Journal of the National Academy of Forensic Engineers®

http://www.nafe.org

ISSN: 2379-3252

Vol. 38 No. 1 June 2021

The Applications of Matchmoving for Forensic Video Analysis of a Fatal Sprint Car Accident: Part I

By Richard M. Ziernicki, PhD, PE, (NAFE 308F), Martin E. Gordon, PE (NAFE 699F), Steve Knapp, PE (NAFE 819S), and Angelos G. Leiloglou, M. Arch. (NAFE 956C)

Abstract

The methodology used for the reconstruction of a high-profile Sprint Car accident that was captured by at least three different video recording devices is presented in two parts. Part I discusses a classical method of an accident reconstruction, and Part II discusses matchmoving technique to accurately analyze the video footage of the accident. Accidents captured on video are unlike most simple car collision evaluations and require expert knowledge from experienced professionals. Understanding the race car vehicle dynamics as it relates to recorded video footage allows a proper methodology to be followed in order to gather and process the evidence needed to provide meaningful data to the trier of fact. This paper discusses the classical process to reconstruct the accident as well as the currently acceptable scientific methodologies that were used to collect and interpolate the available scientific evidence. A visualization of the vehicles involved, Sprint Car #13 (SC#13) and Sprint Car #14 (SC#14), is shown in ***Figure 1****.*

Keywords

Race car, Sprint Car, crash reconstruction, matchmoving, high-definition scanning, camera match

In, 2014, a fatal incident occurred where the decedent was participating in a Sprint Car Race (SC#13) on a low-banked dirt oval track with the straights running southwest and northeast. The grandstands are positioned on the north side of the track. The track corners are divided into quadrants (1 to 4) with the cars racing counterclockwise. Turn 1 is the first turn after passing the grandstands on the main straightaway (as shown in **Figure 2**).

Figure 1
Visualization of SC#13 and SC#14 entering turn 1.

During the race, the decedent driver in SC#13 and a driver in SC#14 entered Turn 1 at approximately the same time as the driver of SC#14 attempted to overtake SC#13. During the overtake, the driver of SC#13 lost control of his vehicle and contacted the west edge track barrier where his vehicle came to a stop near the end of Turn 2.

Figure 2
Google image illustration of the racetrack where the incident occurred.

Richard M. Ziernicki, PhD, PE, 7185 S. Tucson Way, Centennial, CO 80112, (303) 925-1900, rziernicki@knottlab.com
DOI: 10.51501/jotnafe.v38i1.115

After impacting the barrier, the driver of SC#13 exited his vehicle, and the remaining Sprint Car racers went under a "yellow flag" alert. (During a yellow flag, racers are alerted by track officials to exercise caution and reduce speed for a hazard on the racetrack.) A caution announcement was also broadcast over the drivers' helmet headsets with instructions to stay low (toward the infield of the racetrack). As the Sprint Cars slowed for the "yellow flag," they were observed in the video footage passing the wrecked SC#13 on the inside of Turn 2 (as the driver of SC#13 was walking behind the rear of his Sprint Car). As the driver of SC#13 began to walk toward the middle of the track, he was passed by a total of six Sprint Cars traveling on the inside of the track.

Unlike the first six Sprint cars to pass the driver of SC#13, SC#14 failed to acknowledge the yellow flag and radio call to stay low on the track. As SC#14 approached the driver of SC#13 in Turn 2, its right rear wheel impacted SC#13 driver, causing fatal injuries. Witnesses reported that the rear of SC#14 was sliding ("drifting") into the driver of SC#13, and video footage/witness testimony confirmed that the SC#14 had revved its engine prior to impact with the driver of SC#1. The SC#13 driver was thrown a distance of approximately 91 feet after being impacted by the SC#14.

Data Review and Analysis

Witness Statements

Statements from the driver of the SC#14, track officials, spectators in the stands, Safety Truck attendants, and other Sprint Car drivers were taken at the time of the incident. The statements assisted in organizing a sequence of events, but failed to provide the details necessary to accurately reconstruct the accident itself. The statements described drivers hearing the warning for a caution lap. However, there were inconsistencies in the statements regarding whether the driver accelerated or revved his engine prior to the incident. There were also inconsistencies relating to whether the driver of SC#13 walked into the right rear tire — or if SC#14 went sideways — before impacting the decedent (driver SC#13).

A critical component to these inconsistencies was the varying perspectives of the witnesses who gave statements. These witnesses varied in their viewing location, knowledge of the sport, and relationship to the Sprint Car drivers. A summary of the witness statements is presented as follows:

Track Official: Located on the back stretch (south side of the track), a track official testified that he observed the driver of SC#13 get out of his Sprint Car and come down closer to the cars that were on the caution lap. The track official also testified that the driver of SC#13 walked into the right rear of the SC#14 — and that he did not hear any acceleration or revving of SC#14 prior to the incident.

Racer in SC#45: The racer in SC#45 testified that he was racing his Sprint Car in front of SC#14 and witnessed the driver of SC#13 getting out of his Sprint Car as he came back around the track on the caution lap. The driver of SC#45 reported that the driver of SC#13 came toward his car, and he swerved away from him toward the inside of the track.

Racer in SC#1: The racer in SC#1 testified that he was in his Sprint Car directly behind SC#14 at the time of the incident. The SC#1 racer also witnessed the driver of SC#13 walking down the track as he entered into Turn 1. Before the impact, he witnessed the impacting SC#14 rear tires grow tall and skinny with dust rolling off of them. He indicated that the rear of SC#14 kicked out a little bit with "power going to the rear tires."

Racer in SC#00: The racer in SC#00 testified that she was also racing directly behind SC#14. She testified that she heard the caution broadcast on her radio by the time she was in Turn 3 (two corners before the incident occurred). She indicated that she heard on the radio that the officials were instructing all Sprint Cars to stay low on the track. As they approached the driver of SC#13, she witnessed SC#14's left front wheel turn to the right to direct the Sprint Car closer in the direction of where the driver of SC#13 was standing. Just prior to impact, she saw the rear of #SC14 stand up with dust coming off the rear tires as the driver of SC#14 hit the throttle. The witness reported that the application of the throttle caused the rear of SC#14 to come around with the front end of the car pointing to the left. She testified that as SC#14 began traveling sideways, it struck the decedent driver of SC#13.

Spectator Witness: A spectator located in the grandstands near Turn 1 was a witness that was deposed regarding the subject incident. He testified that he witnessed SC#14 enter low into Turn 1 and drift up the track toward the driver of SC#13. He testified that he heard the SC#14 engine rev and witnessed its rear end begin to slide sideways to the right. He saw the driver of SC#13 "stutter step," as if he were attempting to avoid being hit by SC#14. In his opinion, the spectator witness testified that had SC#14 not moved up the track toward the decedent driver of SC#13, the incident would not have occurred.

Safety Official 1 (SO1): The SO1 was positioned in the truck bed of the track Safety Truck that was positioned at Turn 1 at the time of the incident. SO1 testified that he witnessed cars slowing for the caution and going through Turn 1 in single and double file — and that he saw one Sprint Car moving out and an engine rev somewhere on the track. The SO1 testified that he witnessed SC#14 make what appeared to be an intentional "out and in" movement during the incident and reported that SC#14 moved up the track prior to impact.

Safety Official 2 (SO2): The SO2 was positioned in the truck bed of the track Safety Truck that was positioned at Turn 4 at the time of the incident. The SO2 testified that they were in route to SC#13 before Turn 1 when he witnessed SC#14 go up the track, "gas it," and come back down as the right rear tire "collected" the driver of SC#13. The SO2 reported that the vehicle in front of SC#14 was able to steer away to the low side of the track to avoid the driver of SC#13 and indicated that the driver of SC#13 came down and stopped at the mid-section of the track before the impact occurred with SC#14.

Racer in SC#14: The racer in the impacting SC#14 testified that he was made aware of the caution lap through radio communication and from the flagman and yellow flag that was observed on the main straightaway. The driver of SC#14 testified that he attempted to change direction to the left to go down the track by applying throttle to the car.

Imaging of SC#13 and Exemplar Sprint Car

The Sprint Car being driven by the decedent on the night of the subject incident was examined and photographed, as shown in **Figure 3**. The right rear tire of the car is flat and had not been repaired since the incident.

An exemplar Sprint Car was scanned in 2016. The Sprint Car was being prepared for sale and did not have an engine at the time of inspection. Additionally, the wing actuators (device used to move the large wing on the Sprint Car) had been removed. Otherwise, the vehicle had the same dimensions as both SC#13 and SC#14 at the time of the subject collision. The 3D scan collected approximately 390 million data points. An image of the scanned exemplar Sprint Car is presented in **Figure 4**.

Inspection and Testing with Exemplar Sprint Car

Another exemplar Sprint Car was inspected and test driven during the course of this investigation. The physical dimensions, weight, tire sizes, engine, and transfer box were all similar to the Sprint Cars being driven during the subject incident.

After driving and inspecting the exemplar Sprint Car, testing was conducted to determine the effect of avoidance maneuvers relative to the dirt-banked track conditions that were present at the time of the accident. An exemplar track with a similar low-banked dirt construction was utilized for testing. The Sprint Car setup suspension and tire setup were the same for racing at the track where the incident occurred. Prior to testing, the track had been raked and was very dry, making the exemplar track slicker and thus more difficult to drive on than during the subject incident.

A cone was placed at Turn 2 in the vicinity of where the decedent driver was standing when he was struck and killed by SC#14. The exemplar Sprint Car was driven for approximately 10 laps using caution lap pace as well as race driving pace. During the testing, it was concluded that the cone was easily visible coming out of Turn 1, and very

Figure 3
Image of decedent's Sprint Car.

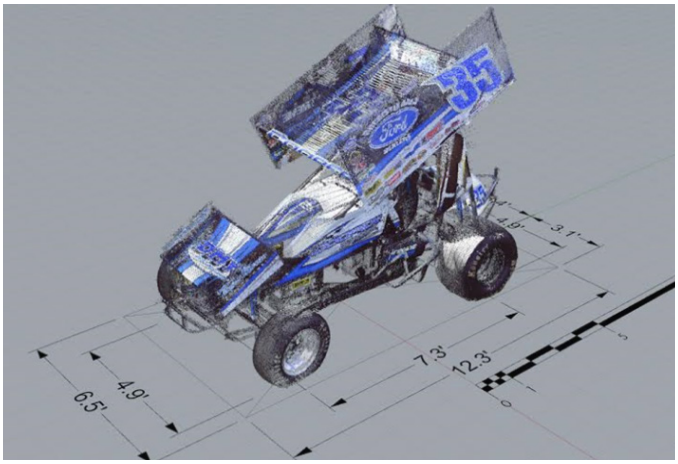

Figure 4
Scanned exemplar Sprint Car with dimensions.

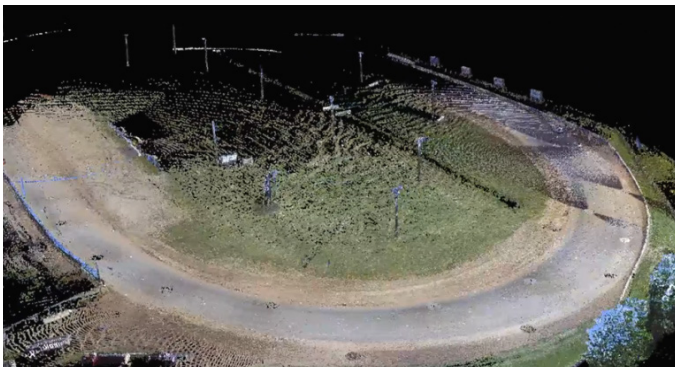

Figure 5
Aerial view of the scanned Sprint Car track.

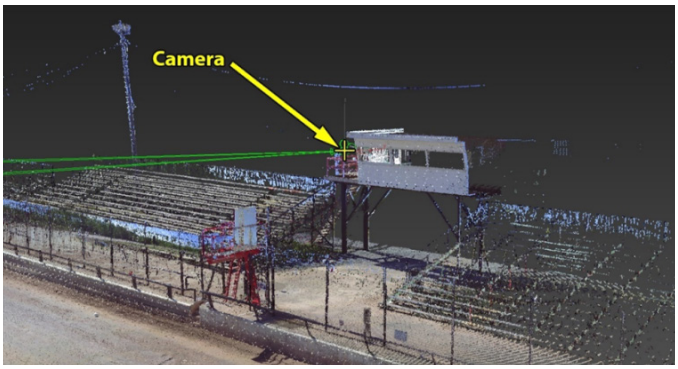

Figure 6
Perspective view of grandstands showing the location of the camera that captured video of the incident.

minor steering input was required to prevent hitting the cone during the testing exercise.

Inspection of Accident Site

The racetrack venue where the incident occurred was scanned for the purpose of documenting relevant areas of the track and grandstands. 3D scanning during the inspection produced approximately 860 million data points. The scans were captured using a Faro Focus 3D X330 Laser scanner and registered together to produce a 3D "point cloud" of the racetrack. Each data point in the point clouds is defined by its three-dimensional coordinates (x, y, z) and is accurate to within a few millimeters. Neither the track geometry nor the grandstand geometry appeared to have changed since the date of the incident. An image of the scanned subject Sprint Car track is presented in **Figure 5**.

By the time the opposition's experts visited the site at a later date, the track had been altered into a different configuration. Visual landmarks and track dimension had changed significantly and became critical factors in the precise reconstruction of the incident. The change of the racetrack landmarks is discussed in Part II of this paper.

Video

The subject incident was captured by three video cameras. Two of the available videos were captured by spectators with cellular phones located in the grandstands. The third video camera was positioned on the east side of the announcer's box, as shown in yellow in **Figure 6**. The camera captured the incident event with video footage recorded at 29.970 frames per second.

Limitations of Reconstruction Based on Physical Evidence

When reconstructing motor vehicle accidents, causes and contributing factors are analyzed to determine how and why an accident occurred. In forensic engineering, after analyzing physics of the accident, understanding how an accident occurs becomes apparent with the speed, direction, acceleration, and motion of the vehicle. Forensic engineering provides the factual basis of the case and the sequence of events that led up to and followed the accident.

In the subject incident, witnesses provided conflicting testimony regarding the SC#14 movement at the time of the impact with the decedent driver of SC#13. In one scenario, the driver of SC#14 is moving down the track in an attempt to avoid the driver of SC#13. In the other scenario, SC#14 is being driven up the track to drift his Sprint Car closer to the driver of SC#13. The second scenario potentially suggests a reckless disregard for the driver of SC#13 that must be carefully evaluated.

There is an engineering limit in determining the cause of an accident, specifically when it comes to analyzing the intent of a driver. It was hypothesized that the second scenario (where SC#14 is going up the track) was an attempt to perform a technique known in the racing community as "stoning" your competitor. This occurs when a racer applies significant throttle to spin the rear driven tires to kick up dirt and rocks onto another competitor. While this is a possible intent of the SC#14 driver, the physics and vehicle motion were the factors that were analyzed and considered by the authors.

What could be deducted from the analysis and witness statements was that it was likely that SC#14 was moving in such a manner that it traveled up the track and struck the decedent driver that was stationary at the time of the impact. Witness reported observing the motion of SC#14 in addition to hearing the car's engine revving and tires spinning prior to impact with the decedent. Regardless of the intent, the observed vehicle dynamics and witness

accounts are, in fact, consistent with one attempting to stone a competitor.

Video Processing

Since the accident scene is constructed of dirt and contains multiple tire paths — and debris existed on the track — no meaningful evidence was available or documented for the purpose of reconstructing the accident. Therefore, video footage that captured the incident became the single most important factor in analyzing the vehicle motions and determining which scenario of the accident, as presented by the drivers and witnesses, was probable.

Unlike the witness statements that offered conflicting scenarios of the accident, the video footage that was a record of the incident could be analyzed and compared to data that was collected at the accident scene. The analyzed video footage of the incident panned rapidly across the racetrack, moving left and right as it began to focus and zoom in on the decedent driver walking toward the middle of the track. Due to camera angle and significant distance between the video camera and the location of the incident (approximately 550 feet), analyzing the Sprint Cars' exact distance from the camera source becomes a highly sensitive analysis and outside the realm of a typical vehicle reconstruction. In order to properly analyze and understand the vehicle dynamics captured in the video of the incident, videogrammetry and matchmoving process was the only viable scientific option. The methodology of utilizing videogrammetry and matchmoving technique to reconstruct this accident is presented in Part II of this paper.

Conclusion

Proper documentation and collection of time-sensitive scene data was conducted in order to perform analysis of the incident that was captured with video footage. Conflicting witness statements indicated two scenarios of the accident. In one scenario, the driver of SC#14 is moving down the track in an attempt to avoid the driver of SC#13. In the other scenario, SC#14 is being driven up the track to drift his Sprint Car closer to the driver of SC#13. Due to the orientation of video camera relative to the incident location, videogrammetry and matchmoving analysis utilizing the data collected from this investigation was employed to determine accurate vehicle location, speed, and heading angle of each Sprint Car. Understanding the relative motion of each Sprint Car and the decedent driver would lay down scientific foundation to understand how the subject accident occurred.