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Abstract

Event Data Recorder (EDR) information provides valuable vehicle data to help a reconstructionist determine the speeds and driver inputs in the seconds leading up to a collision. In later model Kia and Hyundai vehicles, the EDR pre-crash data includes the following: time before the event, vehicle speed, engine rpm, engine throttle input, accelerator pedal input, service brake application, ABS activity, stability control activity, and steering input.

Although the speed and time can yield the approximate distance from impact at each time interval, the path of the vehicle can only be determined by modeling the vehicle motion in response to the recorded steering inputs. The subject vehicle's EDR does not record pre-crash dynamic output data such as longitudinal acceleration, lateral acceleration, or yaw rate. If these parameters had been recorded, we could also make a comparison of the output of those parameters from the HVE SIMON simulation with the recorded values. At low speeds, the relationship between steering and vehicle motion is dictated by geometry. At high speeds, the vehicle motion is dictated by dynamics and the generated slip angles at the tires.

We present a case study, using HVE's SIMON algorithm, to determine the pre-crash path of a Kia from EDR data. This work was crucial in determining lane position and the line-of-sight between the involved vehicles.

Introduction

The incident described in this case study occurred in Rancho Cordova, California, in 2020. An overview of the incident location is shown in Figure 1. A 2017 Kia Optima (V-1) was traveling westbound on an arterial roadway at more than twice the speed limit. Party Two (P-2), driving a 2012 Honda Odyssey (V-2), was departing his residential neighborhood and initiated a left turn onto the arterial roadway after slowing his vehicle to a near stop for a posted stop sign. A tall hedge with interspersed trees was planted between the arterial roadway and a frontage roadway between 200 and 280

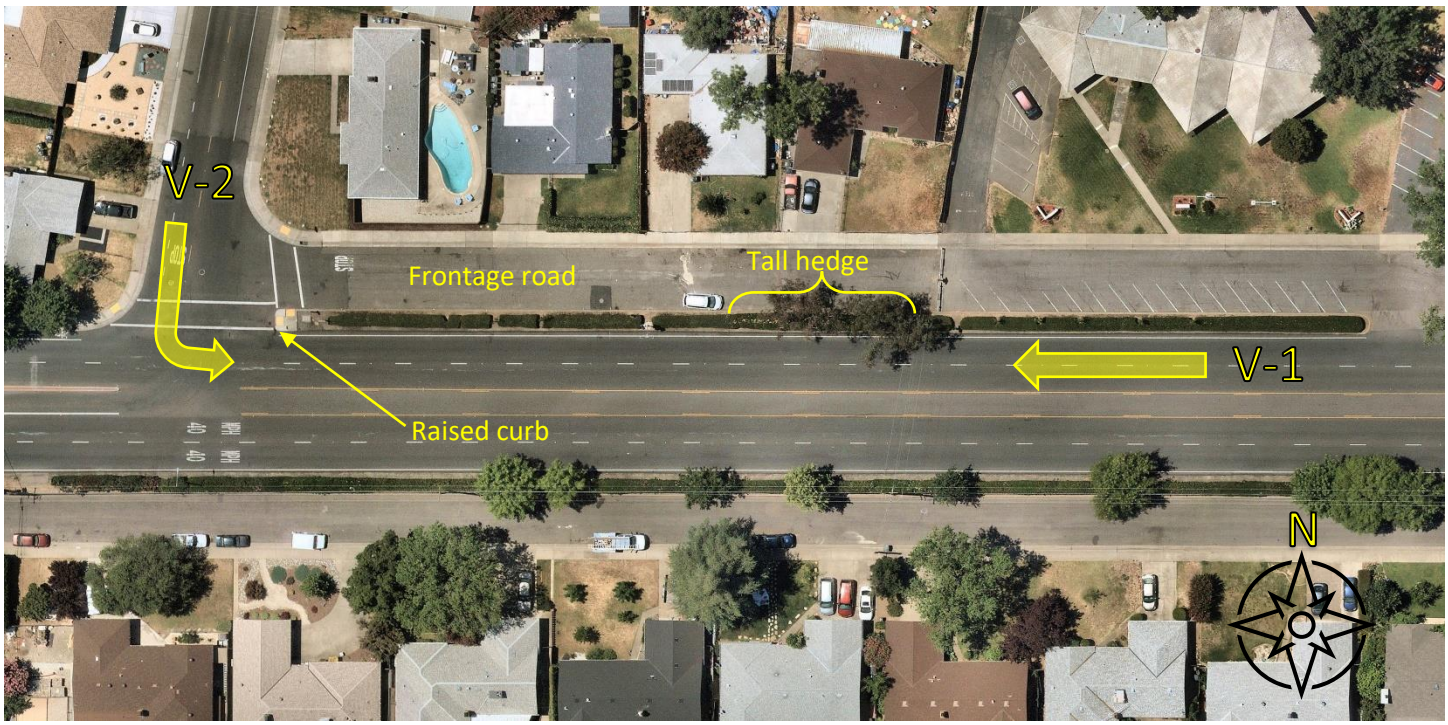

Figure 1: Incident location

feet east of the intersection. This hedge obstructed the line of sight that the left-turning driver had of approaching westbound vehicles. After proceeding into the intersection, P-2 stopped in the westbound lanes of the arterial roadway in response to approaching traffic. P-1 successfully avoided colliding with V-2 by braking and swerving to his right to travel through a narrow gap between a raised curb and the rear end of V-2. There was no evidence that the Kia collided with either the curb or the rear of the Honda. V-1 then traveled off the roadway, passed between two trees and collided with the residence located at the northwest corner of the intersection. Principia Engineering was retained to determine if P-2 could have seen the approaching V-1 before entering the intersection and if V-1 could have avoided colliding with the residence had he been traveling at the speed limit. Much of the work described in this paper was necessitated by conflicting statements and testimony regarding the initial lane of travel of V-1.

Data Collection

The incident location and V-2 were scanned with a Leica RTC360 laser scanner and models of both items were created with Blender, an open-source 3D computer graphics software tool. The site scan captured the locations of surveillance cameras that were installed on homes near the crash site. V-1 was not available for inspection, so a 3D model of a 2017 Kia Optima was purchased from an online source.

Videos from nearby surveillance cameras had been obtained by the Rancho Cordova Police Department and were provided to our office, along with the EDR data that had been extracted from the Kia.

Analysis

The location of V-2 on approach to and into the intersection was determined by tracking its travel through the field of view of one of the surveillance cameras. Figure 2 shows the tracked position in an idealized still frame from one of the available surveillance videos. V-1 was visible in the surveillance video for less than 2 seconds. V-1 could be seen traveling behind V-2 in the middle of this 2 second interval as shown in Figure 3.

Figure 2: Video motion tracking of V-2

Figure 3: Near collision of Kia with stopped Honda

The Kia EDR data showed that P-1 was driving at more than 82 miles per hour and accelerating five seconds prior to the collision, on a roadway with a 40 miles per hour speed limit. Analysis of the Kia EDR data indicated that P-1 had initiated right steering approximately 1 second before the Kia became visible in the surveillance video. To determine the initial lane of travel of V-1, HVE/SIMON simulations were performed utilizing the EDR data obtained from V-1. A 3D model of the roadway was created from scene scan data. The Vehiclemetrics model of the 2021-2022 Kia K5 LXS was used as the starting point for the SIMON model for V-1. Minor dimensional and inertial changes were made to the K5 model to match published specifications for the 2017 Kia Optima. The K5 drivetrain properties were also modified to match the Optima. The steering ratio of the Optima model was adjusted to produce a minimum diameter turning circle that matched specifications.

A SIMON event was created for each of the possible initial travel lanes for the Kia and the driver control tables were populated with the Kia EDR data for throttle percentage and steering angle. The timing of the Kia brake application was based on the Kia EDR data, and the magnitude of the brake pedal force was iteratively

adjusted to match the Kia speed as recorded by the EDR. The initial position for the Kia in each event was chosen such that the Kia impacted the residence at the 5 second point in the simulations. Simulation output variables were exported using the File\Export… option and imported into Microsoft Excel for graphical comparison to the Kia EDR data. Figure 4 shows the comparison of simulated speed of the Kia with the EDR data.

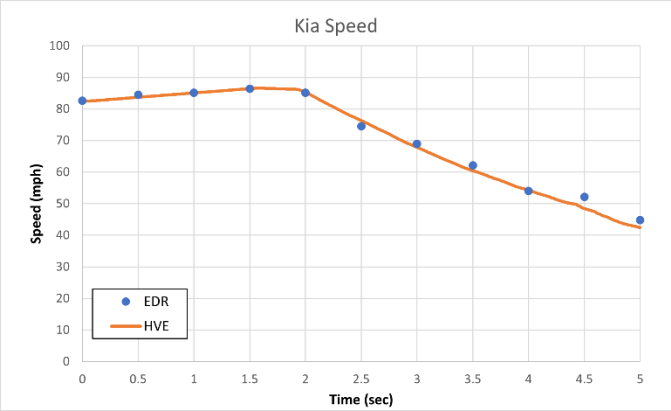

Figure 4: Comparison of simulated and EDR speeds

In order for the Kia to collide with the residence, P-1 had to thread a narrow gap between a raised curb and the rear of the stopped Honda, then traverse a sidewalk and travel across the front yard of the residence between two trees. The simulation analysis determined that this restricted path could only be followed when the initial position of the Kia was within the number two lane of the arterial roadway. When the initial position of the Kia was within the number one lane, the simulated path of travel of the Kia passed through the stopped location of the Honda. Figure 5 shows the simulated Kia track starting in the #1 lane and Figure 6 shows the simulated Kia track starting in the #2 lane.

Conclusion

Our analysis shows that V-1 was traveling in the number two westbound lane of the arterial roadway, within the large sightline obstruction created by the tall roadside hedge, when P-2 was approaching the entrance to the intersection and that P-1 could have brought his vehicle to a safe stop had he been driving at the speed limit.

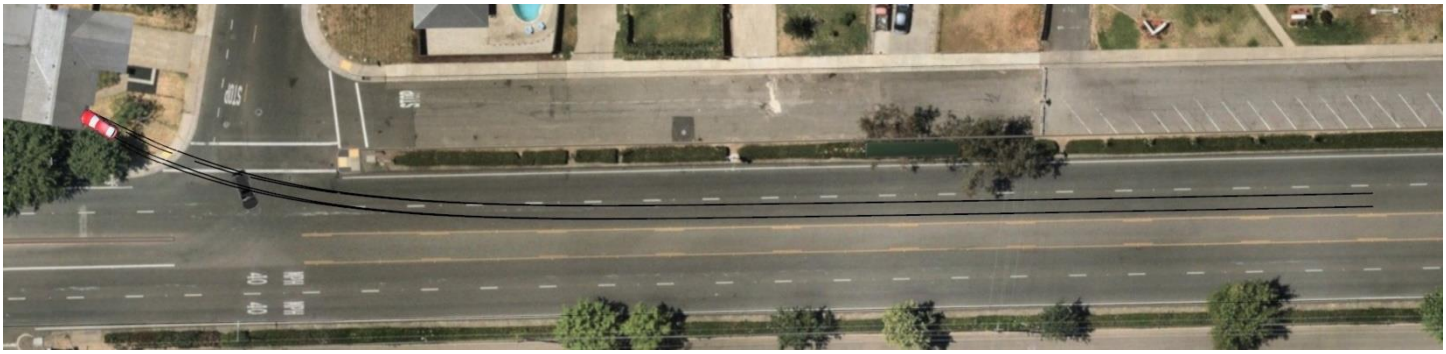

Figure 5: Simulated Kia path of travel beginning in the number one lane

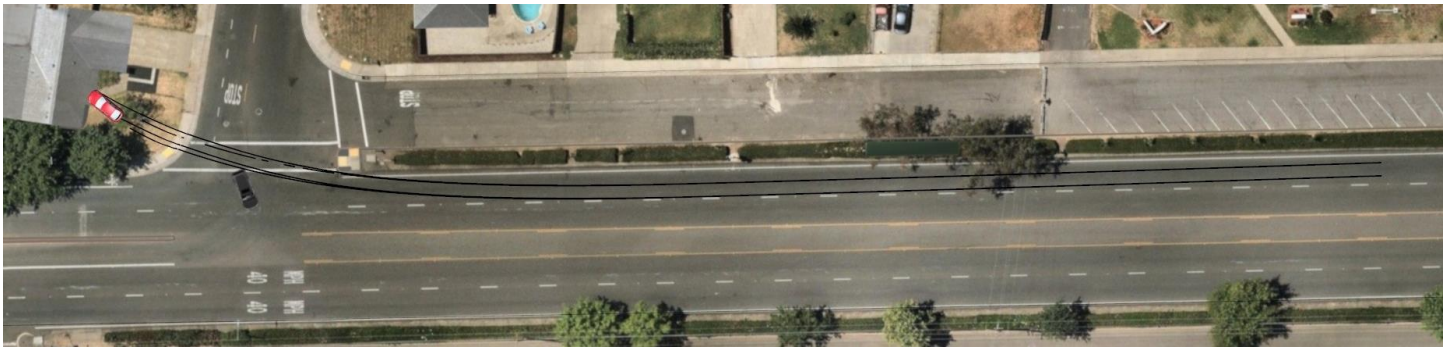

Figure 6: Simulated Kia path of travel beginning in the number two lane