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Kineticorp™

Forensic Engineering | and Visualization

July 20, 2020

David Mills
Cooley, LLP
1299 Pennsylvania Avenue NW, Suite 700
Washington, DC 20004-2400

RE: *Crash Reconstruction for Sines v. Kessler*

Dear Mr. Mills:

As requested, I have investigated and reconstructed the car crash that occurred around 1:43 p.m. on Saturday, August 12, 2017, at the intersection of Water Street and Fourth Street in Charlottesville, Virginia. The crash occurred between a 2010 Dodge Challenger (the "Challenger"), a group of pedestrians walking on Fourth Street, a 2004 Toyota Camry (the "Camry") and a Honda Odyssey (the "Odyssey"). The Challenger was traveling southbound on Fourth Street, the group of pedestrians was walking northbound on Fourth Street and the Camry and Odyssey were stopped at a stop sign on Fourth Street at the intersection of Water Street. The Challenger crashed into the group of pedestrians as they were walking up Fourth Street, and then it impacted the rear end of the Camry, which was pushed into the Odyssey. It is my understanding that defendant James Fields was driving the Challenger.

The aerial photograph below (dated March 5, 2018 and obtained from Nearmap) depicts Fourth Street with the area of the crash circled in yellow and the Challenger's direction of travel depicted with a yellow arrow. The incident occurred during daylight and the weather was clear and dry. The speed limit on Fourth Street was 25 mph.

Summary of Conclusions: As a result of the investigation, which was completed by me and my team under my direction, I reached the following conclusions related to the crash:

a. Mr. Fields was traveling approximately 31 mph at impact with the Camry.

b. Mr. Fields accelerated from approximately 13 mph to 31 mph into the crowd of pedestrians.

c. Mr. Fields did not brake for the pedestrians.

d. Mr. Fields steered towards the pedestrians that were near a parked pickup truck.

e. Mr. Fields could have exited Fourth Street before the crash without impacting any people or other vehicles.

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 vehicle crash reconstruction. The above-listed conclusions, to which this procedure led, were reached to a reasonable degree of certainty.

Procedure: In conducting our investigation and analysis, me and a team under my direction at Kineticorp reviewed the materials listed in Appendix A of this report. In addition:

a. We obtained aerial photographs of the area where the crash occurred.

b. We visited, documented, photographed, and scanned the crash site on February 6, 2019.

c. We analyzed the unique Vehicle Identification Number (VIN) of the subject vehicle to determine the appropriate specifications for the vehicle involved in this crash. We used published technical specifications obtained from the vehicle manufacturers to produce computer models of the vehicles involved in this crash.

d. We produced a computer model of the crash site. This computer model was created based on three-dimensional digital scan data collected during the site investigation. We supplemented the survey data by conducting photogrammetric analysis on photographs and still frames from video taken the day of the crash. Photogrammetry encompasses techniques used to obtain measurements and three-dimensional positional data from photographs and videos. 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 crash 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," SAE Technical Paper 861422, Warrendale: Society of Automotive Engineers, 1986.
- Chou, C., McCoy, R., Fenton, S., et al., "Image Analysis of Rollover Crash Test Using Photogrammetry," SAE Technical Paper 2006-01-0723, Warrendale: Society of Automotive Engineers, 2006.
- Fenton, S., et al., "Determining Crash Data Using Camera-Matching Photogrammetric Technique," SAE Technical Paper 2001-01-3313, Warrendale: Society of Automotive Engineers, 2001.
- Husher, Stein E., et al., "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., Fenton, S., et al., "A Video Tracking Photogrammetry Technique to Survey Roadways for Accident Reconstruction," SAE Technical Paper 2004-01-1221, Warrendale: Society of Automotive Engineers, 2004.

- Neale, W.T.C., et al., "Photogrammetric Measurement Error Associated with Lens Distortion," SAE Technical Paper 2011-01-0286, Warrendale: Society of Automotive Engineers, 2011.
- Pepe, Michael D., et al., "Accuracy of Three-Dimensional Photogrammetry as Established by Controlled Field Tests," SAE Technical Paper 930662, Warrendale: Society of Automotive Engineers, 1993.
- Rose, Nathan A., Neale, W.T.C., Fenton, S.J., et al., "A Method to Quantify Vehicle Dynamics and Deformation for Vehicle Rollover Tests Using Camera-Matching Video Analysis," SAE Technical Paper 2008-01-0350, Warrendale: Society of Automotive Engineers, 2008.
- Rucoba, Robert, et al., "A Three-Dimensional Crush Measurement Methodology using Two-Dimensional Photographs," SAE Technical Paper 2008-01-0163, Warrendale: Society of Automotive Engineers, 2008.
- Tandy, D., et al., "Benefits and Methodology for Dimensioning a Vehicle Using a 3D Scanner for Accident Reconstruction Purposes," SAE Technical Paper 2012-01-0617, Warrendale: Society of Automotive Engineers, 2012.
- Voitel, Tilo and Terpstra, Toby, "Benefits of 3D Laser Scanning in Vehicle Accident Reconstruction," Technology White Paper, FARO Technologies, Inc., 2012
- Bailey, Ann, James Funk, David Lessley, Chris Sherwood, Jeff Crandall, William Neale and Nathan Rose, "Validation of a Videogrammetry Technique for Analysing American Football Helmet Kinematics," Sports Biomechanics, DOI: 10.1080/14763141.2018.1513059. October, 2018.

<u>Kineticorp Site Inspection:</u> On February 6, 2019, my team and I inspected, documented, scanned, and photographed the site of the subject crash. During the site inspection, we documented the intersection where the crash occurred. The photographs below were taken during the inspection of the crash site. The photographs depict the subject intersection, facing northbound and southbound, respectively.

The site was digitized using two Faro Focus high-definition 3D laser scanners. The photographs below show the documentation of the crash site.

The data from the scanning process was used to produce a 3D computer model of the scene. The model consists of millions of data points representing the 3D geometry. Below is an image showing the data points captured during the scanning process.

Crash Scene and Diagram: During our inspection, the layout of the incident area was documented with the 3D scanners, as well as permanent roadside features and landmarks. We created a scaled computer model of the subject intersection and the entirety of Fourth Street between Water Street and Market Street based on these scan measurements. We confirmed the location of crash-related physical evidence, including the vehicles' points of rest and pedestrian locations, by conducting photogrammetric analysis of photographs and videos taken on the day of the crash. Photogrammetry is the process of obtaining three- dimensional measurements and positional data from photographs and videos. The photogrammetric technique that we used on this case is referred to as camera-matching photogrammetry. This technique involves the following steps:

a. Autodesk 3ds Max computer-modeling software was used to create a three-dimensional computer model of the crash scene from data that was collected at the scene with 3D scanning equipment. This computer model includes features of the environment that were present at the time of the crash such as road boundaries, roadway stripes, signs, structures and other unique aspects of the roadway environment.

b. The computer-modeled environment was then imported into a modeling software package, and several computer-modeled cameras were set up to view the computer environment from perspectives that were similar to the perspectives characterized in the photographs taken shortly before and after the crash.

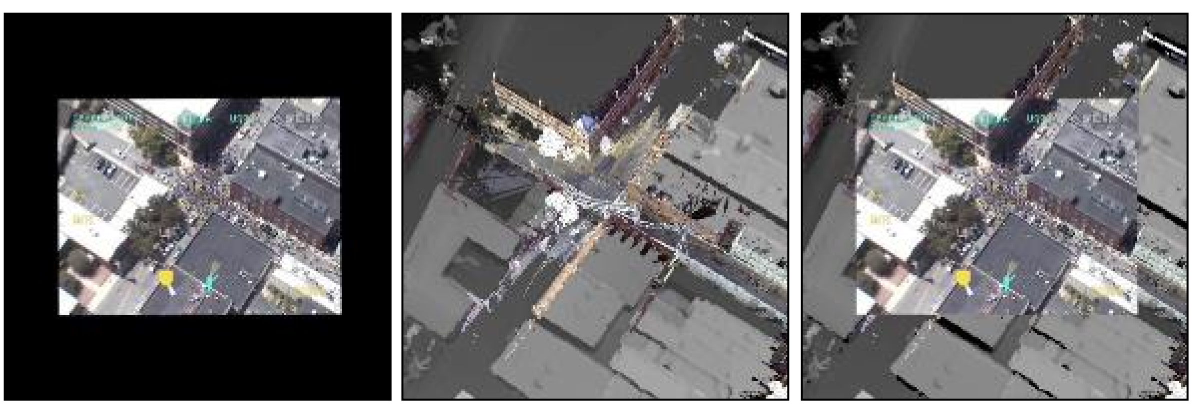
c. Crash scene photographs and video frames were imported into the modeling software and were designated as background images for the corresponding computer-modeled camera with the same perspective.

d. Adjustments to the location, focal length and target location of the computer-modeled camera were made until there was an overlay between the computer-generated environment model and the environment shown in the photograph.

e. Once the camera location and characteristics were determined and the overlay between the environment model and the photograph was obtained, non-permanent features, such as pedestrian locations, were mapped from the photographs and video frames onto the environment model. Computer models of non-permanent features, such as the vehicles' rest positions, were also added to the environment through this same process. Once these non-permanent features were transferred to the environment model, they were measured relative to the known dimensions of the environment model.

The following images contain a sampling of this photogrammetric analysis. The first image in each row is a photograph taken during the police investigation on the day of the crash. The second image of each row shows the scan data gathered during our scene inspection that has been aligned to the police photo. The third image depicts the photograph overlaid with the 3D computer models of the crash vehicles.

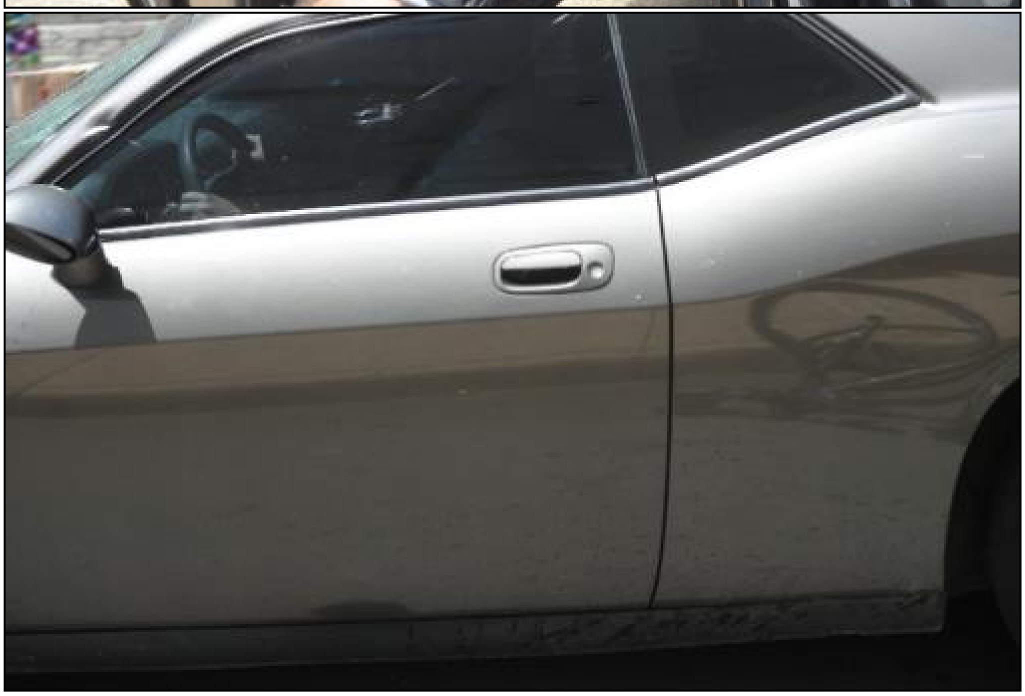
The same process was used to analyze the position of the Challenger in the videos that were provided. With regard to the video taken by helicopter, because the helicopter camera was moving, the video needed to be stabilized relative to the stationary scene which included the buildings and streets. Frames from the video were matched to the stationary scene. The process is shown below with one of the frames from the helicopter video. The first image below is a frame from the police helicopter video. The second image shows the scan data gathered during the scene inspection. The third image depicts the video frame overlaid on the 3D computer model of the scene. This process was performed on all the video frames starting when the Challenger came into view, through impact with the Camry.



The aerial photo below depicts the configuration of the crash site. The crash location is at the intersection of Water Street and Fourth Street.

Dodge Challenger: The subject vehicle was a 2010 model year Dodge Challenger, 2-door sedan (VIN – 2B3CJ4DV8AH111921). It was equipped with a 3.5-liter, six-cylinder, 24-valve engine, and a four-speed automatic transmission. The Challenger was inspected by Kineticorp, photographed, and laser scanned using a Faro Focus scanner. As seen in the photographs, the Challenger sustained direct contact damage to the front portion of the vehicle and windshield as a result of the collision, which is consistent with photos and videos taken the day of the crash.

It was determined during the inspection that the driver and passenger side windows were tinted. As seen in the bottom photograph below taken at the time of the crash, the tinting made it difficult to see inside the Challenger.



Crash Sequence: Four primary cameras show the position of the Challenger as it traveled down Fourth Street.

a. Helicopter Video – I understand this video was taken from a police helicopter that was monitoring the protests. This video shows the impact between the Challenger and the Camry occurring at approximately 1:53:01 p.m. The Call for Service Detail Report ("CFS Report"), which appears to be a 911 call report, shows the crash occurred at 1:42:46 p.m. From my experience, 911 call reports are generally very accurate, therefore, I have adopted the CFS Report time. This means that the clock on the helicopter video is 10 minutes and 15 seconds fast.

b. Red Pump Video – This surveillance camera was located on the west side of the Red Pump Kitchen restaurant. The time stamp on the Red Pump video is approximately one minute and 45 seconds ahead of the helicopter video. For our analysis, the relative time stamps do not matter. We were able to sync the videos based on the audible and visual cues that are common between the videos.

c. Water Street Video – This video was obtained from a pedestrian that was in the crowd at the intersection of Water Street and Fourth Street.

d. Main Street Video – This video was obtained from a pedestrian who was at the intersection of Main Street and Fourth Street.

Based on the four videos, the sequence of the crash was determined. Below is a summary of the sequence.

a. The Red Pump video shows the Challenger followed the Camry down Fourth Street at approximately 1:52 p.m. (time not adjusted to the time in the CFS Report).

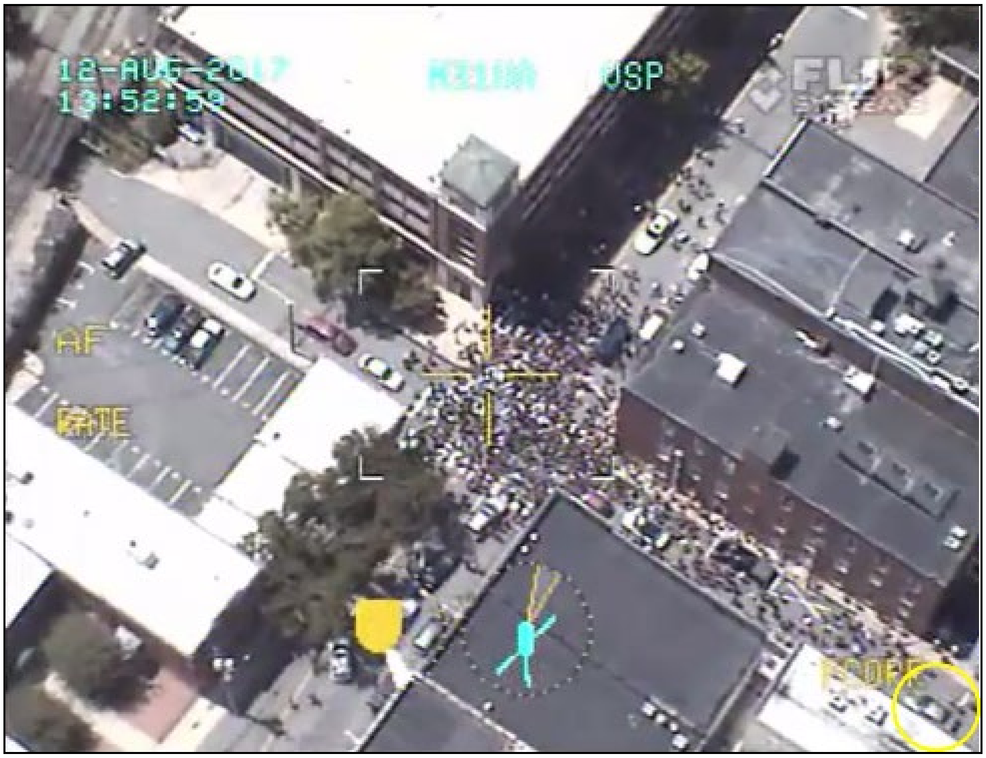
b. The Challenger crossed Main Street and stopped just south of several newspaper boxes seen on the east side of Fourth Street.

c. The Challenger then backed up Fourth Street towards Market Street and was visible a second time in the Red Pump video at about 1:54:23 p.m.

d. The Challenger was seen a third time in the Red Pump video driving down Fourth Street towards Main Street at a high rate of speed moments later at 1:54:38 p.m.

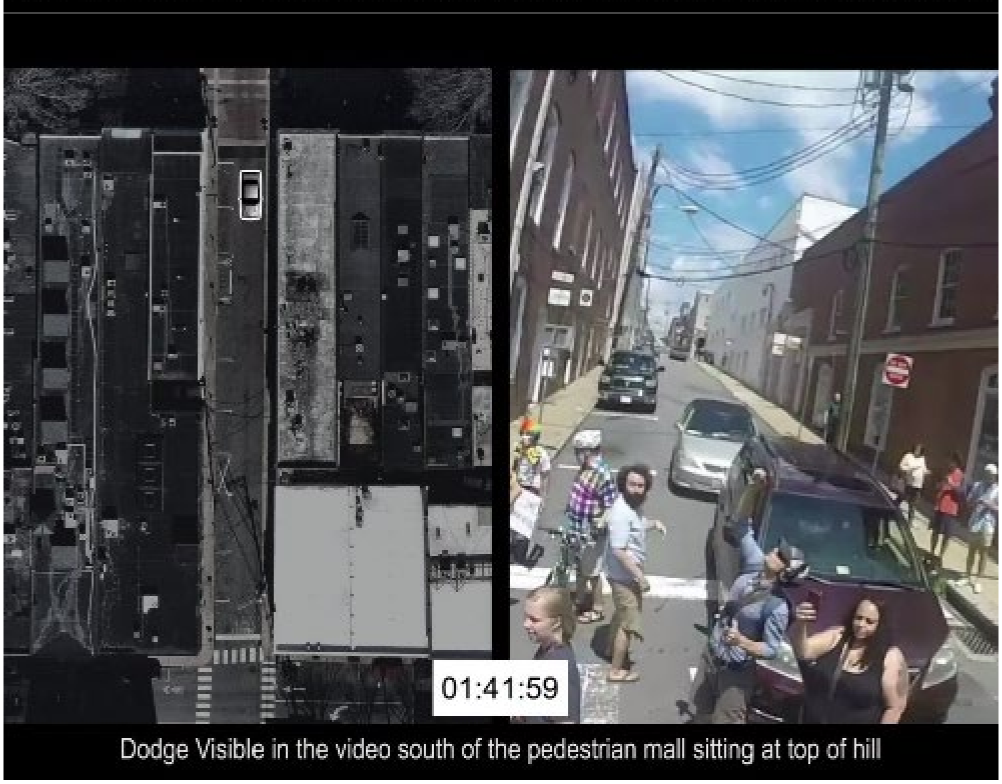
e. The Challenger is seen crossing Main Street traveling at a high rate of speed and continues past several bollards (black posts) on the west side of the street.

f. The Challenger then comes into view in the helicopter video south of the bollards where it can be followed up to the time of impact.

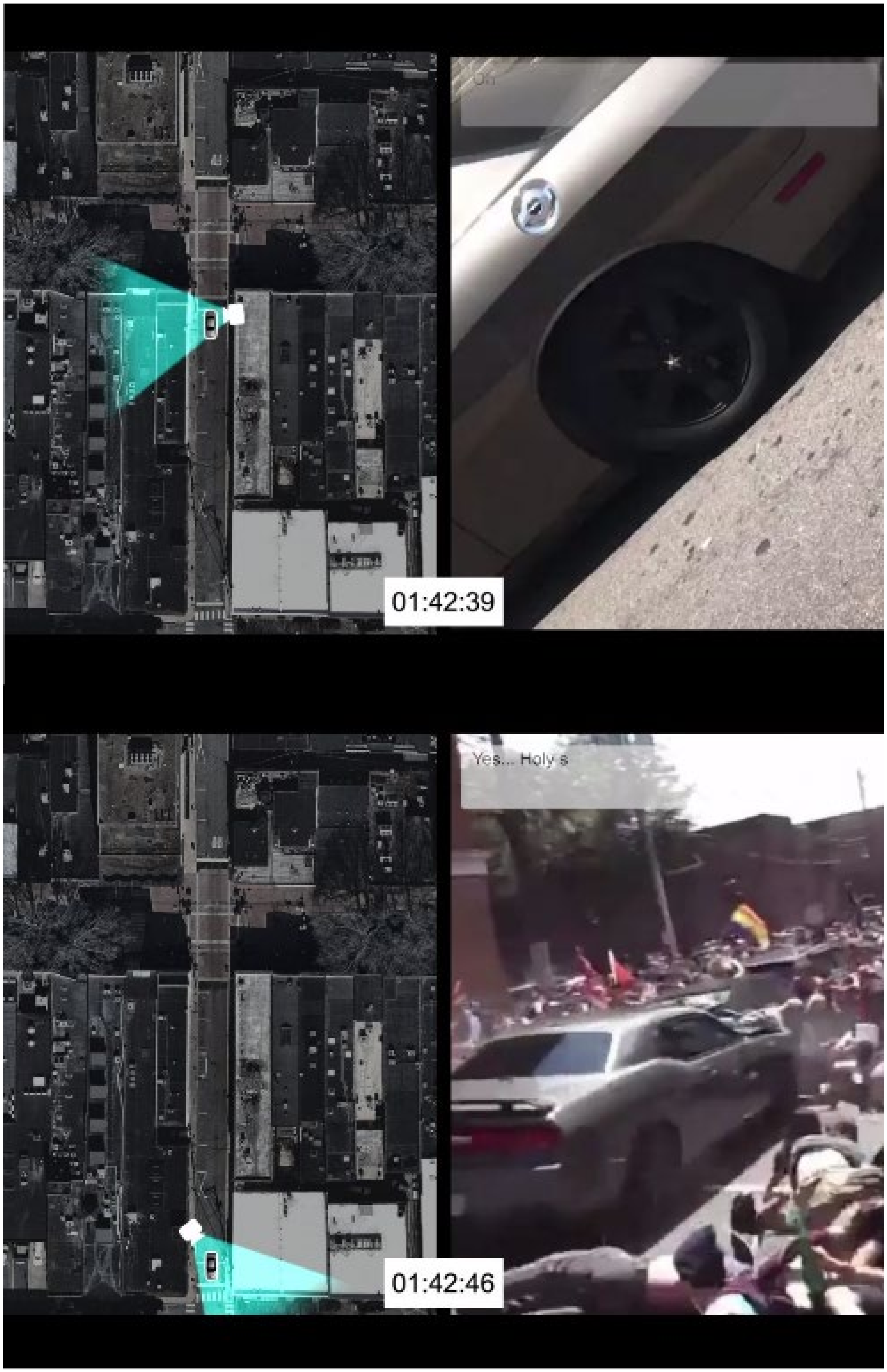


A video showing the timing of these events along with the source of each segment was produced and accompanies this report. The time shown in the video is adjusted to match the CFS Report. Below are several frames from the video.

Dodge Visible in the Red Pump video north of the pedestrian mall, driving south toward the mall



Dodge Visible in the video south of the pedestrian mall sitting at top of hill


01:42:39
Yes... Holy s
01:42:46

<u>Crash Reconstruction</u>: Photogrammetry was used to determine the speed and path of the Challenger in the videos.

a. The speed of the Challenger was determined in the following videos:

i. Speed in Red Pump video:

1. As the Challenger enters the video at approximately 1:54:38 p.m. (Red Pump video time), the Challenger travels approximately 20 feet over 12 frames, which equates to 34 mph.

2. The Challenger is shown speeding up and it travels approximately 24 feet over the next 12 frames, which equates to 41 mph.

ii. Speed in Main Street Video:

1. The Challenger hits the speed bump south of Main Street, heading for the bollards and brakes. In the video, the Challenger travels approximately 16 feet in 11 frames which equates to 30 mph.

iii. Speed in helicopter video:

1. The Challenger enters the video traveling approximately 18 mph and speeds up to approximately 31 mph at impact with the Camry. These speeds were determined using the stabilized video. The first frame below shows the Challenger entering the frame at 18 mph. The second frame shows the Challenger traveling 31.4 mph at impact. The video accompanies this report.

b. The Challenger's brake lights were analyzed as it traveled down Fourth Street:

i. The Challenger's brake lights were illuminated when it came off the speed bump south of Main Street as it headed towards the bollards that surround the bicycle parking area.

ii. The Challenger's brake lights went off when the Challenger cleared the bicycle parking area and remained off as it accelerated and traveled up to impact with the Camry.


STOP

c. The Challenger's path was analyzed to determine steering inputs:

i. As the Challenger came off the speed bump south of Main Street, it was headed towards the bollards that surrounded the bicycle area. The right side of the Challenger is seen up against the white lines that designate the parking spots on the west side of Fourth Street.

ii. The Challenger was then steered to the left to avoid the bollards surrounding the bicycle parking area.

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iii. The Challenger was then steered to the right towards the pickup truck parked on the west side of Fourth Street.

Trooper Thomas's Findings: Kineticorp was provided with Virginia State Police investigative materials, which included a Crash Team Report, Crash Data Retrieval ("CDR") data and calculations. Trooper Thomas stated that according to the Camry's CDR data, the Camry experienced a Delta-V of 17.1 mph. He stated that the Challenger "has to be traveling at a minimum of 17.1 miles per hour to create this change in speed" in the Camry. The Challenger's actual impact speed can be calculated using Conservation of Linear Momentum[1]. The formula is shown below, where m_1 and m_2 are the masses of the Challenger and Camry (respectively), v_1 and v_2 are the pre-impact speeds of the Challenger and Camry (respectively), v_3 and v_4 are the post-impact speeds of the Challenger and Camry (respectively).

$$m_1\mathbf{v}_1 + m_2\mathbf{v}_2 = m_1\mathbf{v}_3 + m_2\mathbf{v}_4$$

Based on the Conservation of Linear Momentum calculation, the Challenger was going approximately 32.4 mph at impact.

Trooper Thomas also analyzed the helicopter video to determine the Challenger's speed prior to impact. Trooper Thomas used a hand-held stopwatch to determine the time it took the Challenger to travel from the "painted parking strip in front of the parked location of Vehicle 2 (Tundra) to the northern most painted line of the crossed out parking spot behind Vehicle 2." He determined it took the Challenger 1.3 seconds to traverse this segment, which he measured to be 44 feet. Frame-by-frame analysis of the helicopter video, which is more accurate than a calculation relying on a stopwatch, shows that it took the Challenger 24 frames to traverse this distance. The video shows that there are 25 frames for every one second interval. Therefore, the time it took can be calculated by dividing 24 frames by 25 frames per second, which is 0.96

[1] John Daily, Fundamentals of Traffic Crash Reconstruction, (Florida, Institute of Police Technology and Management, 2007), 252.

seconds. The speed of the Challenger can be calculated by using the constant velocity equation below, where Δd is the distance traveled and Δt is the time.

$$v = \frac{\Delta d}{\Delta t}$$

Based on the constant velocity equation, the Challenger was traveling approximately 31.3 mph, which is very close to the 32.4 mph speed calculated using the Conservation of Linear Momentum method above. Ultimately, Trooper Thomas determined that the speed of the Challenger was 28.72 mph, which is less accurate but within ten percent of the constant velocity calculation.

<u>Discussion</u>: Based on the analysis of the photographs and videos, the following was determined.

a. Speed: It was determined through photo and video analysis that Mr. Fields accelerated at nearly full throttle from 13 mph to more than 31 mph at impact with the Camry. Had he not accelerated, the pedestrians would have had more time to move out of the Challenger's path.

b. Braking: After the Challenger came off the speed bump south of Main Street and headed toward the bollards protecting the bicycle rack, Mr. Fields applied the brakes, slowing the Challenger down to approximately 13 mph. Had Mr. Fields continued applying the brakes, he could have stopped in less than ten feet, well short of the pedestrians that were impacted.

c. Steering: As Mr. Fields passed the bollards, pedestrians jumped out of the Challenger's path towards the sidewalk on both sides of Fourth Street. Several pedestrians were walking adjacent to the pickup truck on the west side of the street and were not able to get to the sidewalk. Mr. Fields steered to the right, towards these pedestrians who did not have an escape route. Had Mr. Fields not steered to the right, he would not have impacted these pedestrians.

d. Alternative Routes: When Mr. Fields was slowly backing up Fourth Street towards Market Street before the crash, he could have continued backing up and exited on Market Street, as he later did after the crash.

e. Pedestrian with Flagpole: Analysis of the evidence shows that as Mr. Fields was speeding towards the pedestrians, a pedestrian swung a flagpole at the back of the Challenger as it passed him, but he missed and the car was not impacted by the flagpole. Notice that the shadow from the flagpole shows that the pole missed the Challenger. Also, the flagpole's path is not impeded by the Challenger.

<u>Pedestrian Involvement:</u> We performed a detailed path analysis of eight of the pedestrians that were in the area of the crash. The pedestrians are listed below:

a. Elizabeth Sines – Ms. Sines was walking north on Fourth Street when she saw the Challenger. She escaped to the east sidewalk when the Challenger was a few feet away from impacting her.

b. Marissa Blair – Ms. Blair was walking in front of Marcus Martin adjacent to the pickup truck parked on the west side of the street. She was pushed out of the Challenger's path towards the sidewalk by Marcus Martin.

c. April Muniz – Ms. Muniz was walking on the east side of the street at the time of the crash and is pictured on the east sidewalk as the Challenger impacted the Camry.

d. Marcus Martin – Mr. Martin was impacted by the Challenger and went over the top of the Challenger.

e. Natalie Romero – Ms. Romero was impacted by the Challenger and was thrown towards the west sidewalk. She is seen upside down in photo below.

f. Chelsea Alvarado – Ms. Alvarado was carrying a drum. She and the drum were impacted by the Challenger and thrown to the west.

g. Thomas Baker – Mr. Baker was impacted by the Challenger, and he went over the top of the Challenger.

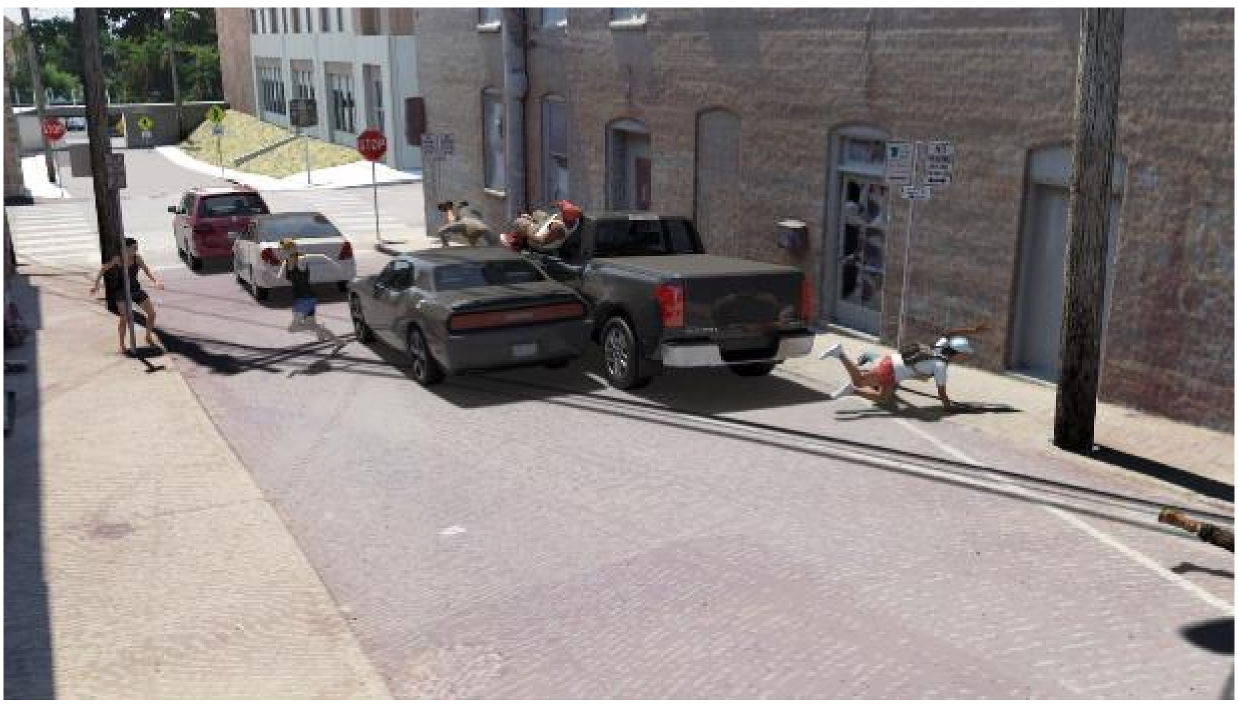
h. Ryan Kelly – Mr. Kelly was north of the area of the collision and photographed the Challenger as it traveled down Fourth Street and then back up towards Market Street.

<u>Animation Production:</u> Using the scan data from the scene inspection, a computer model of the crash scene was created. The computer model accurately depicts the true scale of the crash scene such that dimensions can be determined using computer aided drafting ("CAD") software. The computer model is used to show how the crash happened from multiple perspectives. A camera can be placed at any location within the model to view the crash. Below are images of the crash scene.

The pedestrians were modeled based on their reported heights and weights at the time of the crash. Scene photographs and videos were also used for modeling. Below is a graphic depicting their descriptions.

Several animations were produced to show the impact between the Challenger and the pedestrians, without showing other pedestrians. The animations accompany this report. Frames from the animations are shown below.

View from Street Corner

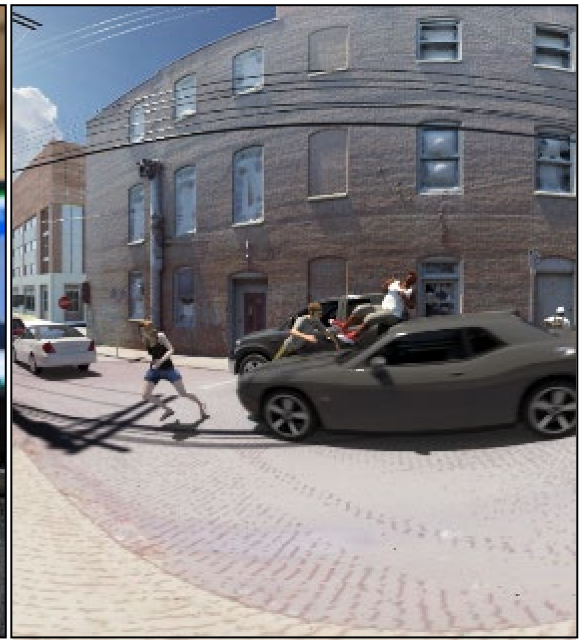


View Looking South

View from Inside Challenger

View Following Thomas Baker

Virtual Reality Production: The three-dimensional computer model that we produced can be viewed with a virtual reality ("VR") headset, where the viewer can see the crash happen in real time. VR headsets may be used at trial to allow the jury to visualize the crash reconstruction accurately from different angles.



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. Research and analysis for this report was performed by me and by Kineticorp personnel under my direction, supervision, and guidance. Review and analysis of this information, together with my background, training, education, and experience, has formed the basis of my opinions. Further information, data, investigation or analysis may lead me to revise or supplement these opinions and conclusions. I may use and rely on the documents listed in the Appendices to convey our analysis and opinions at trial. I may further utilize exhibits that are either included in the figures of this report, identified in this report, and/or that demonstrate my opinion and conclusions. Kineticorp is compensated at the hourly rate of $425 for my time, and some of my time has been donated on a pro bono basis.

Sincerely,

Stephen J. Fenton, P.E.
Principal Engineer

COLORADO LICENSED
STEPHEN J. FENTON
30920
PROFESSIONAL ENGINEER