bravo, et al. | A-11-647859-C | Plaintiff | 11/2/2009 | David Churchill & Jolene Manke | 2/24/2014 | |
| CA | Gonzalez v. Sarabia, SuperShuttle Los Angeles, Inc., Furry, et al. | 30-2010-0356975 | Defense | 4/29/2008 | Sharon Collier | | 4/7/2011 |
| NV | Guillen v. Schneider, et al. | A-12-660862-C | Defense | 11/19/2010 | Jason Fowler | 7/21/2014 | |
| NV | Gunning v. Foster & G.F. Trucking, Inc., et al. | A509153 | Defense | 10/1/2003 | Julie Kruze | 1/19/2009 | |
| NV | Hamrick v. Clagg, Franks, et al. | A565221 | Defense | 6/8/2007 | Jason Fowler | 8/23/2010 | |
| UT | Halladay v. Blakely | 090402595 | Defense | 1/19/2009 | Rafael Seminario | 1/10/2010 | |
| UT | Hamilton v. Day | Civil No. 130906117 | Defense | 9/22/2009 | Jeremy Stuart | 7/7/2014 | |
| UT | Harrison v. CNL Income Properties, Inc., Brighton Resort, LLC, et al. | 090400435 | Plaintiff | 2/16/2008 | Lynn Harris | 5/11/2010 | |
| NV | Hazlett et al. v. American Asphalt & Grading Company, et al. | A538519 | Defense | 4/6/2005 | D. Lee Roberts | 2/9/2009 | |

| State | Client/Case Name | Case# | Hired By | Date of Loss | Attorney/Agent | Deposed | Testified |
|---|---|---|---|---|---|---|---|
| NV | Hernandez v. Herrington & Veolia Transportation Services, Inc., et al. | A-11-646347-C | Defense | 9/10/2009 | Jacqueline Bretell | 3/4/2013 | |
| NV | Hickle v. Mackey | A540257 | Plaintiff | 5/10/2005 | Tracy Eglet | 1/29/2009 | |
| UT | Holden v. Peterson | 138900481 | Defense | 3/17/2013 | Trent Waddoups | | 4/29/2014 |
| UT | Horton v. Purity International Inc. and/or Travelers | 10-0852 | Defense | 8/12/2010 | Mark Sumsion | | 4/12/2011 |
| UT | Hulet v. Low | TRH 050 11 | Plaintiff | 1/30/2009 | Donald Winder | | 12/6/2011 |
| NV | Hurvitz v. Hartford Insurance of the Midwest | No Case Number | Plaintiff | 3/3/2011 | Brad Wibicki | | 11/8/2012 |
| CA | Huynh & Long v. West Bay Builders, Inc., et al. | CGC-10-498583 | Defense | 2/4/2010 | Sharon Collier | 1/18/2012 | |
| NV | Jacoby v. Kassouf | A-12-655331-C | Defense | 12/6/2011 | Stephen Rogers | | 2/13/2015 |
| UT | Johnson v. Montoya aka Luz Giraldo & Montejo aka Diego Pardo, et al. | Civil No. 080920603 | Defense | 8/22/2007 | Michael Lichfield | 11/10/2010 | 9/1/2011 |
| NV | Johnson-Zvulun v. Paz-Lima & Safelite Group, Inc., et al. | A-10-629238-C | Plaintiff | 2/24/2009 | Brian Lunt | 1/9/2013 | |
| NV | Kehr v. Trigler TT3 Corp, et al. | A618454 | Plaintiff | 10/29/2009 | Robert Eglet | 5/8/2012 | |
| NV | Keller & Baldomar v. Stiegler, et al. | A-13-677147-C | Defense | 12/12/2011 | Vicki Driscoll | 10/29/2014 | |
| NV | Knowles v. Moshe, Desert Cab, et al. | A09065623 | Plaintiff | 3/5/2009 | Matthew Hoffman | 3/25/2011 | |
| UT | Kranendonk v. Gregory & Swapp, PLLC, et al. | Civil No. 100923050 MP | Defense | 6/19/2006 | Gregory Sanders | 1/13/2012 | 11/25/2014 & 3/5/2015 |
| UT | Lamadeleine v. Ogden City Corporation, Wright Way Lawn & Tractor & Wright | Civil No. 120904439 | Defense | 12/23/2010 | Anna Nelson | 3/18/2014 | |
| NV | Leroy v. Delgrosso | A-11-648549-C | Defense | 11/19/2009 | Andrew VanNess | 8/21/2013 | |
| NV | Litke v. Santos, et al. | A610992 | Defense | 10/13/2009 | John Kirk | | 10/8/2014 |
| CA | Lopez-Trujillo v. Foster Poultry Farms, et al. | CV002493 | Defense | 6/19/2010 | Sharon Collier | | 6/6/2013 |
| NV | Macklin & Johnson v. Montest, et al. | A-12-655534-C | Defense | 3/29/2010 | David Squires | 5/15/2014 | |
| CA | Mann v. Castrejon & Desert Coastal Transport Inc., et al. | CIVDS 1014172 | Plaintiff | 6/26/2010 | William Portello | 9/5/2012 | |
| NV | Martinez v. Nevada Yellow Cab, Inc. & Feda, et al. | A579951 | Plaintiff | 10/31/2008 | Brian Harris | 8/16/2010 | |
| UT | Martinez & Tejeda v. Salcido | 148700679, 148700680 & 148700681 | Defense | 6/16/2013 | Bill Hansen | | 12/3/2014 |
| UT | Maxfield v. Burdis | 070700310 | Plaintiff | 5/1/2006 | Matt Driggs | 8/15/2008 | 2/5/2009 |
| NV | McCloud & Carneado, et al. v. ATC/Vancom Inc., et al. | A538914 | Defense | 7/19/2006 | D. Lee Roberts | 10/9/2009 | 8/27/2010 |
| NV | McHale v. Kay | A545385 | Plaintiff | 6/1/2007 | Christian Smith | 4/15/2010 | |
| UT | McNamara & Beckstead v. S.T. Distributing, Stacks & Daley, et al. | 070400404 | Plaintiff | 10/7/2005 | Denton Hatch | 2/10/2009 | |
| NV | McWhorter v. Nevada Ready Mix Corporation, et al. | A513841 | Plaintiff | 6/9/2004 | Michaela Tramel | 2/3/2009 | |
| NV | Medlock v. Batey, et al. | A586779 | Plaintiff | 11/2/2007 | Glenn Paternoster | 6/11/2010 | |
| NV | Mesa v. Blake & United Road Towing, Inc., et al. | A-11-630441-C | Defense | 12/7/2008 | Richard Tanasi | 1/31/2013 | |
| UT | Miller v. Allred & Admiral Beverage a Utah Corporation d/b/a M&M Distributing | 100902254 | Defense | 1/22/2007 | Greg Sanders | 8/31/2011 | |
| UT | Miller v. Ogden City Corporation d/b/a Mount Ogden Golf Course | Civil No. 070902205 | Plaintiff | 10/1/2006 | Peter Summerhill | 6/19/2008 | 4/21/2010 |
| NV | Miller v. Sisolak | A-12-665098-C | Defense | 7/28/2010 | Andrew VanNess | 2/23/2015 | |
| NV | Miranda v. Walsh & Benchmark Properties, et al. | 08A557586 | Defense | 1/16/2008 | Tom Deaver | 4/17/2009 | |
| NV | Mofford v. Castrellon et al. | A555539 | Plaintiff | 1/22/2007 | Kevin Hansen | 7/29/2010 | |
| NV | Montano, Reveles, et al. v. Kesterson, et al. | A-12-654601-C | Plaintiff | 2/21/2010 | Jacqueline Bretell | 5/23/2014 | |
| NV | Montano & Vega v. Pohlmeier, et al. | A-13-686429-C | Defense | 12/14/2012 | Vicki Driscoll | | 10/20/2014 |
| UT | Morah v. Wilde | Civil No. 110403091 | Plaintiff | 2/3/2009 | Mike Petro | | 4/16/2013 |
| UT | Morris v. Hobby Lobby Stores, Inc | 070700663 | Plaintiff | 10/31/2006 | Lynn Harris | 7/21/2009 | 10/20/2009 & 10/21/2009 |
| UT | Murray v. Bybee | 100101064 | Defense | 11/10/2006 | Stacy McNeill | 5/23/2011 | |
| UT | Nixon v. Gardner & Scotvale Electrical Systems, Inc., a Utah corporation | 070903193 | Plaintiff | 7/15/2004 | Robert Dahle | 1/29/2010 | |
| UT | Newsome v. Fuerherm & Newsome | Civil No. 120902344 | Defense | 1/15/2011 | Sean Miller | | 6/13/2013 |
| NV | Novick v. Panelized Structures, Inc., Nielsen, et al. | A521975 | Plaintiff | 9/1/2004 | John Shook | | 4/22/2011 |
| CA | Ostrovsky v. Union Pacific Railroad Co. | A-10-615288 | Plaintiff | 10/21/2009 | Anthony Petru | 11/20/2012 | 5/17/2013 |
| NV | Palos v. Southern California Regional Rail Authority et al. | PC051298 | Defense | 9/12/2008 | D. Lee Roberts | 10/29/2012 | |
| NV | Parker v. Carlson & Nevada Yellow Cab Corporation et al. | A571921 | Plaintiff | 10/1/2006 | Glenn Paternoster | | 3/26/2012 |
| NV | Perez v. Ghallab | A-11-637508-C | Plaintiff | 3/31/2010 | Glenn Paternoster | 3/1/2013 | 10/18/2013 |
| NV | Perroni & Barton v. Salgado-Baez, Baez & Salgado, et al. | A492719 | Defense | 12/1/2003 | Trey Dellinger | 1/20/2009 | |
| UT | Perry v. Utah Department of Transportation, et al. | 090904969 | Plaintiff | 6/4/2008 | Dan Wilson | 8/9/2010 | |
| NV | Phillips v. Las Vegas Mini Grand Prix, Inc. a Nevada corporation, et al. | A567748 | Plaintiff | 11/10/2006 | Brook Hammond | 11/9/2009 | |
| NV | Pittman v. Wyndham Vacation Resorts, Inc., et al. | A581217 | Plaintiff | 2/21/2007 | Brian Harris | 3/1/2012 | |
| UT | Ramirez & Campas v. Chatfield | Civil No. 130407113 | Defense | 7/15/2011 | Anna Nelson | | 6/19/2014 |
| NV | Reeve v. Rodriguez | A-09-602531-C | Plaintiff | 1/19/2009 | Erik Ahlander | 11/28/2011 | |
| NV | Reichardt v. Blue Martini | A-10-608169-C | Plaintiff | 3/8/2009 | Christian Smith | 11/11/2011 | |
| NV | Richardson v. Milano, et al. | A-13-676302-C | Plaintiff | 3/31/2012 | Bryan Boyack | 10/1/2014 | |
| CA | Rochetto v. Richey | Clark County 08A557757 | Defense | 6/7/2007 | Kenneth C. Ward | 6/15/2010 | |
| NV | Rodriguez, et al. v. Stafford, AAA Nortern California Nevada, et al. | A-12-667244-C | Defense | 4/7/2011 | Jason Fowler | 9/10/2014 | |
| NV | Root v. Albrecht | A546108 | Plaintiff | 8/30/2005 | Colin Bringhurst | 9/8/2010 | 3/8/2011 |
| NV | Ruelas v. Forrest & Horner, et al. | A-12-670171-C | Defense | 8/19/2011 | John Kirk | 9/24/2014 | |
| NV | Sanchez v. Haskins | A614584 | Plaintiff | 5/2/2008 | George Bochanis | 7/31/2013 | |
| UT | Sanders & Price v. Yellow Cab Drivers Association Inc., et al. | Civil No. 2:11cv00595 | Defense | 8/19/2010 | Linette Hutton | 11/2/2012 | |
| UT | Sawyer v. Prax | Civil No. 080923529 | Defense | 7/10/2007 | Joel Kittrell | 2/25/2011 | |
| UT | Seidel v. AAA Insurance Company | Arbitration | Defense | 8/29/2011 | Anna Nelson | | 4/14/2014 |
| NV | Senn v. Arziarien | A651246 | Defense | 5/13/2011 | Ernest Moran | 7/26/2013 | 1/27/2015 |
| NV | Sill v. Tan | A-11-636270-C | Plaintiff | 4/19/2009 | Cristina Evans | 10/31/2012 | |
| NV | Smith, Jr. & Smith v. Dyer & Spectrum Surveying & Engineering, Inc., et al. | A544414 | Plaintiff | 5/12/2006 | Glenn Paternoster | 10/8/2009 | |
| UT | Sommer v. Jenkins & Haslem | 090908827 | Defense | 12/22/2005 | Lynn Davies | | 4/4/2013 |
| NV | Spurlock, et al. v. Neal & Republic Silver State Disposal, Inc., et al. | A571394 | Defense | 2/14/2007 | Richard Pyatt | 11/26/2012 | |
| UT | State of Utah v. Krueger | 121402525 | Prosecution | 9/19/2010 | Timothy Taylor | | 3/28/2013 |
| UT | State of Wyoming v. Krekorian | CR-2011-220-R | Defense | 9/13/2011 | David Steffensen | | 4/11/2012 |
| UT | Strate v. Mainord | 080401273 | Plaintiff | 3/7/2007 | Damion Kidd | 3/27/2009 | |

| State | Client/Case Name | Case# | Hired By | Date of Loss | Attorney/Agent | Deposed | Testified |
|---|---|---|---|---|---|---|---|
| NV | Tadlock v. Del Rosso | A-10-629885-C | Plaintiff | 11/25/2008 | Christian Smith | 6/10/2013 | |
| NV | Taylor v. Eskildson, et al. | CV2009-016146 | Plaintiff | 8/17/2007 | Mark Jackson | 12/14/2010 | |
| NV | Thompson v. Apple Management, Inc., d/b/a Sandpiper Apartments, et al. | A-11-650359-C | Plaintiff | 7/13/2011 | Brian Harris | 5/15/2013 | |
| NV | Thurber v.Yamaha Motor Corporation, U.S.A., et al. | A512345 | Plaintiff | 10/31/2003 | Farhan Naqvi | 4/14/2009 | |
| WY | Tietema v. National Oilwell Varco, Inc., et al. | 1:14-cv-00039-sws | Defense | 5/13/2013 | Nathan Morris | | 1/29/2015 |
| NV | VanWagner v. Premire Exhibitions, Inc., et al. | 08-A562158-C | Plaintiff | 5/15/2006 | David Thomas | 8/25/2011 | |
| NV | Vesco v. State Farm Mutual Automobile Insurance Company dba State Farm, et al. | 2:13-cv-01490-JAD-CWH | Plaintiff | 2/25/2011 | Michael Haight | 9/3/2014 | |
| NV | Vidrio-Michel, et al. v. Rochell | A-12-665616 | Plaintiff | 4/5/2011 | Kimball Jones | 1/16/2015 | |
| NV | Vollmer v. Cox Communications EBD Holdings, Inc., et al. | A-10-628332-C | Defense | 11/10/2008 | George Ranalli & Jacqueline Bretell | 12/1/2012 | |
| NV | Villareal v. Palomino | A525285 | Plaintiff | 6/21/2005 | Adam Gauz | 1/30/2009 | |
| NV | Walker v. Bell, et al. | A-12-672578-C | Defense | 10/7/2011 | George Ranalli | | 8/29/2014 |
| NV | Warmsley v. Aesculap, Inc., et al. | 2:07-CV-00812-LDG-LRL | Plaintiff | 4/27/2005 | G. Dallas Horton | 3/6/2009 | |
| UT | Webster v. The State of Utah; University of Utah Hospital, et al. | Civil No. 100921188 | Plaintiff | 11/19/2008 | Francis J. Martin | 4/22/2014 | |
| NV | Westbrook v. Jacobson, et al. | A-13-683999-C | Plaintiff | 2/5/2012 | Joseph A. Gutierrez | 8/22/2014 | |
| UT | Wilcox v. Brough, et al. | 120700956 | Defense | 11/29/2008 | Nathan Morris | 11/12/2014 | |
| UT | Wilson & Valdmann v. Krueger | Civil No. 110400083 | Plaintiff | 9/19/2010 | Jack Helgesen | 4/9/2013 | |
| NV | Wise v. Veolia Transportation Services, Inc., et al. | A584027 | Defense | 8/7/2008 | George Ranalli | 8/28/2013 | |
| UT | Woodland v. Woodland | Civil No. 090402753 | Plaintiff | 11/28/2008 | Ryan Christensen | | 12/17/2013 |
| UT | Xiao Yang Li, et al. v. The University of Utah, et al. | Civil No. 050903626 | Plaintiff | 4/7/2003 | Robert Sykes | | 8/5/2009 |
| NV | Young v. Kim, et al. | A-11-653670-C | Plaintiff | 11/22/2011 | Kara Xidis & Tom Christensen | 2/18/2014 | |
| UT | Young v. Waite | Arbitration | Defense | 7/8/2012 | Anna Nelson | | 6/16/2014 |

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CLERK OF THE COURT

**SAO**
MARJORIE HAUF, ESQ.
Nevada Bar No. 8111
IDA M. YBARRA,ESQ.
Nevada Bar No. 11327
GANZ & HAUF
8950 W. Tropicana Ave., Ste. 1
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Tel: (702) 598-4529
Fax: (702) 598-3626

Attorneys for Plaintiff

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**DISTRICT COURT**

**CLARK COUNTY, NEVADA**

JAPONICA GLOVER-ARMONT,

Plaintiff,

vs.

JOHN CARGILE; CITY OF NORTH LAS VEGAS, a Municipal Corporation existing under the laws of the State of Nevada in the County of Clark; DOES I through X, inclusive; and/or ROE CORPORATIONS I through X, inclusive,

Defendants.

CASE NO.: A-13-683211-C
DEPT NO.: XIX

**STIPULATION AND ORDER TO EXTEND DISCOVERY (SECOND REQUEST)**

IT IS HEREBY STIPULATED by and between Plaintiff Japonica Glover-Armont, by and through her attorney of record, Marjorie Hauf, Esq. of the law firm of GANZ & HAUF and Defendants John Cargile and City of North Las Vegas, by and through their attorney, Christopher Craft, Esq., Deputy City Attorney, pursuant to EDCR 2.35: That discovery will be extended as outlined herein. In support of this Stipulation, the parties state as follows:

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## I. COMPLETED DISCOVERY

The parties have conducted the following discovery:

1. All parties exchanged documents and witness lists in accordance with NRCP 16.1 and have submitted supplemental disclosures as appropriate;
2. All parties filed a Joint Case Conference Report on November 25, 2013;
3. Plaintiff has propounded written discovery to Defendants, and Defendants have responded to those requests;
4. Defendants have propounded written discovery to Plaintiff, and Plaintiff has responded to those requests;
5. Plaintiff has been deposed;
6. COR Deposition of Progressive Insurance has been completed;
7. Plaintiff took the deposition of Defendant, John Cargile on October 1, 2014;
8. Plaintiff took the deposition of the Investigating Officer, Jim Bryne on October 1, 2014;

## IV. DISCOVERY REMAINING TO BE COMPLETED

1. Depositions of all experts;
2. Depositions of percipient witnesses.

## V. GOOD CAUSE EXISTS FOR AN EXTENSION

Counsel for the parties have been working diligently conducting discovery in this case including propounding and responding to discovery as well as coordinating depositions. However, scheduling and calendaring issues with regard to scheduling the depositions have caused the need to push back the discovery deadline as Plaintiff's counsel has two firm trials in May and additional time is needed to conduct discovery.

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Therefore, the parties hereby stipulate and request that this Court extend discovery in the above-captioned case for six (6) months. Trial is currently set for September 29, 2015 and will need to be moved.

## VI. PROPOSED EXTENDED DEADLINES

The parties have agreed to extend the discovery deadlines in this case by six (6) months as set forth below:

1. Close of Discovery from May 21, 2015 to November 20, 2015.
2. Last day to amend pleadings/add parties to remain closed.
3. Deadline for disclosure of initial experts to remain closed.
4. Deadline for disclosure of rebuttal experts to remain closed
5. Deadline to file dispositive motions from June 22, 2015 to December 22, 2015.
6. Trial of September 29, 2015 to be moved.

Dated this 5th day of May, 2015.

GANZ & HAUF

ADAM GANZ, ESQ.
Nevada Bar No. 6650
IDA M. YBARRA, ESQ.
Nevada Bar No. 11327
8950 W. Tropicana Ave., Ste. 1
Las Vegas, Nevada 89147
Attorney for Plaintiff

Dated this 4 day of May, 2015.

CITY OF NORTH LAS VEGAS

CHRISTOPHER CRAFT, ESQ
Nevada Bar No. 7314
2250 Las Vegas Blvd. North, Suite 810
North Las Vegas, Nevada 89030
Attorney for Defendants

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**ORDER**

This matter having been stipulated to by the parties, through their respective counsel, and the Court being duly advised:

IT IS HEREBY ORDERED that the discovery deadlines in this case have been extended six (6) months as set forth below:

1. Close of Discovery from May 21, 2015 to November 20, 2015.
2. Last day to amend pleadings/add parties to remain closed.
3. Deadline for disclosure of initial experts to remain closed.
4. Deadline for disclosure of rebuttal experts to remain closed
5. Deadline to file dispositive motions from June 22, 2015 to December 22, 2015.
6. Trial of September 29, 2015 to be moved.
7. A new scheduling order ~~will~~/will not be issued.

TRIAL DATE TO BE SET ON OR AFTER 2/8/16

Dated this 7th day of May, 2015.

DISCOVERY COMMISSIONER

Respectfully submitted by:

GANZ & HAUF

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Attorney for Plaintiff

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ECC
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Attorneys for Plaintiff

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**DISTRICT COURT**

**CLARK COUNTY, NEVADA**

JAPONICA GLOVER-ARMONT,

Plaintiff,

vs.

JOHN CARGILE; CITY OF NORTH LAS VEGAS, a Municipal Corporation existing under the laws of the State of Nevada in the County of Clark; DOES I through X, inclusive; and/or ROE CORPORATIONS I through X, inclusive,

Defendants.

CASE NO.: A-13-683211-C
DEPT NO.: XIX

**PLAINTIFF'S FOURTH SUPPLEMENTAL EARLY CASE CONFERENCE REPORT**

COMES NOW Plaintiff, JAPONICA GLOVER-ARMONT, by and through her attorney, MARJORIE HAUF, ESQ. and IDA YBARRA, ESQ., of the law firm of GANZ & HAUF, and hereby produces her witness list and documentation for the Early Case Conference pursuant to NRCP 16.1.

**<u>DOCUMENTS/TANGIBLE ITEMS</u>**

1. Complaint, filed on June 10, 2013 (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 1, Bates No. Comp 000001-000008);

2. Defendants' Answer to Plaintiff's Complaint filed on September 5, 2013 (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 2, Bates No. Answ 000001-000005);

3. State of Nevada Traffic Accident Report (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 4, Bates No. TAR 000001-0000039);

4. Billing from Advanced Care Emergency Services (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 4, Bates No. ACES 000001);

5. Medical records and billing from North Vista Hospital (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 5 Bates No. NVH 000001-000045);

6. Billing from Medicwest Ambulance (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 6, Bates No. AMBULANCE 000001);

7. Medical records and billing from Matt Smith Physical Therapy (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 7, Bates No. MSPT 000001-0000077);

8. Medical records and billing from Las Vegas Radiology (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 8, Bates No. LV RAD 000001-000003);

9. Medical records and billing from Advanced Pain Consultants (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 9, Bates No. APC 000001-000078); (updated medical records and billing previously produced in Plaintiff's First Supplemental Early Case Conference Report Bates No. APC 000079-000083 as Exhibit 9);

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10. Billing from Sam's Club Pharmacy (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 10, Bates No. Sams 000001-000024);

11. HIPAA compliant authorization (previously produced in Plaintiff's Initial Early Case Conference Report on disc as Exhibit 11);

12. Medical billing from Advanced Care Emergency Services (previously produced in Plaintiff's First Supplemental Early Case Conference Report, Bates No. ACES 000001 as Exhibit 12);

13. Dr. Leon's Medical Records Review (previously produced in Plaintiff's Second Supplemental Early Case Conference Report as Exhibit 13);

14. Dr. Leon's fee schedule, curriculum vitae and prior testimony list (previously produced in Plaintiff's Second Supplemental Early Case Conference Report as Exhibit 14);

15. Sam Terry's Report (previously produced in Plaintiff's Second Supplemental Early Case Conference Report as Exhibit 15);

16. San Terry's fee schedule, testimony list and curriculum vitae (previously produced in Plaintiff's Second Supplemental Early Case Conference Report as Exhibit 16);

17. Aerial Photo of the Scene of the Crash (previously produced in Plaintiff's Third Supplemental Early Case Conference Report as Exhibit 17);

18. **Pictures of Defendant's vehicle before the crash (attached hereto as Exhibit 18);**

19. **Pictures of Defendant's vehicle before the crash (attached hereto as Exhibit 19);**

20. **Invoice from Valley Auto Body for the property damage of Defendant's Vehicle (attached hereto as Exhibit 20);**

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21. Plaintiff may offer, at trial, certain Exhibits for demonstrative purposes, including, but not limited to, the following:

a. Video, story boards, and/or PowerPoint© images, blow-ups, and/or transparencies of exhibits,

b. Diagrams and/or models of the human body, specifically related to Plaintiff's injuries,

c. Samples of hardware such as, but not limited to, cervical and lumbar plates and screws, and spinal cord simulators and leads,

d. Photographs and videos of surgical procedures and other diagnostic tests,

e. Actual diagnostic studies,

f. Samples of tools used in surgical procedures,

g. Diagrams, drawings, pictures, photos, film, video, DVD and CD-ROM of various parts of the human body, diagnostic tests and surgical procedures,

h. PowerPoint© images/drawings/diagrams/animations/story-boards, of the vehicles involved, the parties involved, the location of the motor vehicle accident and what occurred in the motor vehicle accident.

22. Any and all documents provided pursuant to Defendants 16.1 Production of Documents and any supplements thereto;

23. Any and all radiographic studies, including CT, MRI, X-Ray films or fluoroscopic pictures. (All films available for inspection and copy at expense of requestor);

24. Any and all demonstrative spine models, implantable devices, needles, etc.;

25. Plaintiff reserves the right to supplement this list as discovery continues.

**PRODUCED BY DEFENDANTS**

26. Traffic Accident Report (previously produced in Defendants Initial Early Case Conference Report as Ex. No., 1 Bates CNL V 1-CNL V 7);

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27. Vehicle Repair Summary, Estimate and Receipt (previously produced in Defendants Initial Early Case Conference Report as Ex. No., 2 Bates CNLV 8-CNLV 11);

28. Color photographs of property damage (previously produced in Defendants Initial Early Case Conference Report as Ex. No., 3 Bates CNLV 12-CNL V 16);

29. Property damage payment (previously produced in Defendants Initial Early Case Conference Report as Ex. No., 4 Bates no, CNL V 17);

30. Notice of Claim (previously produced in Defendants Initial Early Case Conference Report as Ex. No., 5 Bates no. CNLV 18);

31. Medical records from Matt Smith Physical Therapy (previously produced in Defendants First Supplemental Early Case Conference Report as Ex. No., 6 Bates CNL V 19-CNLV 106);

32. Insurance Claim file from Progressive Insurance (previously produced in Defendants First Supplemental Early Case Conference Report as Ex. No., 7 Bates CNLV 107-CNLV 166);

33. Medical records from MedicWest Ambulance (previously produced in Defendants Second Supplemental Early Case Conference Report as Ex. No., 8 Bates CNLV 167-CNLV 176);

34. Medical records from North Vista Hospital (previously produced in Defendants Second Supplemental Early Case Conference Report as Ex. No., 9 Bates CNLV 177-CNLV 222);

35. Medical records from Advanced Pain Consultants (previously produced in Defendants Third Supplemental Early Case Conference Report as Ex. No., 10 Bates CNLV 223-CNLV 311);

36. Medical records and CD from Las Vegas Radiology (previously produced in Defendants Third Supplemental Early Case Conference Report as Ex. No., 11 Bates CNLV 312-CNLV 318);

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37. Medical records from Sam's Club Pharmacy (previously produced in Defendants Second Supplemental Early Case Conference Report as Ex. No., 12 Bates CNL V 319-CNLV 320);

38. North Las Vegas Police Department Citation #B00051915 (previously produced in Defendants Fourth Supplemental Early Case Conference Report as Ex. No., 13 Bates CNLV 321);

39. North Las Vegas Municipal Court Docket #TR028347-12 (previously produced in Defendants Fourth Supplemental Early Case Conference Report as Ex. No., Bates CNLV 322-CNLV 325);

40. North Las Vegas Police Department Citation #B00051915 (previously produced in Defendants Fifth Supplemental Early Case Conference Report as Ex. No., Bates CNLV 321);

41. North Las Vegas Municipal Court Docket #TR028347-12 (previously produced in Defendants Fifth Supplemental Early Case Conference Report as Ex. No., Bates CNLV 322-CNLV 325);

42. Photographs of subject accident (color-printed and full page standard letter-sized; photos may be duplicative of previous supplements) (previously produced in Defendants Sixth Supplemental Early Case Conference Report as Ex. No., Bates CNL V 326-CNLV 357);

43. **Maintenance and repair records regarding vehicle #1514 (records may be duplicative of previous supplements) (Bates CNLV 358-CNLV 409).**

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**WITNESSES WHOSE TESTIMONY IS EXPECTED TO BE PRESENTED AT TRIAL**

1. Japonica Glover-Armont
c/o Ganz & Hauf
8950 W. Tropicana Ave, Ste 1
Las Vegas, NV 89147

Ms. Glover-Armont is expected to testify regarding the facts and circumstances surrounding the accident of November 5, 2012, her resulting injuries, medical treatment and damages.

2. John Cargile
c/o North Las Vegas City Attorney
2250 Las Vegas Blvd., North, Ste 810
N. Las Vegas, NV 89030

Mr. Cargile is expected to testify regarding the facts and circumstances surrounding the accident of November 5, 2012.

3. **Timothy Bedwell**
**Peter Fitterling, Auto/Equip Supervisor, and/or**
**The Person Most Knowledgeable for**
**City of North Las Vegas**
**Sandra Douglass Morgan, City Attorney**
**Christopher D. Craft, Deputy City Attorney**
**c/o North Las Vegas City Attorney**
**2250 Las Vegas Blvd., North, Ste 810**
**N. Las Vegas, NV 89030**

**The Persons Most Knowledgeable for the City of North Las Vegas is expected to testify regarding the facts and circumstances surrounding the accident of November 5, 2012.**

4. Officer Jim Byrne Badge # 956
North Las Vegas Police Department
1301 E. Lake Mead Blvd.
N. Las Vegas, NV 89030

Officer Byrne is expected to testify regarding the facts and circumstances surrounding the accident of November 5, 2012.

5. Monique Parker
6804 Dorita Way., #101
Las Vegas, Nevada 89108

Monique Parker is expected to testify regarding the facts and circumstances surrounding the motor vehicle accident of November 5, 2012.

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8950 W. Tropicana Ave., #1
Las Vegas, NV 89147
Phone: (702) 598-4529
Fax: (702) 598-3626

6. Donald Pierson
611 Park Landing Court
North Las Vegas, Nevada 89032

Donald Pierson is expected to testify regarding the facts and circumstances surrounding the motor vehicle accident of November 5, 2012.

## WITNESSES THAT MAY BE CALLED IF THE NEED ARISES FOR PLAINTIFF

The following treating physicians are expected to testify, and may give expert opinions, regarding their treatment of Japonica Glover-Armont. Their testimony and opinions will consist of the necessity of the medical treatment rendered, the necessity of future treatment to be rendered, the causation of the necessity for past and future medical treatment, their opinion as to past and future restrictions of activities, including work activities, caused by the accident. Their opinions shall include the cost of past medical care, future medical care, and whether those medical costs fall within ordinary and customary charges in the community, for similar medical care and treatment. Their testimony may include opinions as to whether the Plaintiff has a diminished work life expectancy as a result of the accident.

1. Patrick Flores M.D.
The Person Most Knowledgeable and/or
The Custodian of Records for
Advanced Care Emergency Services
P.O. Box 30102 Dept. 300
Salt Lake City, UT 84130-0102

2. Patrick Flores, M.D.
The Person Most Knowledgeable and/or
The Custodian of Records for
North Vista Hospital
1409 E. Lake Mead Blvd.
N. Las Vegas, NV 89030

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8950 W. Tropicana Ave., #1
Las Vegas, NV 89147
Phone: (702) 598-4529
Fax: (702) 598-3626

3. The Person Most Knowledgeable and/or
The Custodian of Records for
Medicwest Ambulance Service
9 W. Delhi Ave
North Las Vegas, NV 89030

4. Michael McKay, DPT,
Mark Mateja, PT
The Person Most Knowledgeable and/or
The Custodian of Records for
Matt Smith Physical Therapy
3155 W. Craig Rd., Ste 140
N. Las Vegas, NV 89132

5. Bhuvana Kittusamy, M.D.
The Person Most Knowledgeable and/or
The Custodian of Records for
Las Vegas Radiology
7500 Smoke Ranch Rd. Ste 1
Las Vegas, NV 89128

6. Raimundo Leon, M.D.
The Person Most Knowledgeable and/or
The Custodian of Records for
Advanced Pain Consultants
2650 Crimson Canyon Dr.
Las Vegas, NV 89128

7. The Person Most Knowledgeable and/or
The Custodian of Records for
Sam's Club Pharmacy
2650 E. Craig Rd
Las Vegas, NV 89081

8. Patrick Flores, D.O.
The Person Most Knowledgeable and/or
The Custodian of Records for
Advanced Care Emergency Services

**MAY BE USED AT TRIAL AS EXPERT WITNESSES FOR PLAINTIFF**

Plaintiff anticipates that medical providers are expected to give expert opinions regarding the treatment of the Plaintiff, the necessity of the treatment rendered, the necessity of future treatment to be rendered, the causation of the necessity for past and future medical treatment, their expert opinion as to past and future restrictions of activities, including work activities, caused by

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Fax: (702) 598-3626

the incident. Their opinions shall include pain and suffering of the Plaintiff; the mental state of the Plaintiff; the cost of past medical care, diagnostic testing, surgery and medication; future medical care, diagnostic testing, surgery and medication; and whether those medical costs fall within ordinary and customary charges in the community, for similar medical care and treatment. Their testimony may also include expert opinions as to whether the Plaintiff has a diminished work life and/or life expectancy.

1. Raimundo Leon, M.D.
   Advanced Pain Consultants
   2650 Crimson Canyon Drive
   Las Vegas, Nevada 89128

2. Sam Terry
   Exhibit-A
   PO Box 53011
   Henderson, NV 89053

**SUMMARY OF PAST DAMAGES FOR JAPONICA GLOVER-ARMONT**

| **PROVIDER** | **CHARGES** |
|---|---:|
| Medic West Ambulance | $926.76 |
| North Vista Hospital | $11,117.70 |
| Advanced Care Emergency Services | $756.00 |
| Matt Smith Physical Therapy | $5,555.00 |
| Advanced Pain Consultants | $2,846.00 |
| Las Vegas Radiology | $1,650.00 |
| Sam's Club Pharmacy | $104.23 |
| Advanced Care Emergency Services | $756.00 |
| **TOTAL** | **$23,711.69** |

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...

...

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Las Vegas, NV 89147
Phone: (702) 598-4529
Fax: (702) 598-3626

Treatment is ongoing. Intangible damages, inclusive of pain and suffering, will be sought in the amount to be determined at trial.

Dated this 22 day of October, 2015.

GANZ & HAUF

#11743, for

MARJORIE HAUF, ESQ.
Nevada Bar No. 8111
IDA M. YBARRA, ESQ.
Nevada Bar No. 11327
8950 W. Tropicana Ave., Suite 1
Las Vegas, Nevada 89147
Attorney for Plaintiff

## CERTIFICATE OF E-SERVICE

Pursuant to NRCP 5(b) and EDCR 7.26, I certify that on this date, I served the foregoing **PLAINTIFF'S FOURTH SUPPLEMENTAL EARLY CASE CONFERENCE REPORT** on all parties via wiznet:

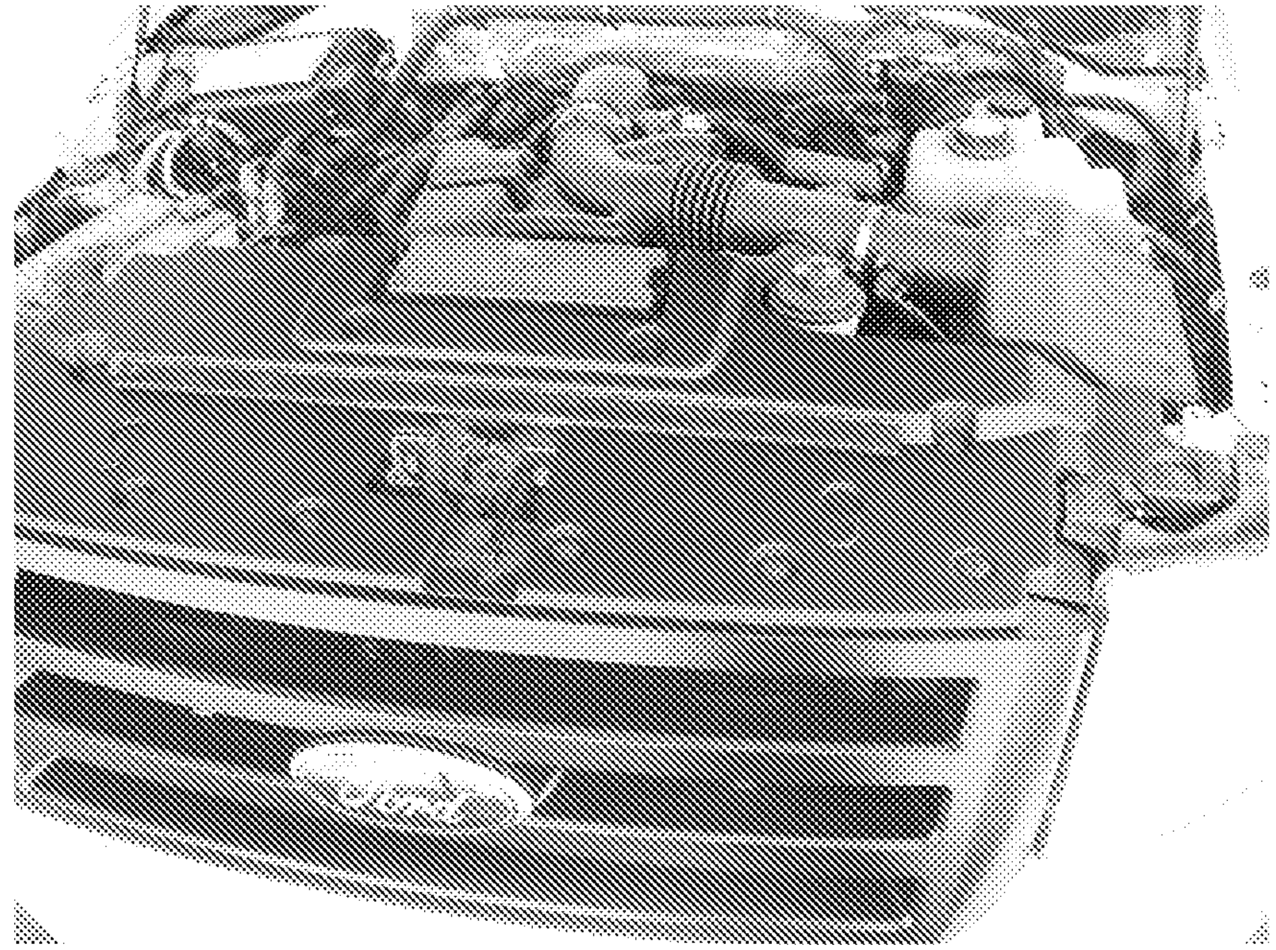
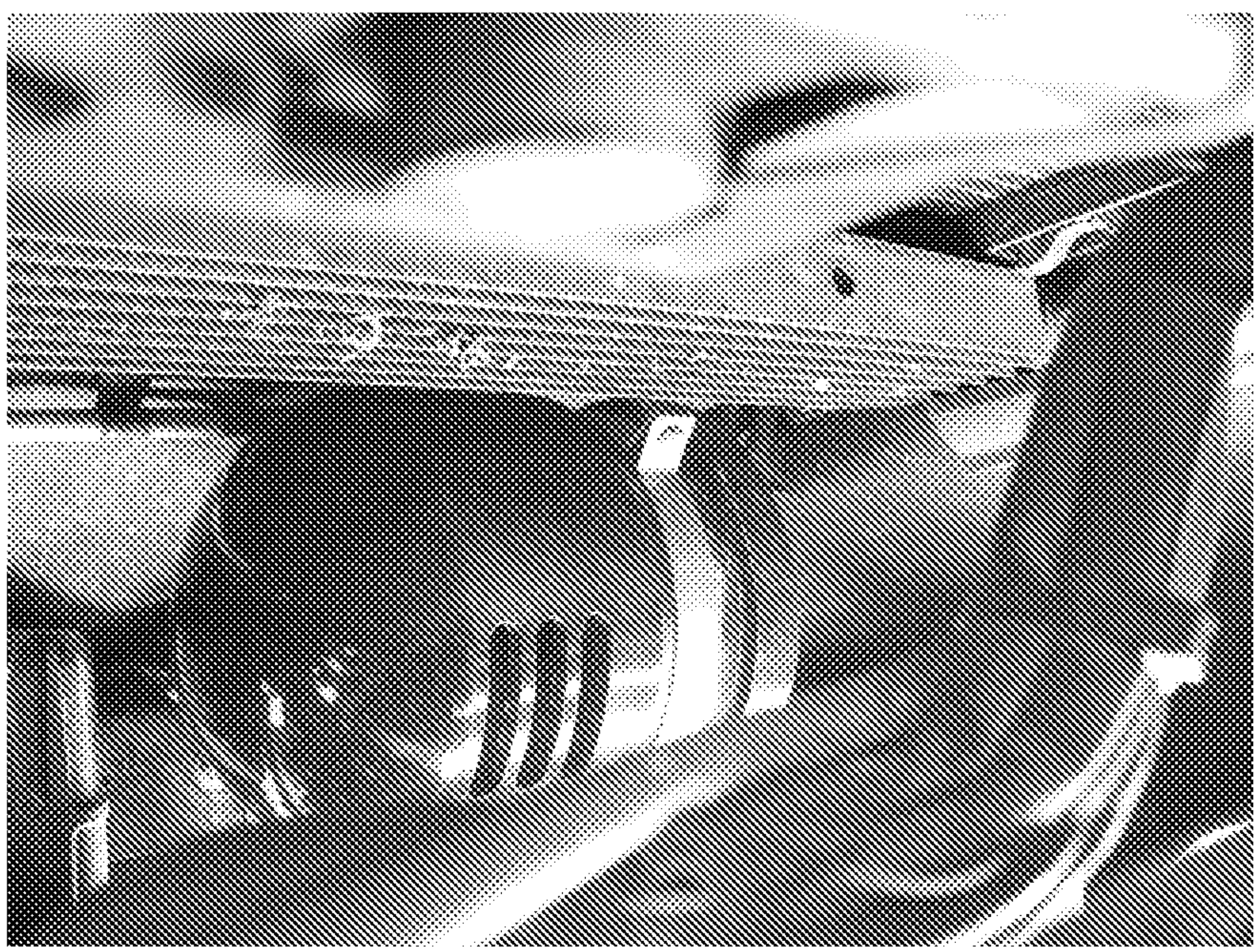
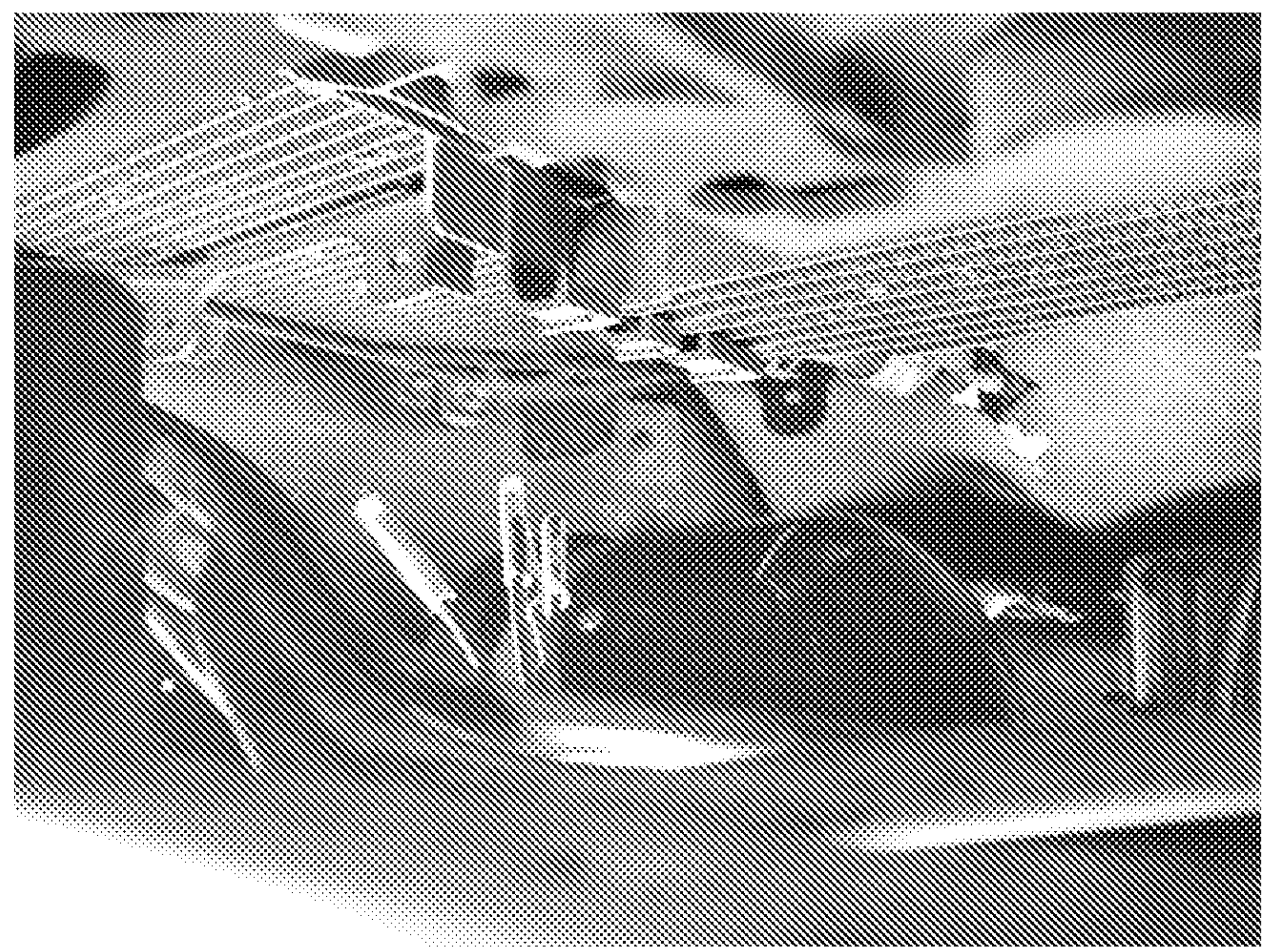
Christopher Craft, Esq.
Deputy City Attorney
2250 Las Vegas Blvd Ste 810
North Las Vegas, NV 89030

Dated this 22nd day of October, 2015.

Brittany Armstrong
An employee of the law firm of GANZ & HAUF

GANZ & HAUF
8950 W. Tropicana Ave., #1
Las Vegas, NV 89147
Phone: (702) 598-4529
Fax: (702) 598-3626

# EXHIBIT 18

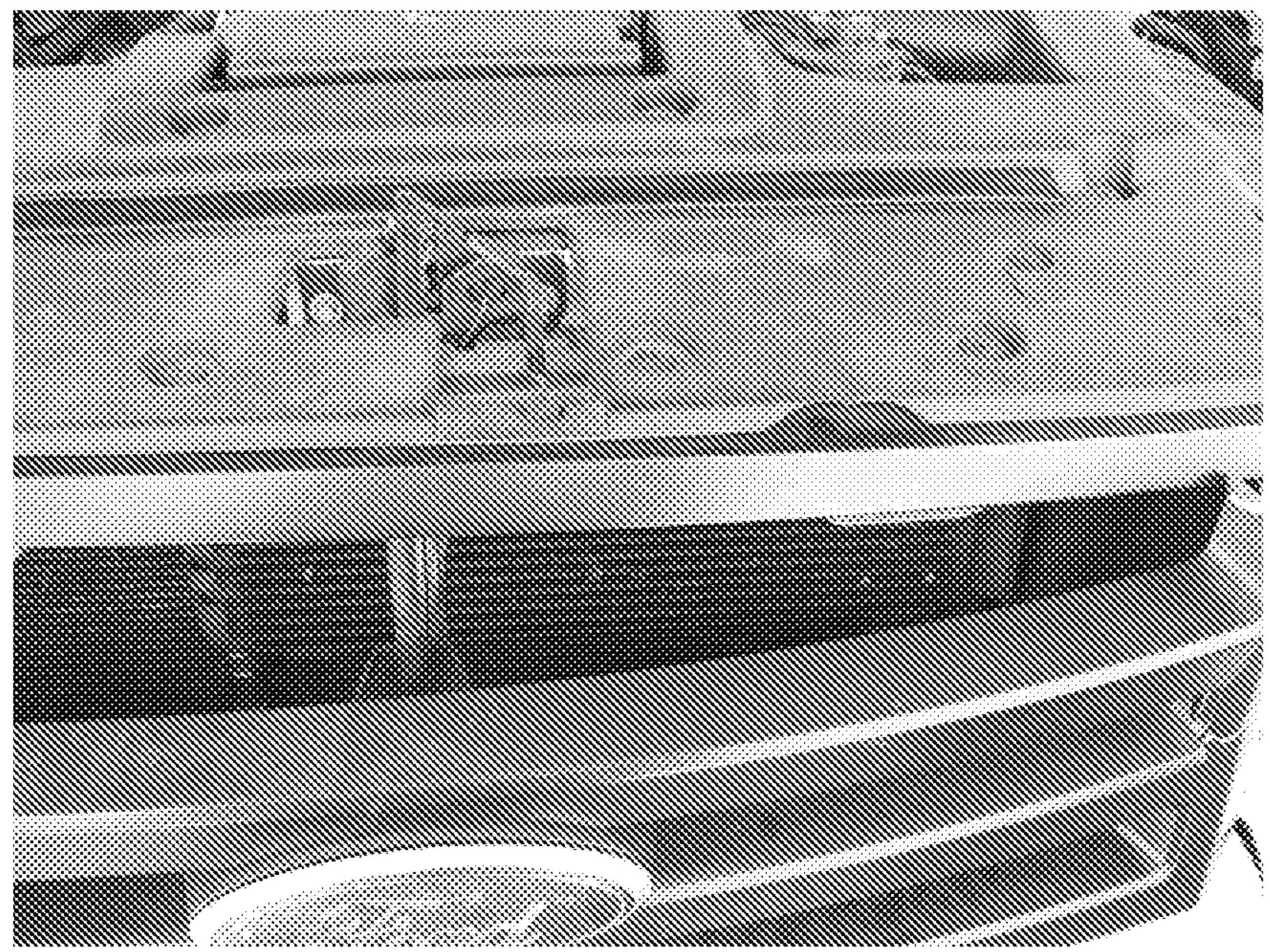





# EXHIBIT 19


POLICE


1514


POLICE




# EXHIBIT 20

**Valley AUTO BODY**

INVOICE NO. 2504

2409 East Gowan Road
North Las Vegas, NV 89030
643-9295
TIN# 88-0249294

WRITTEN BY

Date 12-3-12

Name CITY NORTH LAS VEGAS

Make Of Car 08 FORD

Address

Model EXPEDITION

License EX523116

UNIT 1514

Mileage

Retain Parts

Destroy Parts

Date Wanted

| INSTRUCTIONS | AMOUNT | |
|---|---|---|
| Repair Per Est | | |
| LABOR | 547 | 50 |
| MATERIAL | 174 | 20 |
| PARTS | 1135 | 22 |

Vehicle # 1514

W.O. # 28424

Stock ☐ Non-Stock ☒

Department PD

Received by: PETE

Approved by:

| | | |
|---|---|---|
| Tax | | |
| Total | 1856 | 92 |

I hereby authorize the repair work to be done along with the necessary materials. You and your employees may operate vehicle for purposes of testing, inspection or delivery at my risk. An express mechanic's lien is acknowledged on vehicle to secure the amount of repairs thereto. You will not be held responsible for loss or damage to vehicle or articles left in vehicle in case of fire, theft, accident or any other cause beyond your control.

SIGNED X Date

TERMS CASH: UNLESS ARRANGEMENTS MADE PRIOR TO AUTHORIZATION

VALLEY AUTO BODY
2409 E GOWAN RD
N. LAS VEGAS, NV 89030
702-643-9295

HOST NAME: SPS
DLR# NV15089201 TID# NOVA

xxxxxxxxxxxx4706 MC FLEET EXP 06/14
MANUAL ENTRY

CHARGE

| PRODUCT | QTY | PRICE | AMOUNT |
|---|---|---|---|
| BODY REPAIR | | | $1856.92 |

**TOTAL $1856.92**

DATE: 12/03/12 TKT#: 389411
TIME: 06:19:07 SEQ#: 000135
AUTH: 094955 ORIG#:

ODOM: 26214
VEH#: ******

CUSTOMER COPY

Date: 12/ 3/2012 09:32 AM
Estimate ID: 1514
Estimate Version: 0
Preliminary
Profile ID: lvmpd

# Valley Auto Body

2409 E. GOWAN RD., NORTH LAS VEGAS, NU 89030
(702) 643-9295
Fax: (702) 643-3842
Email: valleyautobody@msn.com

Damage Assessed By: Bill Springer

Deductible: UNKNOWN
File Number: 1514

Owner: city of north las vegas

Mitchell Service: 910828

Description: 2008 Ford Expedition XLT
Body Style: 4D Ut 119" WB
VIN: 1FMFU16598LA23144
Mileage: 26,214
OEM/ALT: O
Color: white
Drive Train: 5.4L Inj 8 Cyl 4WD
License: EX52316 NV
Search Code: None
Options: PASSENGER AIRBAG, DRIVER AIRBAG, POWER DRIVER SEAT, POWER LOCK, POWER WINDOW
REAR WINDOW DEFOGGER, MANUAL AIR CONDITION, CRUISE CONTROL, TILT STEERING COLUMN
ANTI-LOCK BRAKE SYS., TRACTION CONTROL, RUNNING BOARDS, FOG LIGHTS
ALUM/ALLOY WHEELS, AUXILIARY INPUT, LEATHER STEERING WHEEL, TOW HITCH RECEIVER
4WD OR AWD, FRONT AIR DAM, TINTED GLASS, THIRD ROW SPLIT BENCH SEAT
VARIABLE ASSISTED STEERING, SIDE AIRBAGS, ANTI-THEFT SYSTEM
AUTOMATIC HEADLIGHTS, INTERIOR AUTOMATIC DAY/NIGHT OR ELECTROCHROMATIC MIRROR
SIDE HEAD CURTAIN AIRBAGS, AM/FM STEREO CD/MP3 PLAYER
ELECTRONIC STABILITY CONTROL, FRONT BUCKET SEATS, KEYLESS ENTRY SYSTEM
POWER DISC BRAKES, POWER HEATED EXTERIOR MIRRORS, REAR AC & HEATER
REAR AUDIO CONTROLS, REAR WINDOW WIPER, SECOND ROW SPLIT FOLDING BENCH SEAT
STEERING WHEEL MOUNTED CONTROLS

| Line Item | Entry Number | Labor Type | Operation | Line Item Description | Part Type/ Part Number | Dollar Amount | Labor Units |
|---|---|---|---|---|---|---|---|
| 1 | AUTO | BDY | OVERHAUL | Frt Bumper Assy | | | 3.2 # |
| 2 | 000004 | BDY | REMOVE/REPLACE | Frt Upr Bumper Cover | 7L1Z 17D957 APTM | 240.80 | INC # |
| 3 | AUTO | REF | REFINISH | Frt Upr Bumper Cover | | | C 2.0 |
| 4 | 003220 | BDY | REMOVE/REPLACE | Frt Bumper Face Bar | CL1Z 17D957 BPTM | 291.03 | INC # |
| 5 | AUTO | REF | REFINISH | Frt Face Bar | | | C 2.1 |
| 6 | 000008 | BDY | REMOVE/REPLACE | Frt Bumper Grille | CL1Z 17D635 A | 76.48 | INC # |
| 7 | AUTO | BDY | REMOVE/INSTALL | Frt Bumper Assy | | | INC # |
| 8 | 000018 | BDY | REMOVE/REPLACE | Frt Bumper Impact Bar | CL1Z 17757 A | 190.55 | 0.3 # |
| 9 | 000024 | BDY | REMOVE/REPLACE | Frt Bumper Impact Absorber | CL1Z 17C882 A | 106.88 | INC |
| 10 | 004988 | BDY | REMOVE/REPLACE | Grille | 7L1Z 8200 BA | 296.10 | 0.3 # |
| 11 | 000030 | BDY | REMOVE/REPLACE | Grille Emblem | 4L3Z 1542528 AB | 57.70 | INC # |
| 12 | 003673 | BDY | REMOVE/REPLACE | Grille Bracket | 7L1Z 19E525 A | 48.98 | INC # |
| 13 | 000035 | BDY | REMOVE/REPLACE | Grille Bracket | 7L1Z 16758 B | 40.63 | INC # |
| 14 | AUTO | BDY | REMOVE/INSTALL | Grille Assy | | | INC # |
| 15 | 000067 | BDY | REPAIR | Hood Panel (Alum) | Existing | | 2.0* |
| 16 | AUTO | REF | REFINISH | Hood Outside | | | C 2.8 |
| 17 | 000323 | BDY | REMOVE/REPLACE | L Frame Tow Hook | 7L1Z 17A954 AA | 56.12 | 0.2 |
| 18 | 936012 | | ADD'L COST | Hazardous Waste Disposal | | 5.00 * | |
| 19 | 900500 | BDY * | REMOVE/REPLACE | misc clips | Sublet | 10.00 * | 0.0* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20 | 933006 | FRM | ADD'L OPR | FRAME/RACK SET UP | 0.00 | * | 2.0* |
| 21 | 933034 | FRM | ADD'L OPR | PULL FOR SAG | | | 2.0* |
| 22 | 933002 | REF | ADD'L OPR | Clear Coat | | | 2.5* |
| 23 | 933017 | REF | ADD'L OPR | FINISH SAND & BUFF | | | 2.0* |
| 24 | 933018 | REF | ADD'L OPR | MASK FOR OVERSPRAY | 5.00 | * | 0.3* |
| 25 | AUTO | | ADD'L COST | Paint/Materials | 169.20 | * | |

*** - Judgment Item**
**# - Labor Note Applies**
**C - Included in Clear Coat Calc**

# Estimate Totals

| I. Labor Subtotals | Units | Rate | Add'l Labor Amount | Sublet Amount | Totals |
|---|---|---|---|---|---|
| Body | 6.0 | 25.00 | 0.00 | 0.00 | 150.00 |
| Refinish | 11.7 | 25.00 | 5.00 | 0.00 | 297.50 |
| Frame | 4.0 | 25.00 | 0.00 | 0.00 | 100.00 |
| Non-Taxable Labor | | | | | 547.50 |
| Labor Summary | 21.7 | | | | 547.50 |

| II. Part Replacement Summary | Amount |
|---|---|
| Taxable Parts | 1,405.27 |
| Parts Adjustments | 281.05- |
| Non-Taxable Parts | 10.00 |
| Parts Adjustments | 1.00 |
| Total Replacement Parts Amount | 1,135.22 |

| III. Additional Costs | Amount |
|---|---|
| Taxable Costs | 169.20 |
| Non-Taxable Costs | 5.00 |
| Total Additional Costs | 174.20 |

Paint Material Method: Rates
Init Rate = 18.00 , Init Max Hours = 99.9, Addl Rate = 0.00

| IV. Adjustments | Amount |
|---|---|
| Customer Responsibility | 0.00 |

| | | |
|---|---|---|
| I. | Total Labor: | 547.50 |
| II. | Total Replacement Parts: | 1,135.22 |
| III. | Total Additional Costs: | 174.20 |
| | Gross Total: | 1,856.92 |
| IV. | Total Adjustments: | 0.00 |
| | Net Total: | 1,856.92 |

**This is a preliminary estimate.**
**Additional changes to the estimate may be required for the actual repair.**

ESTIMATE RECALL NUMBER: 11/15/2012 16:09:21 1514
Mitchell Data Version: OEM: OCT_12_V
Software Version: 7.0.482