



**Virginia Commonwealth University
Transportation Safety Training Center
Crash Investigation Team**

Report Number 191 - October 2003

ABSTRACT

The crash described on this report occurred on a rural, undivided two-lane primary highway intersection with another two-lane facility. The collision occurred between a southbound Cadillac Seville driven by a 78-year-old male and an eastbound Ford Escort driven by a 24-year-old male. The Cadillac driver failed to detect and respond to a stop sign at the intersection and was struck in the right side by the Ford. The severe impact resulted in the deaths of the Cadillac driver and a passenger and two injuries.

This report illustrates the hazards of inattentive motorists driving on unfamiliar roads and not obeying highway signing. It also describes the crash history of this intersection and the many highway sign/signal changes made in an attempt to modify driver's behaviors. Also noted in the report is the favorable relationship of the physical evidence interpretation to the Cadillac's Event Data Recorder. This investigation emphasizes the need for the highway safety authorities to continue to monitor this site for future problems and the need for research groups and regulatory agencies to study the affects of aging driver behavior.

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SYNOPSIS

Day, Time, Season: Wednesday, 10:34 a.m., spring

Road/Weather: Dry and clear

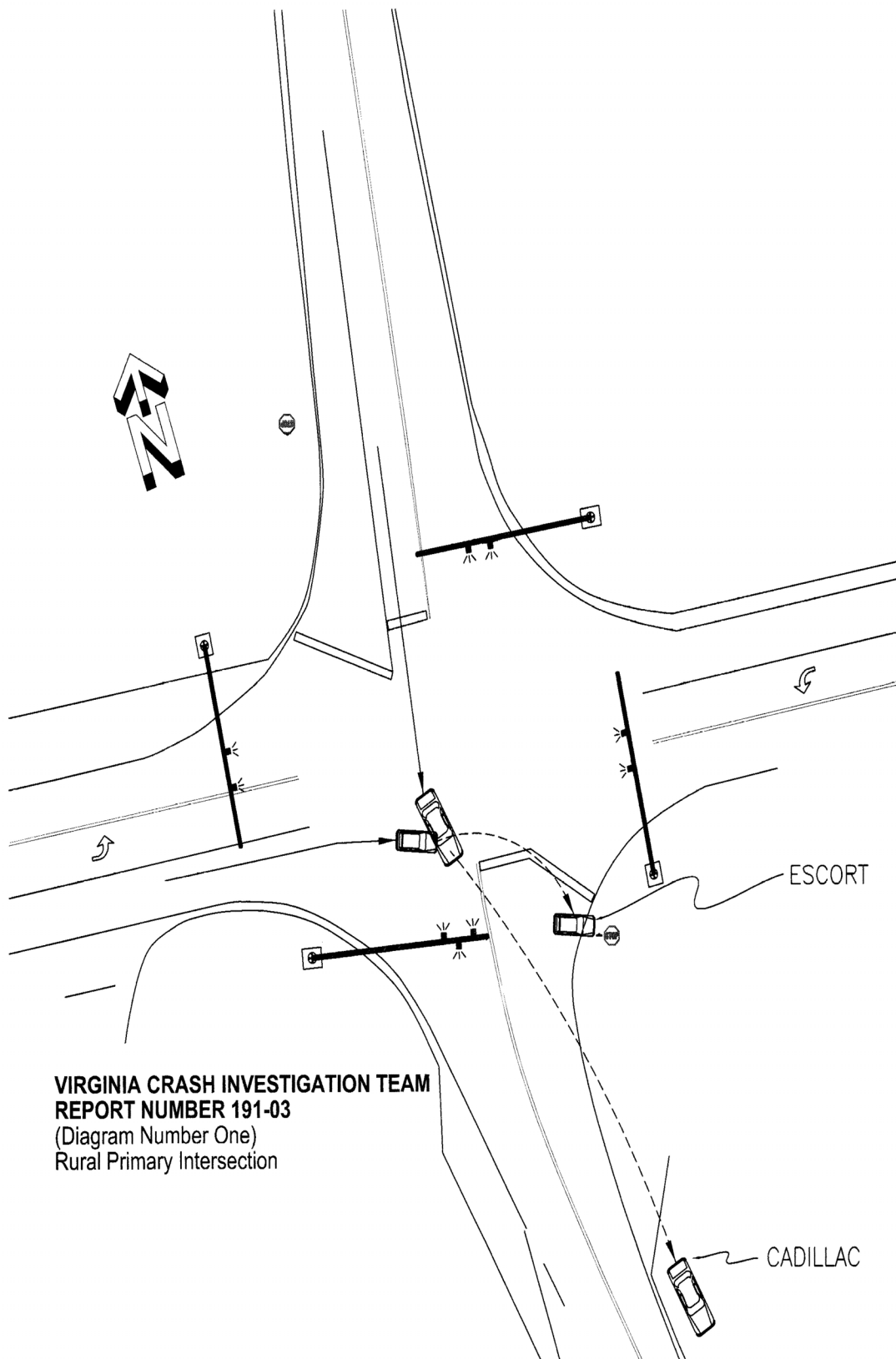
Vehicles Involved: 2000 Cadillac Seville (**Event Data Recorder**)
1998 Ford Escort

Summary: The Cadillac failed to stop at a stop sign on a rural cross road intersection and was consequently struck in the right side by the Ford that had just entered the intersection.

Severity: Two fatalities, two injuries and extensive property damage.

Probable Cause: The 78-year-old Cadillac driver failed to detect and respond to the stop sign for various reasons.

Significant Points: Driver unfamiliarity with roadway and intersection; driver not suspecting a stop situation; older driver characteristics; complex and cluttered intersection with a history of multiple crash involvement and subsequent sign/markings changes; physical evidence interpretation and eyewitness statements compared to the Cadillac's Event Data Recorder.



CRASH DESCRIPTION

On a clear, dry Wednesday morning in April at 10:34 a.m., a 78-year-old male was driving his 2000 Cadillac Seville SLS, four-door sedan south on a rural two lane undivided primary highway. He was from out of state and not familiar with the roadway or his surroundings. The driver was visiting with friends who live about 40 miles away from the crash site and he was taking them to a medical facility about 30 miles away. The driver was accompanied by a 78-year-old male in the right front seat and the passenger's 77-year-old wife in the right rear. All three occupants were properly wearing the car's three point lap and shoulder safety belts.

The Cadillac driver had just exited an interstate highway, turned right onto the primary highway, and then proceeded south about one mile. The two-lane roadway is posted for 55 mph and typically marked with yellow and white pavement striping. Approximately 1000 feet before an upcoming intersection, the level road gently turns to the left and then straightens out. Typical posted signs advise southbound motorists that they are approaching a stop requirement. Additional measures had been implemented to warn drivers of the intersection: two red traffic beacons flash above the four-way crossroad and an oversize stop sign compliments a white stop line just before the intersection. On the southern leg of the intersection, the road curves to the left. A convenience store and gasoline station sit on the right corner on the southern side of the intersection. Large, predominantly red signs conspicuously advertise this retail establishment.

The Cadillac driver intended to go straight through the intersection and continue to his destination. However, he apparently failed to detect the warnings and traffic controls and did not stop before entering the intersection. The Cadillac proceeded about 52 feet beyond the stop line when it was struck by an eastbound auto that had entered the intersection in the center of the right, eastbound lane.

The eastbound car was a 1998, Ford Escort ZX2 two-door coupe, driven by a lone, unbelted 24-year-old male. He had been traveling less than 10 miles on this asphalt-paved, undivided primary highway, en-route to a doctor's office. As he entered the intersection, the Ford driver slammed on his brakes and steered slightly to his right,

apparently seeing the Cadillac enter his lane of travel. After skidding 36 feet on the slight downgrade, the Ford's full front impacted the Cadillac in the front section of its right side, squarely in the door adjacent to the front passenger. The Cadillac sustained 18 inches of collapse in the door while the Ford collapsed in front about 20 inches. Because the Cadillac was moving at impact and crossing the Ford's path left-to-right, the Ford's front end was pulled to the right about 10 inches off its normal alignment. The Ford then rotated rapidly clockwise nearly 340 degrees on the road and came to rest about 50 feet southeast of the point of impact. The Cadillac was initially pushed about 10 feet eastward at impact, where it ran off the eastern edge of the highway. At final rest, it still faced south, positioned on the gravel/sod shoulder 137 feet south of the impact point. No evasive pre-crash evidence existed for the Cadillac.

All occupants remained inside the vehicles at final rest. A state Trooper came across the scene while on patrol and summoned medical help. The rescue squad arrived shortly thereafter and administered aid to the victims. The Cadillac's right front passenger died instantly in the collision from massive head, neck and chest injuries. The Cadillac driver initially lost consciousness but regained consciousness at the scene. He fractured an upper vertebra and suffered blunt head trauma. He died within three weeks of the crash, however, from complications of his injuries. The Cadillac's rear passenger survived the collision with only minor physical injuries. The Ford driver survived the collision with moderate chest, extremity and head injuries.

REMARKS

The Drivers:

During the investigation, the Crash Investigation Team learned that the Cadillac driver had been visiting the other occupants of his car. The two men had served in the military together during WWII. At the time of the crash, the driver was taking his friend to a medical appointment at a veteran's hospital located approximately 70 miles from his home. The driver was unfamiliar with both the area generally and the road specifically. He exited the interstate with the apparent intention of traveling a "back roads" route to the hospital.

Since he had recently moved to the state, little is known about his driving history. He held a valid driver's license from his previous state of residence, and the Trooper reported he was not operating his vehicle under the influence of alcohol or drugs. The investigating Trooper reported that he was not impaired at the time of the crash. Additionally, his vehicle did not have any known defects that might have contributed to the crash.

This location has been the site of previous crashes. Consequently, transportation department personnel added warning signs to prepare drivers for the upcoming requirement to stop. They also installed overhead red flashers and the over-sized stop sign to alert drivers and reinforce the message to stop. Despite all these cues, and despite the fact that he was unimpaired, the Cadillac driver failed to stop. From a safety research standpoint, this is a critical issue, and one that ties directly to the human factors aspect of this crash.

When the Team visited the crash site, the importance of the environmental context on the perception of signs and beacons became clear. First, although the southbound approach is straight just before the intersection, it curves slightly to the left before straightening out, and while traveling along this curvature the intersection is within a driver's sight. From that perspective, it appears that the road runs directly into the convenience store/gas station. As a driver gets closer to the intersection, it becomes apparent that the southern leg of the intersection is offset to the left. Although the northern leg intersects the intersection at a nearly 90-degree angle, the driver's line of

sight is drawn to the left, his intended direction of travel, and away from the stop sign in the center and right areas of his visual field. An additional factor increases the driver's likelihood of missing these critical cues. Both traffic devices (beacons and stop sign) are red and their color conspicuity can be "lost" against the background of the large, predominately red signs placed near the corner, advertising the location of the convenience store and the price of gas. The shade and intensity of the stop sign, the beacons and the retail signs are almost identical. The warning signs should suffice to alert drivers to be watching out for the intersection and to expect to stop, but some drivers may have a difficult time identifying the traffic signs as they approach the intersection.

A second area of consideration from the human factors perspective is the Cadillac driver, a 78-year-old man in an unfamiliar, somewhat confusing situation. As individuals age, many changes occur in physical and cognitive ability that can affect driving skills. Several of the most obvious changes occur in the eyes. Different parts of the anatomy of the eye lose their clearness, flexibility and/or adaptability, resulting in the degradation of visual perception across many variables. Peripheral vision, especially what is technically termed "the useful field of vision" narrows, meaning objects in the outer areas of the visual field are most likely to be missed, unless the driver compensates with increased head movements for scanning the environment. The resting size of the pupil, which controls the amount of light that enters the eye, shrinks as a person ages, while yellowing of the lens and changes in the clear substance in the eyeball itself also alter the light that reaches the retina. Consequently, responsiveness to changes in light is reduced, poor illumination more significantly affects vision (as evidenced in problems with night driving), and colors may appear less bright, especially reds. Thickening of the lens also hampers the ability to change focus rapidly.

Cognitive changes can also impact driving skills. Although older drivers can rely on a wealth of experience and practice, neurological changes associated with age result in slower reaction times. Older drivers require more time to sense and identify stimuli, especially in situations where they experience unexpected or multiple stimuli. So, their reaction times are affected by the unfamiliar and by "busy" visual fields, where many objects compete for attention. Second, processing such information is also slower and multi-tasking interferes with both perception and processing. These compounded by

changes in the neuromuscular system, which increase the length of time for the muscles to respond to action commands from the brain once decisions have been made.

With regard to this specific crash, the Cadillac driver's age is a relevant factor to consider when attempting to understand his failure to stop at the intersection. He was driving in an unfamiliar area and taking a rural route to his destination. He had also just exited a rural interstate highway and passed a posted 55mph speed limit sign in plain view. Since the speed limit was not reduced and with only a stop ahead sign, he had no reason to suspect he was approaching such a complex intersection. He was probably relying on verbal instructions from his passengers while negotiating the gentle left curve and trying to assess the layout of the approaching terrain. The multiple mental tasks could have easily distracted him from perceiving the warning signs alerting him to the stop ahead. Without that expectation as a part of his mind set, he approached an intersection that was confusing and atypical. The intersection had an offset leg, which pulled his attention to the left, reducing his peripheral field on the right. Even if he looked at the center of the intersection as he approached it, he may not have been able to clearly discriminate the red of the flashing beacons or the stop sign from the retail behind them. The physical evidence reveals that he never applied his brakes. Yet, his confusion after the accident was obvious. He could not believe that he had made a mistake. Instead of saying that he had not seen the stop sign, the driver told the trooper, "If there was a stop sign, I must have stopped."

The Ford driver had been off work prior to the crash and was heading for a doctor's office to get a note to satisfy his employer's sick leave requirements. The investigating Trooper, however, did not report that he suffered any impairment that may have contributed to the crash. The driver was, on the other hand, operating a vehicle under a suspended license. A review of his DMV record revealed the following violations cited over several traffic stops: no safety belt (two violations), speeding 1-9 miles above the limit, failure to display both license plates, insufficient tire tread and improper equipment and improper towing. Despite his violation of the suspension and his history of unsafe practices, this driver's actions did not contribute to the causes of the crash.

The Roadway:

The location of this crash is in a rural county where two U.S. designated primary highways intersect in a four leg, crossroad pattern. Both highways are undivided two lane roads with typical left and right turn lanes. The north-south highway (the highway that the southbound Cadillac was traveling) is controlled by stop signs. It has an annual average daily traffic volume of approximately 5300 vehicles per day. The east-west route has an average traffic count of about 2500 vehicles per day and is uncontrolled. Due to the change in traffic patterns and the population increase in the vicinity, the north-south highway within the past several years has experienced a higher volume of traffic passing through the intersection than the east-west highway. The junction intersects at a near 90-degree angle. Both approaches to the intersection on the north-south leg curve slightly several hundred feet before reaching the intersection. While the north-south route is basically level at the intersection, the east-west route is constructed on a grade. Located about 800 feet west of the intersection is a hillcrest, which hides the approach of eastbound vehicles.

The intersection and its immediate surroundings have gone through a number of changes over the past several years. Located in the southwest quadrant is a gas station and convenience store, which generates many turning movements producing traffic conflicts. In the northwest quadrant is a vehicle commuter parking lot near a U.S. post office. In the southeast quadrant is an auto garage and the northeast corner is a grassy field.

As late as several months prior to the fatal crash described in this report, the north-south route at the intersection was controlled by two stop signs in each direction, one erected in the pavement's center to the left of the motorists and one on the right shoulder. Initially two flashing red traffic beacons were installed overhead, mounted on span wires facing north traffic as well as south traffic and two yellow flashing beacons facing east and west traffic. At the time of the fatal crash, however, the overhead flashing beacons had been mounted on mast arms and only one oversized stop sign was positioned on the right shoulder for north-south traffic. The pavement is marked with double solid yellow centerlines. The original white painted stop lines had been repainted and moved closer to the intersection to increase visibility. In advance of the stop signs, typical,

graphic “stop ahead” warning signs were installed. After the crash, these warning signs were also marked with double yellow flashers with the intent to make motorists more aware that they are approaching an intersection controlled by stop signs. Additionally, after the crash the spacing between the two flashing red beacons above the roadway for southbound traffic was widened and a third red flashing beacon was added for northbound traffic. The posted speed limit on both the approaches and intersection remains at 55 mph.

The intersection is appropriately marked and signed; however, there is a vast difference between the north and south directions. Whereas the north direction is signed only with a single stop sign on a striped delineator post, the south approach is controlled by one stop sign, which is cluttered with numerous no-parking signs, delineator posts, and informational/directional signs. Of significance, the stop sign is placed to the right of a motorist’s normal vision by the width of the right turn lane and shoulder, a distance of 32 feet. Likewise, the stop sign is placed 43 feet before the painted stop line.

During the 35 months prior to this crash, this intersection experienced 24 reported traffic crashes, including this fatal crash. (Five occurred during the first five months of 2003, ten in 2002, five in 2001 and four in 2000). All 24 were angle collisions involving 13 vehicles traveling north, 11 traveling southbound, and 12 vehicles each going eastbound and westbound. Six motorists ran the stop signs (four southbound) and 18 apparently stopped first and then pulled out and were struck by east-westbound traffic. (See collision diagram on page 14)

Data regarding the at fault drivers age, condition at the time of the crash and environmental conditions revealed no discernable patterns. However, driver familiarity does appear to be a factor. Only 7 of the 24 at-fault drivers could be considered local. The remaining 17 lived either out-of-state or in another area of the state.

It would appear that the intersection is, from a human factors standpoint, complex in nature. This is partly due to the many traffic conflicts present at such a rural intersection. These conflicts include vehicle turning movements, sight distance restrictions and visual signing clutter, especially on the southbound approach. All of these factors taken together with motorists who are unfamiliar with the intersection create an unsafe situation. The many traffic changes conducted by VDOT both at the intersection

and along its approaches within the past several years were an attempt to improve the safety of the intersection. It is hoped that the latest traffic changes will reduce the number and severity of crashes occurring at this location. The Crash Investigation Team recommends that VDOT continue to monitor this location and if the crash rate does not improve, other modifications are in order.

The Vehicles:

In addition to the human factors and highway issues, this crash was studied as part of an ongoing investigation of the usefulness and validity of Event Data Recorders. The Cadillac was equipped with an Event Data Recorders (EDR) that was downloaded by the team several days after the crash. Several of the captured items could be favorably compared to the relevant physical evidence, both on the roadway and vehicles. The Supplemental Inflatable Restraint (SIR) warning lamp status was recorded as “Off”. Both front airbags deployed, indicating that the system was working properly. The driver’s belt switch circuit status indicated the driver was “Buckled”. The facts that the driver was found by rescuers still belted necessitated cutting the webbing (as well as the driver’s admission that he was belted) confirm the reading on the EDR.

The Cadillac’s speeds over the last five recorded seconds, beginning five seconds out, were “44,40,40,39 and 39” respectively. The brake switch circuit status indicated that the driver tapped his brakes at five and four seconds and that no braking occurred during the last three recorded seconds. By using the principles of the *Conservation of Momentum*, it was calculated that the Cadillac and Ford were traveling about 37 and 49 mph respectively at the instant of impact.

The Team conducted acceleration test analysis to calculate the maximum speed that the Cadillac could have attained from the stop line, had it stopped, to the point of impact. The likely speed for this calculation was only about 22 mph, well below what the EDR and momentum analysis yielded. The Ford driver and an off duty sheriff’s deputy who saw the collision, both said that the Cadillac did not stop before the collision.

The Crash Team concludes that the data contained in the Cadillac EDR could be corroborated with the existing physical evidence. In this instance, the Cadillac’s speed,

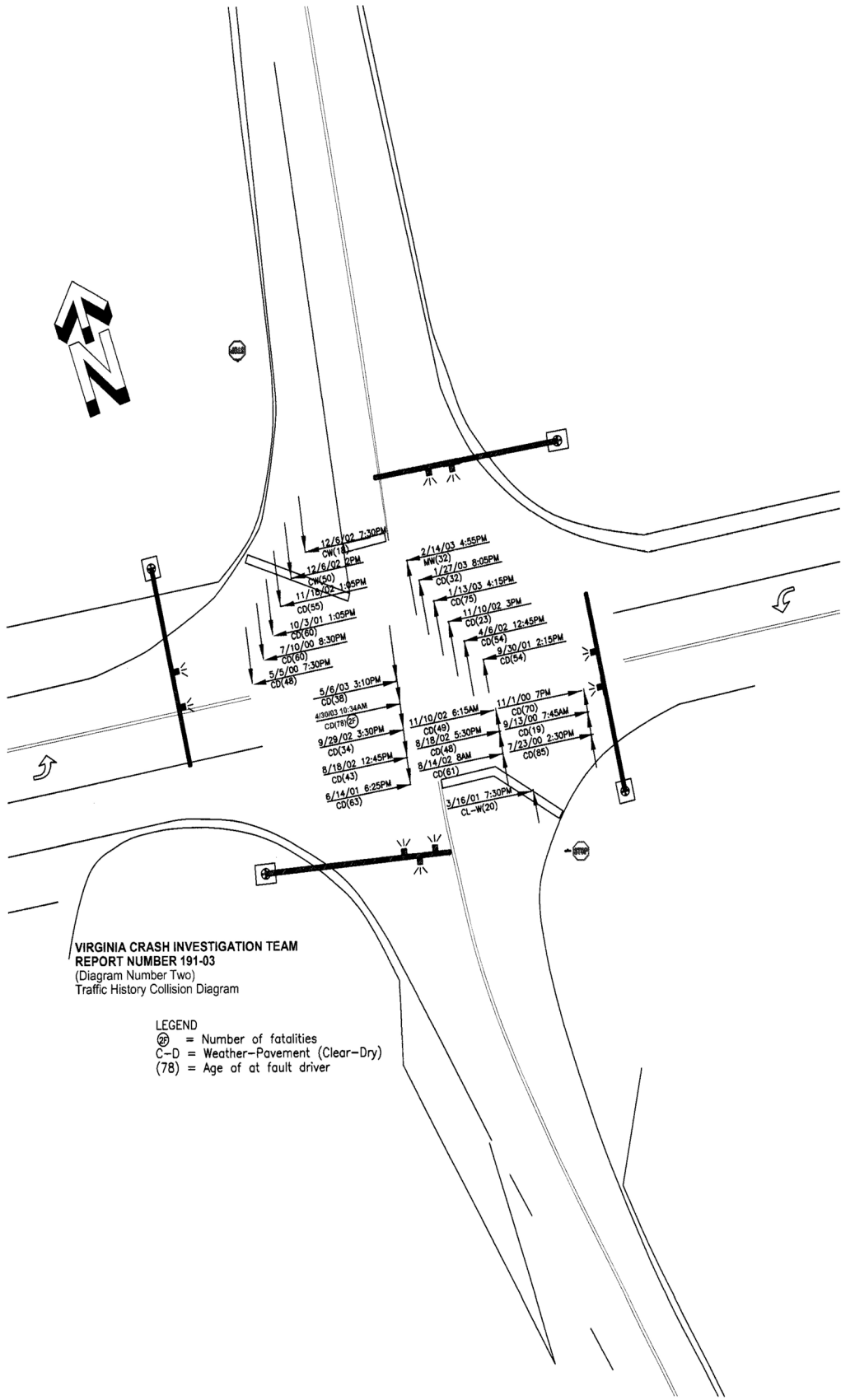
whether or not the car was being braked just before impact and whether or not the driver's belt was being worn at the time of impact could all be validated through typical methods used in accident reconstruction.

The deputy confirmed that the Ford driver attempted to stop by skidding as it entered the intersection. This witness also said that the Ford's speed before it began to skid was more than the posted speed limit of 55 mph. When the Team combined the Ford's pre-impact skid marks speed with the momentum-calculated speed, an initial minimum speed was estimated at 57 mph. However, when considering that the speeds calculated by using these types of equations tend to be conservative, it is likely that the Ford was traveling at least several mph higher than the 57 mph calculated.

In conclusion, the cause of this double fatal crash was the failure of an older, unaware driver who was not familiar with the roadway and area. As a result, the driver failed to respond/obey the stop situation and was struck as he entered the intersection against the stop sign. The intersection design, compounded by the signing and surroundings, also contributed to him not correctly responding to the proper controls. The mechanical condition of the Cadillac, the driving behavior of the Ford operator and the weather conditions did not contribute to the cause of the crash. Information downloaded from the Cadillac's Event Data Recorder closely matched eye witness statements and physical evidence calculations made at the scene.

RECOMMENDATIONS

1. The Virginia Department of Transportation should continue to monitor this intersection and the occurring traffic conditions/conflicts. If crashes are not reduced, an engineering study should be conducted to determine if further changes to the intersection are warranted. Among these considerations should be:
 - a. Lower the speed limit to 45 mph for all four approaches.
 - b. Double indicate the stop signs by the use of islands on the north-south approaches.
 - c. Consider the installation of raised, painted rumble strips and the inclusion of painted STOP messages on the north-south approaches.
 - d. Consider installing a four-way stop condition for all approaches.
2. The Virginia Department of Motor Vehicles and/or the Virginia Transportation Research Council consider studying the crash causes and rates of older drivers in an attempt to determine whether public information, education and/or mandatory testing (both physical and cognitive) is warranted. Such considerations are especially important due to the rapid rise in older drivers (above 70) within the coming years.
3. Motorists should continue to devote their full attention to their driving tasks and watch for/obey all traffic warnings and regulatory signs.
4. Motorists should continue to wear their available safety belts at all times.
5. The purchase and use of Event Data Recorder (EDR) download devices along with appropriate training by police investigators, reconstructionists, insurance investigators and research personnel, is encouraged. The reliance on physical evidence supported by the EDR download is imperative.



VIRGINIA CRASH INVESTIGATION TEAM
 REPORT NUMBER 191-03
 (Diagram Number Two)
 Traffic History Collision Diagram

LEGEND
 ⊙ = Number of fatalities
 C-D = Weather-Pavement (Clear-Dry)
 (78) = Age of at fault driver



Photo #1- Damage to the 1998 Ford Escort ZX2 caused from colliding with the Cadillac. Maximum static crush sustained to the Ford's front was measured at 20 inches. Momentum analysis indicated that at impact the Ford was traveling at least 49 mph and the Cadillac at 37 mph.



Photo #2- Damage to the 2000 Cadillac Seville SLS from impact with the Ford Escort. Maximum deformation was measured on the right side at 18 inches. The EDR recorded the speed of the Cadillac at 44-39 mph before the airbag triggering system activated (AE).



Photo #3- View looking south, the direction the Cadillac driver was traveling, taken about .6 miles before the intersection. This location is about 500 feet after the Cadillac driver exited the interstate. Note the 55mph speed limit sign, and the long/ straight, rural nature of the roadway, and the gas station appearing to be directly in the line of travel.



Photo#4- Closer view looking south, taken about 1200 feet before the intersection. The “stop ahead” sign as depicted now has flashing yellow lights attached to it for better detection. Note the road’s design and numerous signs in the background.



Photo#5- View looking south, taken about 100 feet before the intersection. Note placement of the stop sign. Its color and position tends to reduce its target value for approaching motorists as it blends into the visual clutter of its surroundings. Note the two red flashing beacons above the intersection.