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Kineticorp™

Forensic Engineering | and Visualization

December 19, 2011

Matthew D. Stockwell
Callahan & Fusco LLC
72 Eagle Rock Avenue, Suite 320
East Hanover, NJ 07936

RE: *Kline et al. v. Loman Auto Group*

Dear Mr. Stockwell,

As requested, Kineticorp investigated and reconstructed a fatal motor vehicle accident that occurred on February 24, 2007 at approximately 8:53 a.m. The crash occurred on southbound Interstate 287 at milepost 42.8 in Parsippany, New Jersey. A 1998 Subaru Outback, driven by Natalie Rawls, slowed or stopped in the right travel lane of southbound I-287. Susan Morris Kline slowed or stopped her 1996 Jeep Cherokee behind the Subaru. The Jeep was then impacted in the rear by a 2004 Toyota Sienna operated by Victoria Morgan-Alcala. As a result of this initial impact the Jeep was pushed into the rear of the Subaru before coming to rest between the right and center lanes of I-287. During the accident sequence a fire erupted. As a result of the crash, Ms. Kline was killed. In the area of the accident, southbound I-287 is an asphalt roadway with three lanes of travel bordered to the right by a gore area separating the through-travel lanes from the exit lane for Parsippany Road. Figure 1, a photograph taken by police, shows the accident scene. At the time of the accident the weather was clear and the roadway was dry, straight and level. Shortly prior to the accident location, the speed limit had changed from 65 mph to 55 mph.

Figure 1

Summary of Conclusions

As a result of our investigation and analysis, Kineticorp reached the following conclusions related to this crash:

1. The Jeep was involved in two impacts. The first occurred when the Jeep was rear ended by the Toyota. The second occurred when the Toyota pushed the Jeep into the Subaru.

2. During the first impact, the Toyota was traveling approximately 73 mph and the Jeep was either stopped or moving slowly.

3. As a result of being impacted by the Toyota, the Jeep experienced a ΔV of approximately 38 mph.

4. During the second impact, the Toyota and Jeep were traveling approximately 33 mph and the Subaru was either stopped or moving slowly.

5. The fire did not occur until the second impact when the Jeep was crushed between the Toyota and the Subaru.

6. The Jeep's fuel system was not breached during the first impact.

7. During the second impact, the Toyota penetrated underneath the Jeep, causing the Jeep to roll towards the passenger's side.

8. The initial impact between the Toyota and the Jeep was approximately 6 times greater than the Federal Motor Vehicle Safety Standard (FMVSS) 301 test for fuel system integrity, in terms of impact energy.

9. The severity of accident was increased substantially due to the Jeep being crushed between the Toyota and the Subaru.

Basis for Conclusions: The remainder of this report describes the basis for these conclusions and outlines the procedure through which they were reached. The procedure described below utilized reliable methods, techniques and processes which conform to standard and accepted practices within the field of motor vehicle accident reconstruction. The above-listed conclusions, to which this procedure led, were reached to a reasonable degree of certainty.

<u>Procedure</u>

- In conducting our investigation and analysis, Kineticorp engineers reviewed and analyzed the documents, photographs and video listed in Appendix A. These materials were provided to Kineticorp.

- Kineticorp obtained technical specifications for the vehicles involved in the crash.

- Kineticorp inspected, documented, photographed and surveyed the accident site on July 7, 2011.

- Kineticorp inspected, documented, photographed and scanned an exemplar 2004 Toyota Sienna on August 5, 2011.

- Kineticorp inspected, documented, photographed and scanned an exemplar 1996 Jeep Grand Cherokee on August 18, 2011.

- Kineticorp inspected, documented, photographed and scanned an exemplar 1998 Subaru Legacy Outback on August 25, 2011.

- Kineticorp inspected, documented, photographed and scanned the subject Jeep Grand Cherokee on December 1, 2011.

- Kineticorp produced computer models of the involved vehicles using data collected from our three-dimensional scans.

- Kineticorp produced a computer model of the crash site. This computer model contains the roadway and shoulder geometries, along with the physical evidence deposited by vehicles during the crash. This computer model was created from data collected during our crash site inspection, photographs and other documents provided to Kineticorp.

- In creating our computer models of the crash site and vehicles, Kineticorp utilized principles and techniques of three-dimensional visualization and photogrammetry to locate and place the physical evidence and vehicle positions, and to document accident related vehicle damage. Photogrammetry encompasses techniques used to obtain measurements and three-dimensional positional data from photographs. The following technical literature describes the photogrammetric principles and techniques employed by Kineticorp. These principles and techniques are widely accepted and used within the field of accident reconstruction.

    - Brach, Raymond M., et al., Vehicle Accident Analysis and Reconstruction Methods, "Chapter 10: Photogrammetry," Society of Automotive Engineers, Warrendale, PA, 2005.

    - Breen, Kevin C, et al., "The Application of Photogrammetry to Accident Reconstruction," Paper Number 861422, Society of Automotive Engineers, Warrendale, PA, 1986.

    - Chou, C., McCoy, R., Fenton, S., Neale, W., Rose, N., "Image Analysis of Rollover Crash Test Using Photogrammetry," Paper Number 2006-01-0723, Society of Automotive Engineers, Warrendale, PA, 2006.

    - Fenton, S., Neale, W., Rose, N., Hughes, C., "Determining Crash Data Using Camera-Matching Photogrammetric Technique," Paper Number 2001-01-3313, Society of Automotive Engineers, Warrendale, PA, 2001.

    - Husher, Stein E., Michael S. Varat, John F. Kerhoff, "Survey of Photogrammetric Methodologies for Accident Reconstruction," Proceedings of the Canadian Multi-Disciplinary Road Safety Conference VII, Vancouver, BC, Canada, June 1991.

    - Neale, W.T.C., Hessel, D., Terpstra, T., "Photogrammetric Measurement Error Associated with Lens Distortion," Paper Number 2011-01-0286, Society of Automotive Engineers, Warrendale, PA, 2011.

    - Neale, W.T.C., Fenton, S., McFadden, S., Rose, N.A., "A Video Tracking Photogrammetry Technique to Survey Roadways for Accident Reconstruction," Paper Number 2004-01-1221, Society of Automotive Engineers, Warrendale, PA, 2004.

    - Pepe, Michael D., et al., "Accuracy of Three-Dimensional Photogrammetry as Established by Controlled Field Tests," Paper Number 930662, Society of Automotive Engineers Warrendale, PA, 1993.

    - Rose, Nathan A., Neale, W.T.C., Fenton, S.J., Hessel, D., McCoy, R.W., Chou, C.C., "A Method to Quantify Vehicle Dynamics and Deformation for Vehicle Rollover Tests Using Camera-Matching Video Analysis," Paper Number 2008-01-0350, Society of Automotive Engineers, Warrendale, PA, 2008.

    - Rucoba, R., Duran, A., Carr, L., Erdeljac, D. "A Three Dimensional Crush Measurement Methodology Using Two-Dimensional Photographs." Paper Number 2008-01-0163, Society of Automotive Engineers, Warrendale, PA, 2008.

- Having created computer models of the crash scene, scene evidence and subject vehicles, Kineticorp engineers then analyzed the motion of the vehicles through the scene evidence. Our analysis of the vehicle motion relied on widely utilized and accepted literature related to the interpretation of physical evidence from vehicular crashes. A sampling of this literature is listed below:

    - Baker, Kenneth S., "Traffic Collision Investigation." Northwestern University Center for Public Safety, 2001.

    - Beauchamp, Gray, Hessel, David, Rose, Nathan A., Fenton, Stephen J., "Determining Steering and Braking Levels from Yaw Mark Striations," Paper Number 2009-01-0092, Society of Automotive Engineers, Warrendale, PA, 2009.

    - Daily, John, et al., Fundamentals of Traffic Crash Reconstruction, Institute of Police Technology and Management, 2nd Printing, June 2006.

    - Fricke, Lynn B., Traffic Accident Reconstruction, Northwestern University Center for Public Safety, First Edition, 1990.

- Kineticorp reconstructed the crash utilizing principles of Conservation of Energy and Conservation of Momentum. These principles are described and validated extensively in the literature pertaining to vehicular accident reconstruction. The follow list is a sampling of that literature.

  - Brach, Raymond M., et al., Vehicle Accident Analysis and Reconstruction Methods, Society of Automotive Engineers, Warrendale, PA, 2005.
  - Daily, John, et al., Fundamentals of Traffic Crash Reconstruction, Chapter 13 – Critical Speed Yaw, Institute of Police Technology and Management, 2006.

- Kineticorp also utilized crush analysis in reconstructing the crash. The principles and techniques of crush analysis are described and validated extensively in the literature pertaining to vehicular accident reconstruction. The following list is a sampling of that literature:
  - Campbell, K.L., "Energy As A Basis For Accident Severity – A Preliminary Study," Doctoral Thesis, University of Wisconsin, 1972.
  - Emori, Richard I., "Analytical Approach to Automobile Collisions," 680016, Society of Automotive Engineers, Warrendale, PA, 1968.
  - Neptune, James A., Flynn, James E., "A Method of Determining Accident Specific Crush Stiffness Coefficients," 940913, Society of Automotive Engineers, Warrendale, PA, 1994.
  - Rose, Nathan A., Fenton, Stephen J., Ziernicki, Richard M., "An Examination of the CRASH3 Effective Mass Concept," 2004-01-1181, Society of Automotive Engineers, Warrendale, PA, 2004.
  - Rose, Nathan A., Fenton, Stephen J., Ziernicki, Richard M., "Crush and Conservation of Energy Analysis: Toward a Consistent Methodology," 2005-01-1200, Society of Automotive Engineers, Warrendale, PA, 2005.
  - Rose, Nathan A., Fenton, Stephen J., Beauchamp, Gray A., "Restitution Modeling for Crush Analysis: Theory and Validation," 2006-01-0908, Society of Automotive Engineers, Warrendale, PA, 2006.
  - Warner, Charles Y. et al., "A repeated-Crash Test Technique for Assessment of Structural Impact Behavior," 860208, Society of Automotive Engineers, Warrendale, PA, 1986.

2004 Toyota: The Toyota involved in this crash was a 2004 model year Sienna XLE (VIN - 5TDZA22C34S052135). This vehicle was equipped with a 3.3-liter 6-cylinder gasoline engine and an automatic transmission. Figure 2 shows the Toyota at the accident scene. As can be seen in the figure, the Toyota shows signs of frontal impact and fire damage. The Toyota was not available for Kineticorp's inspection.

Figure 2

<u>1996 Jeep:</u> The Jeep involved in this crash was a 1996 model year Grand Cherokee Laredo (VIN- 1J4GZ58S9TC401311) equipped with a 4.0-liter 6-cylinder gasoline engine and an automatic transmission. Figure 3 shows the Jeep at the time of our inspection. As can be seen in the figure, the Jeep exhibits signs of impact damage to both the front and rear of the vehicle as well as fire damage.

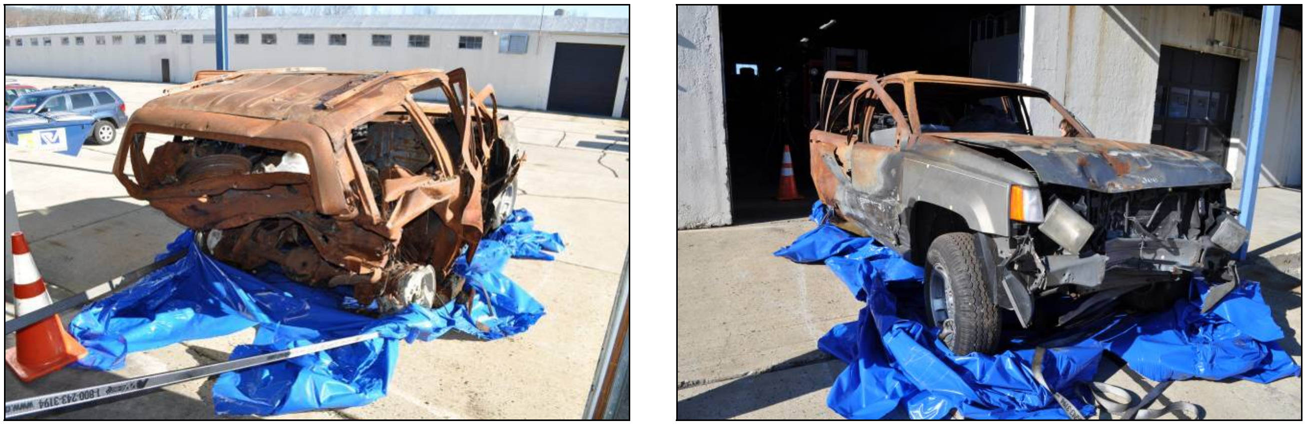

Figure 3

Kineticorp determined that the maximum static crush to the rear of the Jeep was approximately 37 inches. The forces of the collision caused the rear axle of the Jeep to move forward.

<u>1998 Subaru</u>: The Subaru involved in this accident was a 1998 model year Legacy, Outback Edition (VIN - 4S3BG6852W7610862). This 4-door wagon was equipped with a 2.5-liter, 4-cylinder gasoline engine and an automatic transmission. Figure 4 shows the Subaru at the time of the accident. As can be seen in the figure, the Subaru sustained damage to the rear of the vehicle. The Subaru was not available for Kineticorp's inspection.

Figure42

<u>Accident Scene Diagram:</u> At the time of Kineticorp's scene inspection, gouging and burn mark evidence were still present on the roadway. Kineticorp surveyed this evidence and the site geometry and created a three dimensional model of the accident scene. Using this three dimensional model, Kineticorp located additional physical evidence and positions of involved vehicles by conducting photogrammetric analysis on photographs provided to Kineticorp.

Photogrammetry is the process of obtaining three-dimensional measurements and positional data from photographs. The photogrammetric technique that Kineticorp used on this case is referred to as camera-matching photogrammetry. This technique involves the following steps:

(1) Computer-modeling software is used to create a three-dimensional computer model of the crash scene from data that was collected at the scene with surveying equipment. This computer model includes features of the environment that were

present at the time of the accident such as road boundaries, roadway stripes and other unique aspects of the roadway environment.

(2) The computer-modeled environment is then imported into a modeling software package and a number of computer-modeled cameras are setup to view the computer environment from perspectives that are similar to the perspectives characterized in the photographs taken shortly after the accident.

(3) Each of the accident scene photographs that are to be analyzed are imported into the modeling software and is designated as a background image for the corresponding computer-modeled camera with the same perspective.

(4) Adjustments to the location, focal length and target location of the computer-modeled camera are made until there is an overlay between the computer-generated environment model and the environment shown in the photograph.

(5) Once the camera location and characteristics are determined and the overlay between the environment model and the photograph is obtained, non-permanent features, such as physical evidence on a roadway and vehicle positions can be mapped from the photograph onto the environment model. Computer models of non-permanent features, such as vehicle rest positions can also be added to the environment through this same process. Once these non-permanent features are transferred to the environment model, they can be measured relative to the known dimensions of the environment model.

Figure 5 depicts a sampling of our photogrammetry analysis. The first image of the figure is a photograph taken by police. In the second image of the figure, the accident scene photograph has been aligned with the computer model which is visible as an overlay of lines. The third image of Figure 5 ((continued on following page), shows the aligned computer model with the physical evidence traced. Additionally, vehicle models have been positioned to locate the involved vehicles points of rest. In the bottom image of Figure 5-continued, the photograph has been removed leaving the geometry from the computer model.

Figure 5

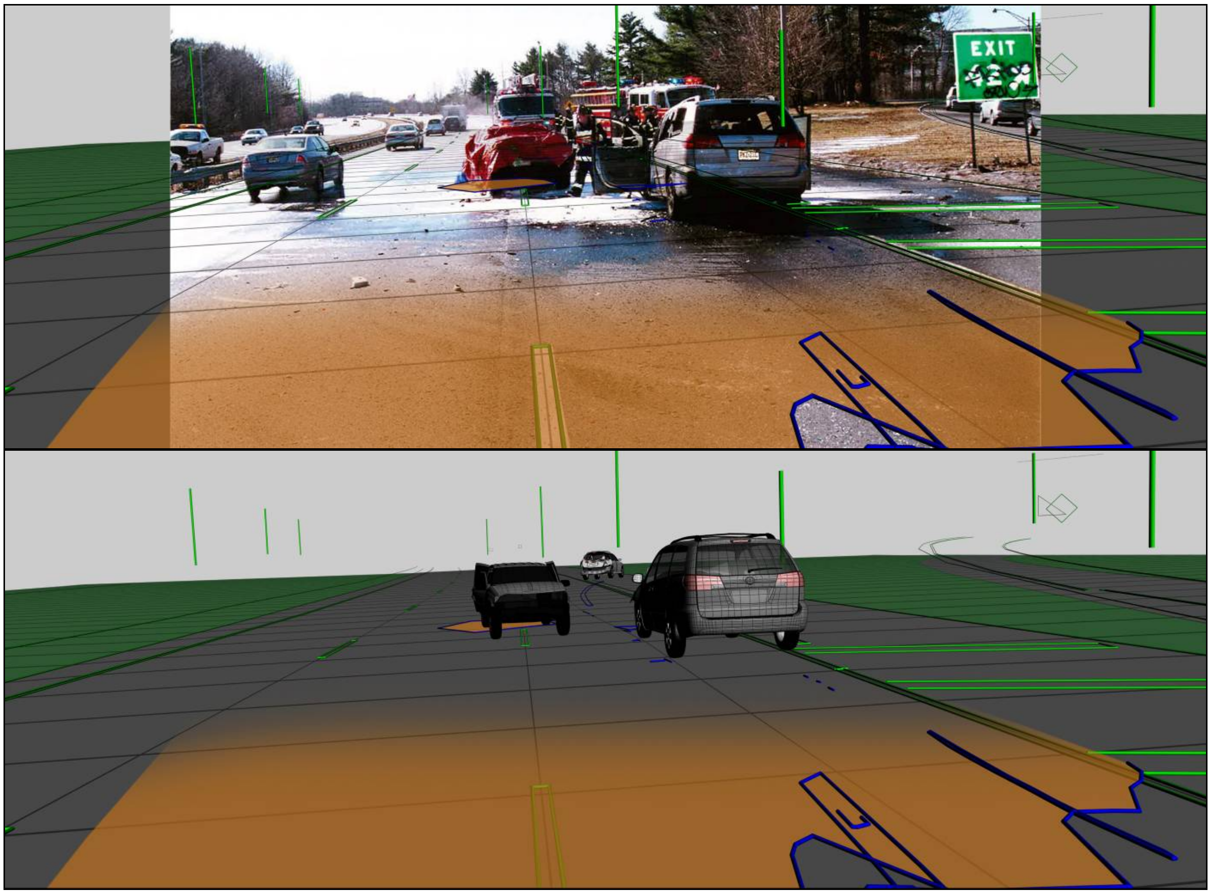

Figure 5-continued

Figure 6 depicts our accident scene diagram, including the rest positions of the vehicles that were located using photogrammetry. Glass, gouge marks and tire marks are indicated in blue. Fluid and burn areas are shown in orange.

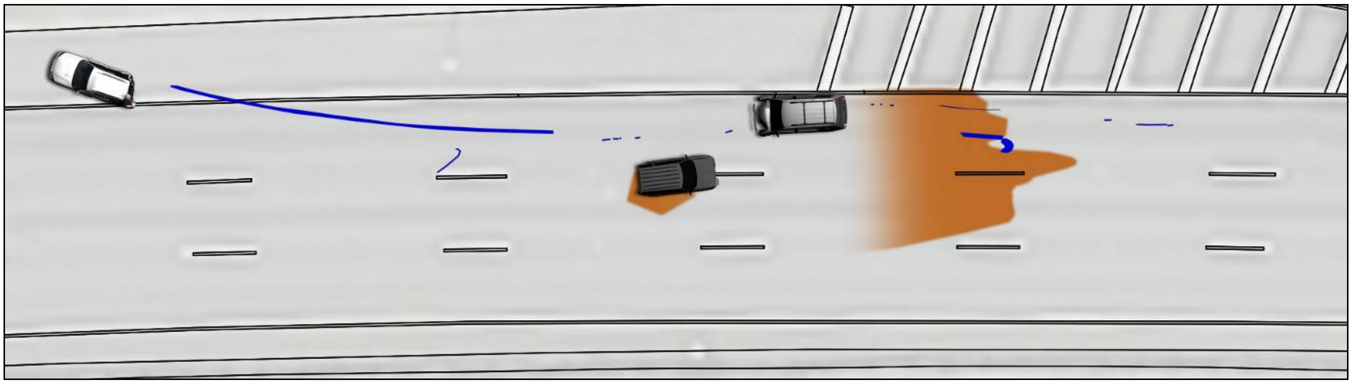

Figure 6

Analysis: Gouge and tire mark evidence were used to locate the points of impact on the roadway. Figure 7 depicts the location of the vehicles at first impact as dictated by the physical evidence.

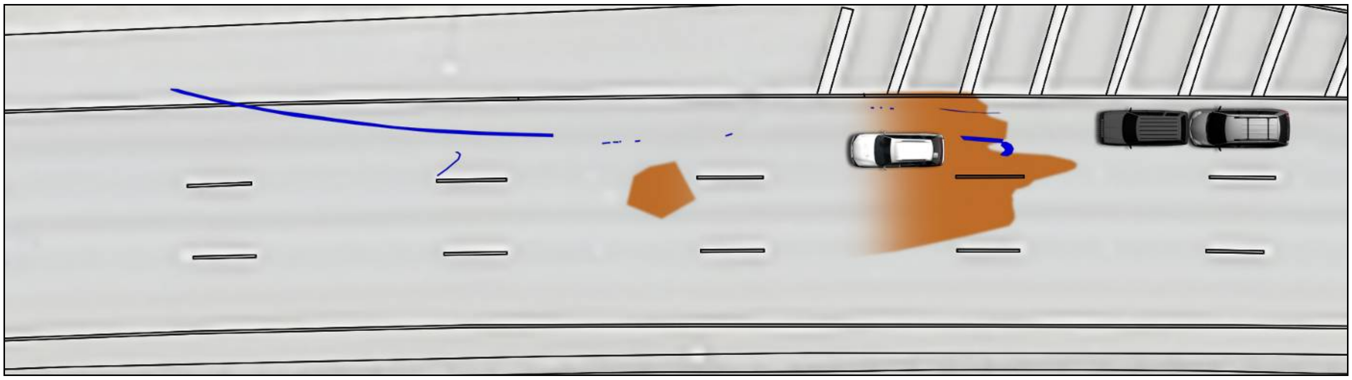

Figure 7

After the initial impact, the Jeep and Toyota traveled approximately 30 feet before impacting the rear of the Subaru. Figure 8 depicts the position of the vehicles at the second impact. As seen in the figure, the Jeep is crushed between the Toyota and Subaru. During impact two, the Jeep and Toyota were both damaged more extensively, as evidenced by the glass deposit at the location of the impact. As the Jeep was crushed, it rolled towards the passenger side and the Toyota under-rode the rear of the Jeep as depicted in Figure 9. The Jeep rolled approximately 25 degrees based on the damage pattern to the rear lift gates of the Jeep and the Subaru. Specifically, the window opening of the Jeep's rear lift gate exhibits more damage to the right side than the left, consistent with the Jeep being rolled to the right as the Toyota penetrated underneath the rear on the Jeep. Also, the rear lift gate of the Subaru exhibits damage consistent with the front of the Jeep being lifted up above the Subaru's rear bumper. Additionally, the right rear wheel of the Jeep gouged the pavement as it rolled to the right.

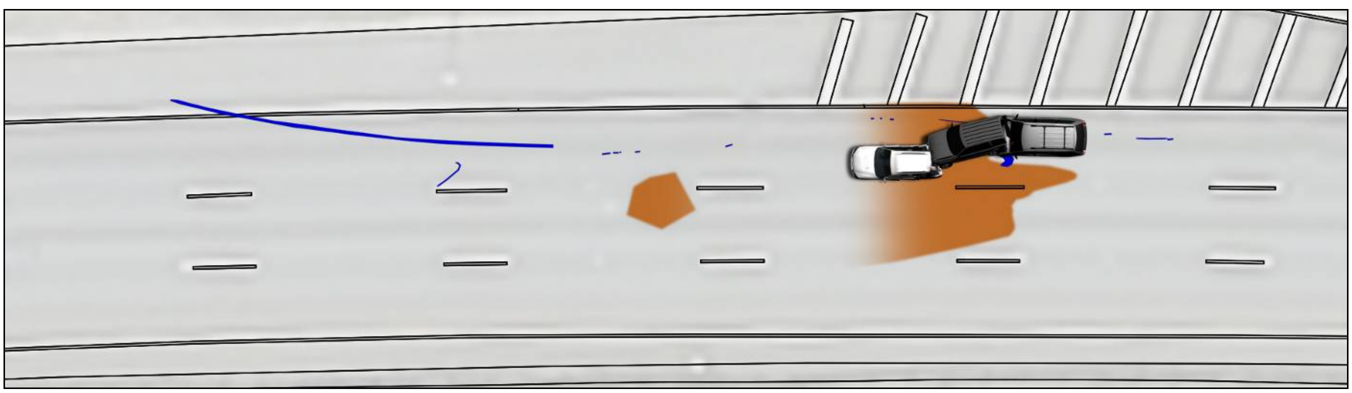

Figure 8

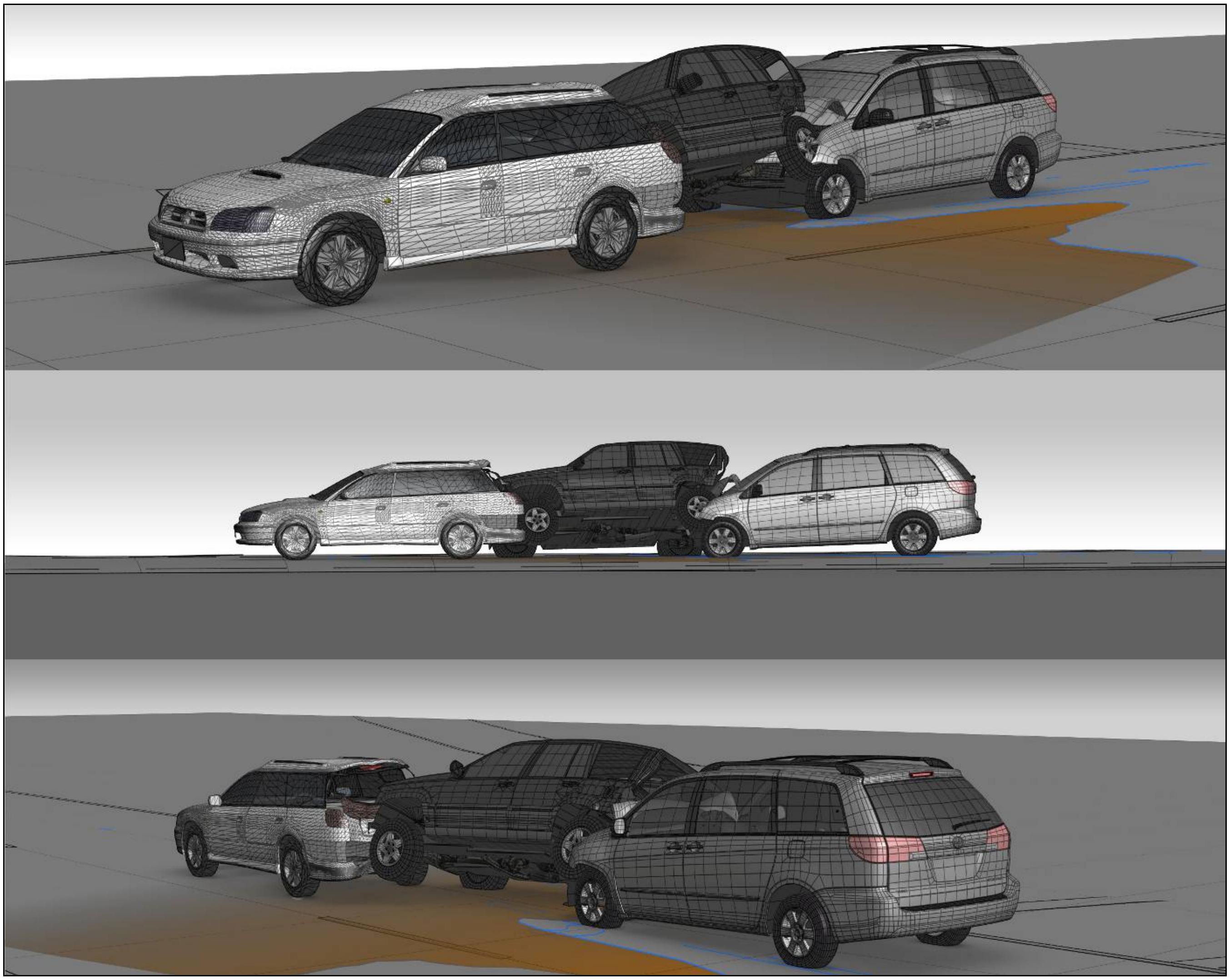

Figure 9

The vehicles then traveled to rest. The collision locked the rear right tire of the Subaru, causing it to leave a dark tire mark that led to its rest position. The Subaru traveled approximately 130 feet after the impact and came to rest on the shoulder. The Toyota traveled approximately 40 feet before coming to rest in the right lane. As the Jeep was crushed between the Subaru and the Toyota, it began to rotate counter-clockwise. The Jeep traveled approximately 50 feet, and rotated approximately 180 degrees before coming to rest straddling the right and middle lanes. The motion of the Jeep as it traveled to rest is depicted in Figure 10.

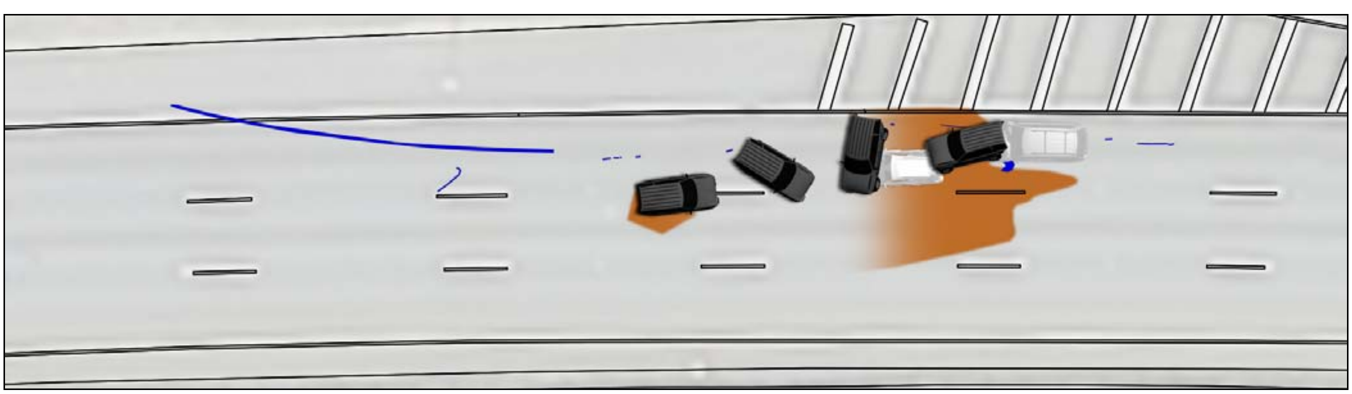

Figure 10

Through analysis of the accident sequence, Kineticorp determined that the Toyota impacted the Jeep at a speed of approximately 73 mph. There was no evidence of braking prior to the point of initial impact. Both the Jeep and Subaru were stopped or moving slowly when they were impacted. As a result of being impacted by the Toyota, the Jeep experienced a ΔV of approximately 38 mph.

Figure 11 below shows a gouge mark created during impact one when the Toyota first impacted the rear of the Jeep. The gouge mark was likely created when the Jeep's undercarriage made contact with the pavement. Analysis of the vehicle's bumper structures shows that the height of the Toyota's front bumper is in line with the Jeep's rear bumper and that there was good engagement between the bumper structures. As mentioned earlier, the Toyota pushed the Jeep ahead approximately 30 feet into the rear of the Subaru. During this second impact, the Jeep was crushed between the two vehicles and the rear structure of the Jeep, which had already been damaged, was crushed additionally. As seen in Figure 11, the fire pattern on the ground is located in the area of impact two. As depicted in Figure 9, the Toyota penetrated underneath the left side of the Jeep causing it to roll towards its right side. It is during this second impact where there is evidence of a fire pattern on the ground due to the Jeep's fuel system being breached.

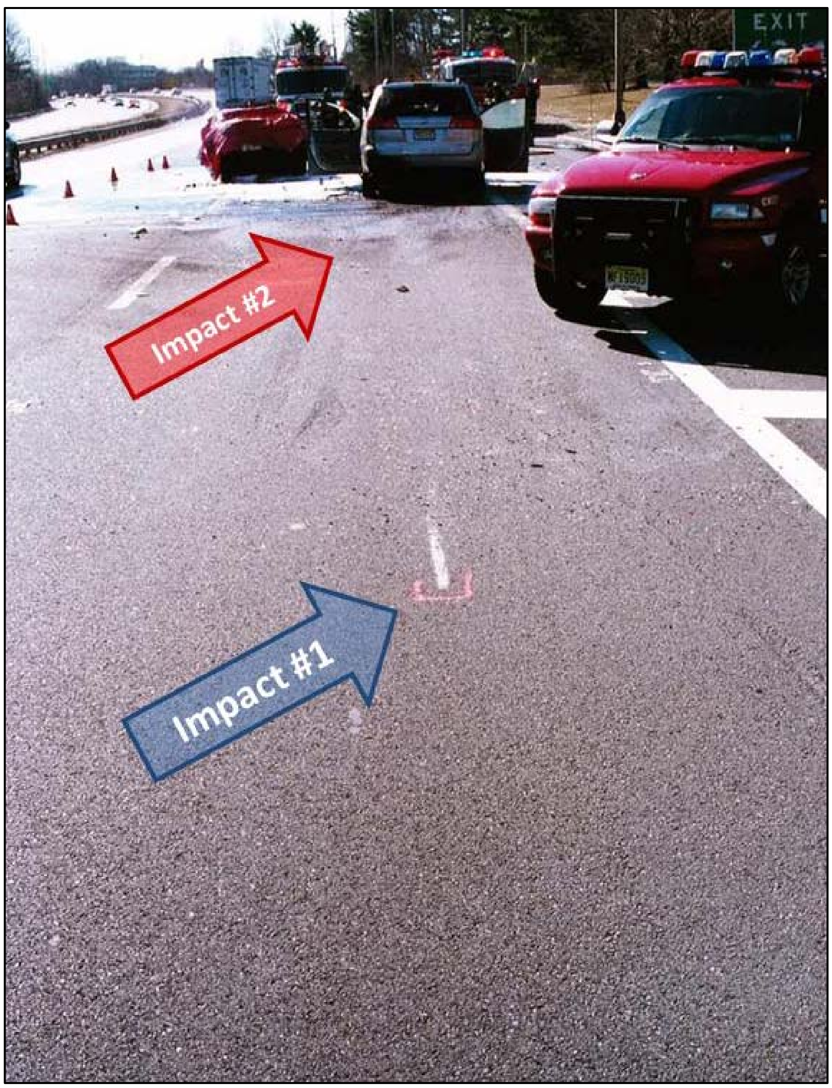

Figure 11

The top image in Figure 12 depicts the damage to the Jeep, as documented with our three-dimensional scan. The rear axle is highlighted in blue in Figure 12. The bottom image of Figure 12 depicts the relative movement of the rear axle compared to its original undamaged position. The axle would have moved further forward dynamically during the crash.

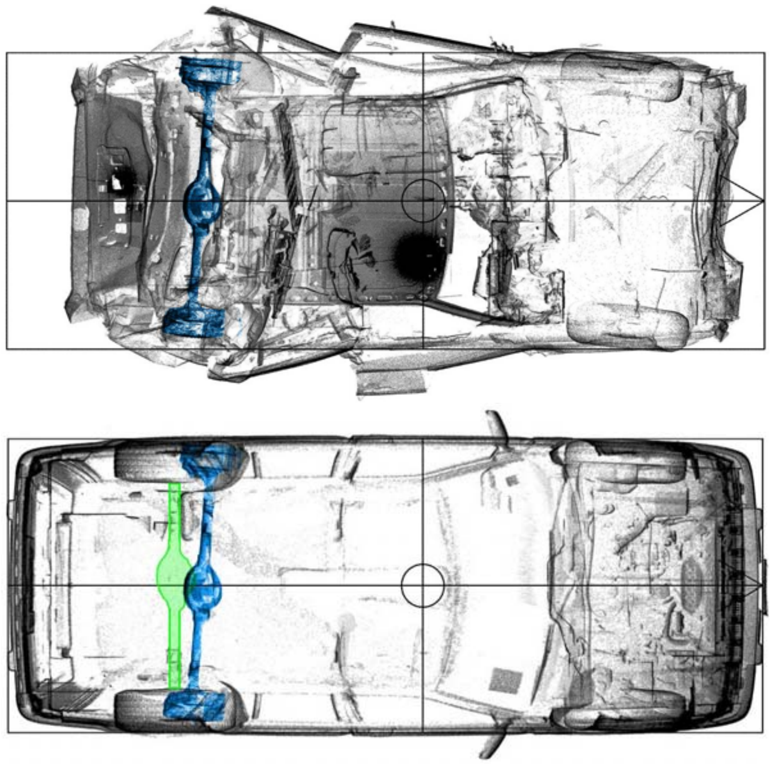

Figure 12

Discussion: Kineticorp compared the severity of the initial impact to the Jeep to the FMVSS 301 fuel system integrity test. In the FMVSS 301 test, a four-thousand-pound, rigid barrier impacts the rear of the vehicle at 30 mph. Kineticorp determined that the first impact between the Toyota and Jeep was approximately 6 times more severe than the FMVSS test conditions.

Kineticorp also examined crash test reports produced for the Center for Auto Safety (CAS) by KARCO[1]. These tests involved 1999 and 1996 Jeep Grand Cherokee vehicles being impacted by Ford Taurus'. Kineticorp determined that the energy involved in the initial impact between the Toyota and Jeep in the subject accident was approximately 2 times greater than the 1999 Jeep test, and approximately 4 times greater than the 1996 Jeep test.

The subject accident was significantly different than the KARCO tests in terms of the lateral and vertical alignment of the vehicles. The top image in Figure 13 depicts the initial impact alignment between the Toyota and the Jeep. The image below shows the alignment between the Taurus and Jeep from test TR-P31070-01-NC. The top of the bumper of each vehicle has been indicated, the Jeep in red and the impacting vehicle in yellow. As depicted, there was good bumper alignment in the subject accident. However, in the KARCO test, the entire bumper of the Taurus was beneath the bumper of the Jeep. The test setup is conducive to vehicle under-ride, the subject accident was not. In both KARCO tests, the tires on the Jeep were significantly larger than the tires on the subject Jeep at the time of the accident. Also, the tires on the test Taurus were significantly smaller than the recommended tire size for that vehicle in test TR-P31070-01-NC. These tire differences make it easier for the Taurus to under-ride the rear of the Jeep in the tests. Further, the test tire pressures were not listed in the test reports and it appears that the tires of the Taurus were underinflated for the test. This would lower front of the Taurus and make it easier for the tires of the Taurus to compress during the impact. Low tire pressure would also make it easier for the Taurus to under-ride the Jeep. The alignment between the test vehicles was drastically different than the alignment during the accident. In terms of under-ride propensity, the vehicle and tire selections in the test are skewed towards a worst case scenario for the Jeep's structural ability to absorb the crash energy. These conditions did not exist in the subject accident.

[1] Test numbers TR-P31070-01-NC and TR-P31015-01-A

Figure 13

In the subject accident, the Toyota impacted squarely into the entire rear of the Jeep. In the KARCO tests, the collision was offset, such that the entire rear of the Jeep was not directly involved in the collision. This offset in the test is significant because less of the vehicle's width is available to absorb the impact energy. In other words, offset collisions are more severe in terms of energy absorption demands placed on the impacted vehicle. Since the subject accident was a full overlap collision, the offset tests are misrepresentative of the subject accident. The top image in Figure 14 depicts the lateral alignment of the vehicles in the subject accident. The red line indicates the center of the Jeep, the yellow line indicates the center of the Toyota. The KARCO test is depicted below.[2] In the KARCO test, the Taurus is offset significantly to the left at impact. Due the lateral and vertical alignment differences, no meaningful comparisons can be made between the subject accident and the KARCO test results. It should also be noted that components in the test Jeeps were removed, such as the spare tire, door panels and the rear side windows. At this time Kineticorp has not made a determination as to the effect of removing these items in the tests.

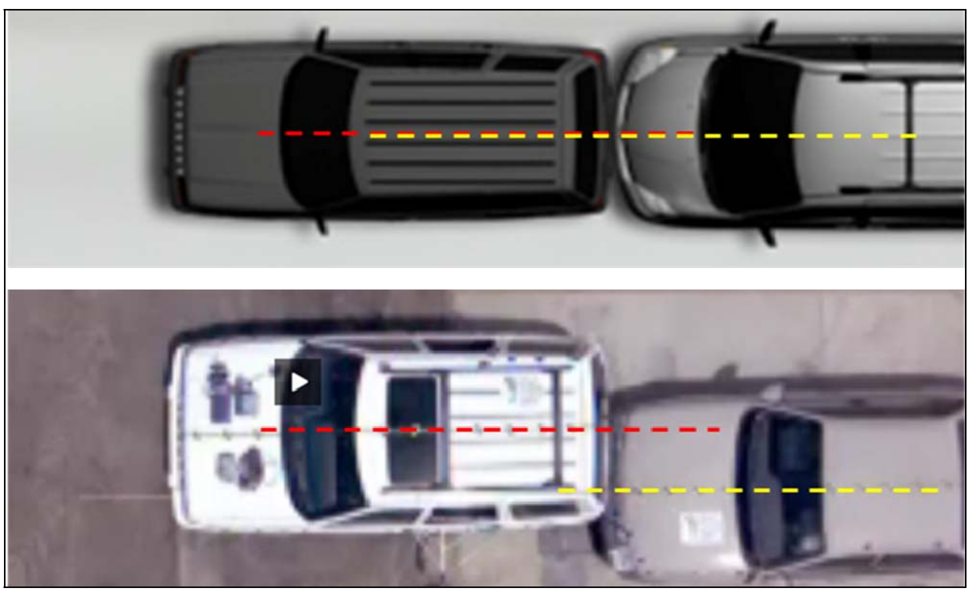

Figure 14

[2] Note the distortion from the KARCO video makes the Jeep appear wider than it is.

Both the FMVSS and KARCO tests are single impact tests and do not involve a secondary impact as occurred in the subject accident. These tests do not take into account the additional severity introduced by a second loading event or under-ride to an already damaged vehicle.

Closing: The opinions and conclusions expressed in this report were reached to a reasonable degree of engineering certainty based on our investigation and analysis to date. We reserve the right to critique opposing experts after having the opportunity to review their file materials and testimony. Further information, data, investigation or analysis may lead us to revise or supplement these opinions and conclusions. Kineticorp may produce additional graphics and animations for use at trial.

Sincerely,

Stephen J. Fenton, P.E.
Principal Engineer

COLORADO LICENSED
STEPHEN J. FENTON
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PROFESSIONAL ENGINEER

Gray Beauchamp, P.E.
Senior Engineer

COLORADO LICENSED
ARTHUR GRAY BEAUCHAMP
43741
PROFESSIONAL ENGINEER

Appendix A
List of Provided Materials

New Jersey Police Crash Investigation Report; Case No. B080-2007-00445A dated 02/24/2007
State of New Jersey Division of Fire Safety Incident Report dated 02/24/2007

- **Digital Photographs**
  - PDF containing 41 police photos
  - PDF containing 420 photos of Vehicle Inspection taken by Dynamic Analysis Group
  - PDF containing 16 photos of Scene Inspection taken by Dynamic Analysis Group
  - PDF containing 81 black and white photos taken by Mr. Alcala
  - 41 8x10 police photos

- **Digital Video**
  - Video provided by Paul Sheridan

- **Deposition Transcripts** *(with Exhibits*)*
  - Victoria Morgan-Alcala*
  - Detective Kevin Bartles
  - Natalie Rawls
  - Phillip Kaeser
  - Paul Sheridan*
  - Trooper Elkin Orellano*

- **Expert Reports**
  - Donald Phillips Initial Report (National Forensic Engineers, Inc.) dated 04/22/09
  - Donald Phillips Supplemental Report (National Forensic Engineers, Inc.) dated 07/25/2011
  - Neal Hanneman Preliminary Report (Forensic Automotive Consulting Team) dated 12/04/2009
  - Neal Hanneman Supplemental Report (Forensic Automotive Consulting Team) dated 08/03/2011
  - William Bush Report (Bush Investigative Services, LLC) dated 12/03/09
  - Paul Sheridan Report – Second Revision dated 08/10/2011
  - Ross IS Zbar Report (Plastic and Reconstructive Surgery) dated 08/09/10
  - Nicholas Durisek Report (Dynamic Analysis Group, LLC) dated 03/14/11
  - Robert Banta Report (Banta Technical Services, LLC) dated 03/24/11
  - Robert Banta Supplemental Report (Banta Technical Services, LLC) dated 12/12/11
  - Carl Nash Report dated 08/11/2011
  - Thomas Bennent Report (Forensic Medicine and Pathology) dated 09/09/11
  - Rose Ray Report (Exponent Failure Analysis Associates, Inc.) "Analysis of the Real-World Crash Performance of 1993-1998 Jeep Grand Cherokees dated 12/15/11

- **Legal Documents**
  - Second Amended Complaint
  - Natalie Rawls Answers
  - Deposition Notices for Plaintiff's Experts
  - Deposition Subpoena Notices
  - Answers to Form C Interrogatories

- **Other Documents**
  - Natalie Rawls Statement of Order
  - ZJ Real World Crash Study

- ZJ Frames and Bumpers Manual
- ZJ Fuel System Manual