2008
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NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation *February 12, 2010*

Volunteer Captain Dies in Engine Rollover - Colorado

SUMMARY

On February 23, 2008, a 33-year-old male volunteer captain (the victim) was fatally injured when the engine he was driving to a medical emergency left the roadway and rolled one-half time onto its top. The victim was ejected from the apparatus and was pronounced dead at the scene. Key contributing factors identified in this fatality include, lack of seat belt use, failure to maintain control of the apparatus, and the location of the radio in the cab.

Final location of apparatus following rollover
Photo courtesy of the State Patrol

NIOSH investigators concluded that, to minimize the risk of similar occurrences, fire departments should:

- ***ensure that all persons responding in emergency apparatus are wearing and belted securely by seat belts at all times the vehicle is in motion***
- ***ensure apparatus cab layouts enable drivers to safely access switches and electronic devices while remaining seated and secured by seat belts***
- ***provide training to driver/operators as often as necessary to meet the requirements of NFPA 1451, and incorporate specifics on rollover prevention into their standard operating procedures (SOPs)***

Additionally governing municipalities (federal, state, regional, and local) should

- ***consider enacting new, or enhancing current legislation to specifically mandate seat belt use by operators and occupants of fire department vehicles***

INTRODUCTION

On February 23, 2008, a 33-year-old male volunteer captain (the victim) was fatally injured when he was involved in a single-vehicle crash. The victim was driving Engine 3 while en route to a medical call. On February 25, 2008, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research (DSR) of this incident. On March 19, 2008, an investigation of this incident was conducted by a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Program. Meetings and interviews were conducted with the chief, members of the volunteer department, the state patrol officer who investigated the incident and emergency personnel who arrived following the incident. The NIOSH investigator, accompanied by the state patrol investigating officer, visited the vehicle impound facility where the apparatus was inspected and photographed. The crash scene was visited and photographed. Copies of the Colorado state patrol report, the department's SOPs, training records, maintenance records, the witness statement, call logs and dispatch records, emergency responder statements, coroner's report, incident scene diagrams and photographs were reviewed by the NIOSH investigator.

STATE REGULATIONS

In the state where the incident occurred, motor vehicle regulations provide exemptions for highway use of emergency vehicles, Colorado Revised Statute §42-2-108, *Public officers to obey provisions-exception for emergency vehicles*, states that the operator of any emergency vehicle may exceed the lawful speed so long as the driver does not endanger life or property. The section further states that

the provisions of this section shall not relieve the driver of an authorized emergency vehicle from duty to drive with due regard for the safety of all persons.[1]

The Bureau of Transportation Statistics, Research and Innovative Technology Administration, prepares a report on state-specific key provisions of occupant restraint laws. According to the information provided in the December 1, 2008 report, Colorado specifically exempts passenger and school busses, ambulances, postal service vehicles, and delivery/pickup services.[2] There is no verbiage in the state law specifically pertaining to fire service vehicles and/or apparatus.

FIRE DEPARTMENT

The volunteer fire department involved in this incident was formed by the merger of two small town departments. It serves a population of approximately 4,500 residents in an area of about 80 square miles of mostly small rural communities and farm land, and has approximately165 miles of roadway. The fire department maintains two stations that are staffed by approximately 20 volunteer fire fighting personnel.

The fire department involved in this incident had a SOP requiring the use of seat belts; however police determined that the victim was not wearing a seat belt at the time of the crash.

TRAINING AND EXPERIENCE

The state of Colorado has a Fire Fighter Certification Program that is applicable to the volunteer fire service as well as the career fire fighters.[3] The purpose of the program is to measure the level of knowledge, skills and abilities possessed by fire fighters and to attest that each individual meets the nationally recognized standards. To ensure consistency throughout all levels of accreditation relating to written and practical examinations, all levels are conducted in accordance with the International Fire Service Accreditation Congress (IFSAC)[4] guidelines and the National Board on Fire Service Professional Qualifications.[5] However, the state has no licensing requirements for drivers of fire apparatus.

The victim had completed the certification program and had extensive department training in fire suppression, pump operation, vehicle extrication, strategic and tactical operations, fire scene management, and he was certified in cardio pulmonary resuscitation. In July of 2007, he had completed classroom and hands-on driver/operator training on the apparatus involved in the incident. The department training records show that driver training was conducted every two years.

The victim had three and one half years with the volunteer department and had been promoted to captain one month prior to the crash. He was employed by the state department of transportation as a heavy equipment operator/mechanic.

APPARATUS INVOLVED

The apparatus involved in this incident, Engine 3 (E3), was a 1995 diesel, three-axle tanker/pumper. It was equipped with a rectangular 2,000 gallon capacity, factory-installed, baffled water tank. The tank was reported to be filled to capacity when it left the station on the morning of the incident and therefore the truck would have weighed approximately 53,000 pounds which is well below the gross vehicle weight rating of 62,740 pounds. Engine 3 was equipped with a speed governor that was set at 65 miles per hour and police estimate that it was travelling at approximately 45 miles per hour when the incident occurred.

The police inspection following the crash revealed that the steering, suspension, tires and brakes were within industry standards for safe operation and there were no post-crash mechanical defects found that would have caused or contributed to the events which led to the fatality. Maintenance records revealed that the tanker was inspected on a regular basis and all required work was performed in a timely manner. In accordance with department protocol, the tanker was running with emergency lights and siren activated en route to the call on the morning of the incident.

The State Patrol investigating officer and the NIOSH investigator visited the impound yard and inspected the apparatus. Measurements were taken inside the cab to determine the approximate distance required for the victim to reach the radio. Due to the awkward shape of the engine box (Photos 1,2), the unknown arm length of the driver and seat position, obtaining an exact reach distance was difficult. The seat was approximately 19" wide. There was a 3" gap between the seat and the engine box which had sloped sides and measured approximately 40" across. There were two radio decks on the center console. The main digital radio deck was located off to the right next to the windshield. An experiment on a driver's capability to reach the radio was conducted by police and the fire department. Taking all of the known factors into consideration, it was determined that the driver would have to reach approximately 35" to 40" and most likely would have had to remove his seat belt in order to operate the radio. The fire department involved in this incident had and enforced a SOP requiring the use of seat belts. It was reported by family members and co-workers that the victim always wore a seat belt.

ROAD AND WEATHER CONDITIONS

The two-lane asphalt roadway where the incident occurred runs north to south and is bordered by dirt shoulders. A white fog line is painted to the right of each lane with a double yellow line dividing the north/south lanes. To the west of the road there is a shallow irrigation ditch and to the east there is a deeper irrigation ditch (Photo 3). Both the road surface and the ditches were dry at the time of the crash. There is a posted speed limit of 55 MPH in the area.

The incident occurred at approximately 0614 hours. According to the U. S Naval Observatory records, sunrise was scheduled to occur at 0643 hours with civil twilight[a] occurring at 0615 hours. The ambient air temperature was approximately 46°F with 38% humidity, and minimal wind. Neither the road nor weather conditions appeared to be a factor in this fatality.

TIMELINE

Note: This timeline is a summary of events that occurred as the incident evolved. Not all events are included in this timeline. The times are approximate and were obtained by studying the dispatch records, witness statements, and other available information. In some cases, the times are rounded to the nearest minute.

The response, listed in order of arrival (all times are approximate) and events, include:

- **0602 Hours**
  The county paramedic service was dispatched to a medical emergency

- **0605 Hours**
  A medical helicopter was requested to standby

- **0608 Hours**
  Fire rescue went en-route

- **0610 Hours**
  Fire rescue was on-scene

- **0611 Hours**
  The victim went en-route in Engine 3

- **0613 Hours**
  The victim radioed a request for a fire ground channel

- **0617 Hours**
  A civilian driver called 911 to report a fire truck upside down in a field.

[a] According to the U.S. Naval Observatory,[6] civil twilight is defined to begin in the morning, and to end in the evening when the center of the sun is geometrically 6 degrees below the horizon. Complete darkness ends sometime prior to the beginning of morning civil twilight and begins sometime after the end of evening civil twilight.

INVESTIGATION

At approximately 0608 hours on the morning of February 23, 2008, the victim was dispatched to a medical call to assist setting up a landing zone for a medical helicopter that was on stand-by for possible patient transport. At 0611 hours he radioed that he was en-route and at 0613 hours radioed dispatch for permission to go to the fire ground channel.

At 0617 hours, county 911 received a call from a driver who reported that he had just driven upon a fire truck that had run off of the road and overturned in a field. In his statement to police, the caller stated that he was driving north on the two-lane state highway when he noticed flashing emergency lights in the distance. He originally thought that it was a police car. As he drove closer toward the lights they disappeared. He then drove upon the crash scene and realized that the lights he had seen in the distance must have been coming from the approaching fire truck that was now overturned and laying in the field to the west of the roadway. The caller was the only witness and he told police that he was not able to see exactly what happened because it was still fairly dark and he was too far away from the point where the lights vanished.

The state patrol reconstructed the crash. Their report indicates that the victim was driving E3 south on the two-lane roadway at approximately 45 miles per hour. It ran off of the right side of the roadway, then over-corrected to the left and travelled across the roadway running onto the left shoulder where it struck a road sign before travelling back across to the right while rotating in a clockwise direction. E3 ran off of the roadway to the right a second time and the left front corner of the tanker impacted the soft dirt near the irrigation ditch. The impact dislodged the driver's side door, causing it to open and the victim was ejected. E3 then rolled onto its left side and onto the victim before coming to rest on its top facing west (Diagram 1). The victim was pronounced dead at the scene by the county coroner.

CONTRIBUTING FACTORS

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. NIOSH investigators identified the following items as key contributing factors in this incident:

- Lack of seat belt use
- Failure to maintain control of the apparatus
- Location of radio inside the cab

CAUSE OF DEATH

According to the county coroner's report, the victim died from multiple blunt force injuries.

RECOMMENDATIONS

Recommendation #1: Fire departments should ensure that all persons responding in emergency apparatus are wearing and belted securely by seat belts at all times the vehicle is in motion.

Discussion: NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program* states that all persons riding in fire apparatus shall be seated and belted securely by seat belts in approved riding positions at any time the vehicle is in motion. The standard further states that seat belts shall not be released or loosened for any purpose while the vehicle is in motion.[7] Fire departments should develop, implement and enforce SOPs on the use of seat belts in accordance with National Fire Protection Association (NFPA) guidelines. Numerous nationally recognized fire service entities have guidance available on implementing a seat belt policy. The International Association of Fire Fighters (IAFF) provides guidance in their document *Fire Department Vehicle Safety, Emergency and Non-Emergency Response, and Safe Emergency Operations on Roadways*,[8] and recommends that all employees use seat belts at all times and "All personnel shall ride only in regular seats provided with seat belts. The company officer and driver of the vehicle shall confirm that all personnel and riders are on-board, properly attired, with seat belts on, before the vehicle is permitted to move. This confirmation shall require a positive response from each rider." The International Association of Fire Chiefs (IAFC), *Guide to IAFC Model Policies and Procedures for Emergency Vehicle Safety*, states that "The driver shall not begin to move the vehicle until all passengers are seated and properly secured. All passengers shall remain seated and secured as long as the vehicle is in motion. Seat belts shall not be loosened or released while en-route to dress or don equipment." [9] NFPA 1901, *Standard for Automotive Fire Apparatus*, establishes requirements for the minimum length of seat belts, together with how they are measured. The standard also recommends that a seat belt warning device be installed to indicate when seat belts are not being properly used.[10]

Vehicle crashes are historically the second leading cause of fire fighter line of duty deaths. Seat belts are not only important for protecting occupants in the event of a crash, but they may be useful in helping to avoid crashes. The U.S. Fire Administration's *Safe operation of fire tankers* states "Some crash reconstruction specialists have speculated that particular incidents may have occurred after the unrestrained driver of a truck was bounced out of an effective driving position following the initial contact with a bump in the road or another object."[11] In the same publication, the USFA also cites a Department of Transportation (DOT) study of seat belt use which revealed the following statistics: 1) 75 percent of the people ejected from vehicles suffer fatal injuries; 2) 80 percent of fatalities in rollover incidents involve occupants being ejected from the vehicle; and 3) in a rollover incident, occupants are 22 times more likely to be thrown from the vehicle if they are not wearing their seat belts.

To increase the use of seat belts by fire fighters, the National Fire Service Seat Belt Pledge campaign was created.[12] The United States Fire Administration, National Fallen Fire Fighters Foundation, National Institute for Occupational Safety and Health, International Association of Fire Chiefs, National Volunteer Fire Council, and the National Fire Protection Association support the campaign

as a method of raising awareness of the importance of mandatory use of seat belts by all fire fighters.[13] Fire fighters who take the pledge, and fire departments who achieve 100% pledge participation, show their individual and organizational commitment to fire fighter safety.[14]

The fire department involved in this incident had a SOP requiring the use of seat belts and there is evidence of seat belt enforcement; however the victim was not wearing a seat belt at the time of the crash. According to the police report, both the department members and the victim's family stated that he was "religious" about wearing a seat belt. The victim was employed by the state department of transportation as a heavy equipment operator/mechanic, and co-workers reported that he always wore a seat belt.

Recommendation #2: Fire departments should ensure apparatus cab layouts enable drivers to safely access switches and electronic devices while remaining seated and secured by seat belts.

Discussion: The cab design is a very important factor for the safe operation of a fire or rescue apparatus. NFPA 1901 states that "controls and switches that are expected to be operated by the driver while the apparatus is in motion shall be within convenient reach for the driver." The standard defines convenient reach as "the ability of the operator to manipulate the control from a driving/riding position without excessive movement away from the seat back or without excessive loss of eye contact with the roadway."[10] However, the standard does not specifically address placement of the radio.

Since there were no mechanical defects found with the tanker, the seat belt was operable and in good condition, and due to the timing of the victim's final communication with dispatch, police centered their investigation on radio placement within the cab(Photo 1). The investigating police officer and the chief of the fire department conducted an experiment using the cab of the crashed apparatus. The chief, who is approximately 4 to 5 inches taller than the victim, sat in the driver's seat and attempted to reach the radio. He was unable to operate the radio dial without holding on to the steering wheel and partially coming out of the driver's seat, an action which could not be done when properly restrained by a seat belt (Photo 2).

The 911 call records reveal that at 0613 hours the victim radioed dispatch and requested to go to the fire ground channel. However, when E3 was powered on during the police inspection following the crash, the radio was still on the dispatch channel, which indicated that he never connected to the fire ground channel. If the victim had to momentarily remove his seat belt and reach to the right to adjust the radio, his movement to the right while holding the steering wheel would possibly have caused the tanker to turn toward the right and travel off of the pavement. The movement to the right could logically have then been followed by an inclination to over-correct to the left. These movements could have set into motion the chain of events that ultimately led to the tanker rollover.

Best practice indicates that the driver of a fire apparatus should be responsible for arriving safely at the incident scene and the person seated in the officer's seat should be in charge of communications.

There are times when a second fire fighter is not available due to minimal staffing or other circumstances. If apparatus drivers will be routinely called upon to respond solo to incidents, departments should ensure that all controls and switches that are expected to be operated by the driver while the apparatus is in motion, are within safe reach for the driver and should consider purchasing hands-free communication devices suitable to the department's specific needs.

Recommendation #3: Fire departments should provide training to driver/operators as often as necessary to meet the requirements of NFPA 1451, and incorporate specifics on rollover prevention into their SOPs.

Discussion: NFPA 1451, *Standard for a Fire Service Vehicle Operations Training Program*, states that fire department personnel must be trained in and exercise applicable principles of defensive driving techniques under both emergency and nonemergency conditions.[15] SOPs for driving fire department vehicles during nonemergency travel and emergency response should include, but not be limited to, the principles of skid avoidance and the effects of liquid surge, load factors, general steering reactions, and speed on vehicle control. Common causes for loss of control are driving too fast for road conditions, failing to properly react to weight shifts of heavy emergency vehicles/apparatus, driver distraction, and failing to anticipate obstacles.

Driver training should incorporate vehicle characteristics, capabilities and limitations. Tankers, for example, tend to be heavier and to have a higher center of gravity than other fire vehicles. Both of these factors affect the driver's ability to control a tanker. Based on simple physics and inertia, a top heavy vehicle like a tanker is inclined to tip over if driven through a curve at an unsafe speed or if the driver suddenly turns the steering wheel in an effort to bring the wheels back onto the road. The U.S. Fire Administration's *Safe Operation of Fire Tankers* lists some vehicle rollover prevention points to increase a driver's ability to maintain control of a vehicle should it run off the road onto the shoulder. It cautions that the vehicle should be slowed gradually by taking the foot off the accelerator and only after the vehicle has been brought down to a safe speed, should it be gently steered back onto the road.[11]

Driver training should be documented and given in accordance with NFPA 1451, *Standard for a Fire Service Vehicle Operations Training Program*[15] and NFPA 1002, *Fire Apparatus Driver/Operator Professional Qualifications*[16]. These standards state that departments should establish and maintain a driver training education program and each member should be provided driver training not less than twice a year. During this training, each driver should operate the vehicle and perform tasks that the driver/operator is expected to encounter during normal operations to ensure the vehicle is safely operated in compliance with all applicable State and local laws. The department involved in this incident provided both hands-on and classroom driver training approximately once every two years.

Recommendation #4: Governing entities should consider enacting new, or enhancing current legislation to specifically mandate seat belt use by operators and occupants of fire department vehicles.

Discussion: The Federal Motor Carrier Safety Administration exempts the occupants of fire trucks and rescue vehicles while involved in emergency and related operations from wearing seat belts.[17] These laws are in direct opposition to NFPA standards, and IAFC and IAFF recommendations as mentioned previously.[7,8,9] The Colorado occupant restraint law does not appear to specifically exempt fire service vehicles.[2] However, wording that explicitly includes these vehicles would eliminate the ambiguity.

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INVESTIGATOR INFORMATION

This investigation was conducted and the report was authored by Virginia Lutz, Safety and Occupational Health Specialist, with the NIOSH, Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH. An expert technical review was provided by Dr. Burton A. Clark, EFO, CFO, National Fire Academy.

PHOTOS AND DIAGRAMS

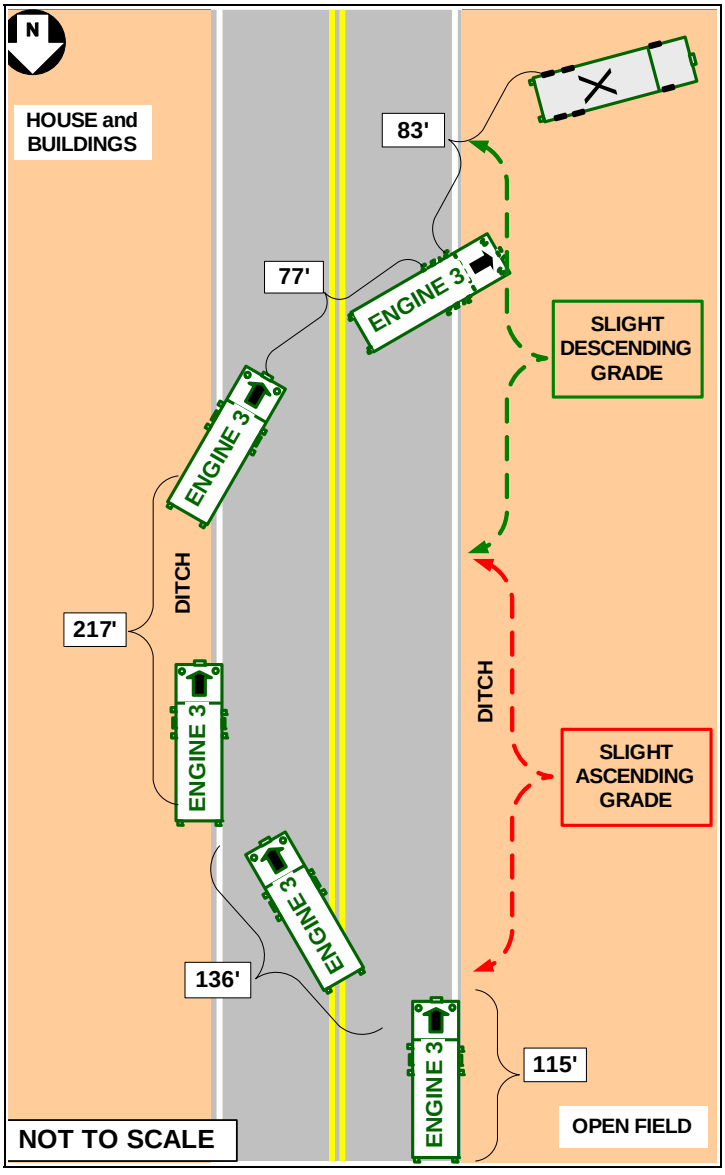

Diagram 1. Depiction of incident scene showing E3 path of travel.

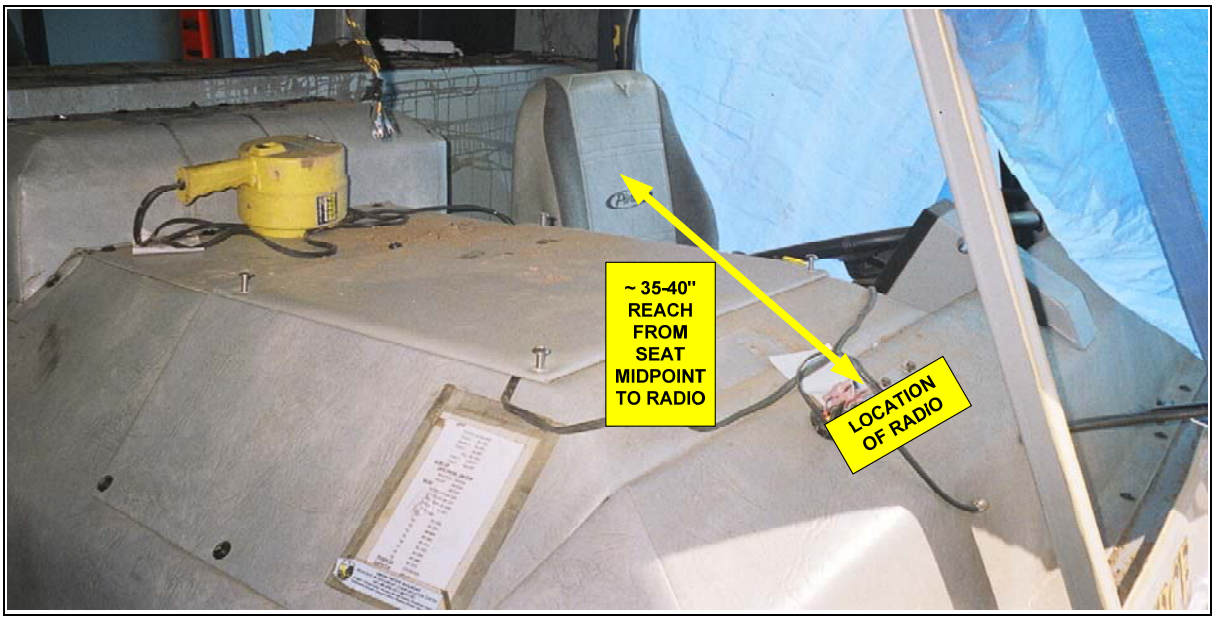

Photo 1. View of the cab interior showing reach distance from seat to radio.
(NIOSH photo)

Photo 2. View of the driver's seat showing awkward reach from sitting position to radio.
(NIOSH photo)

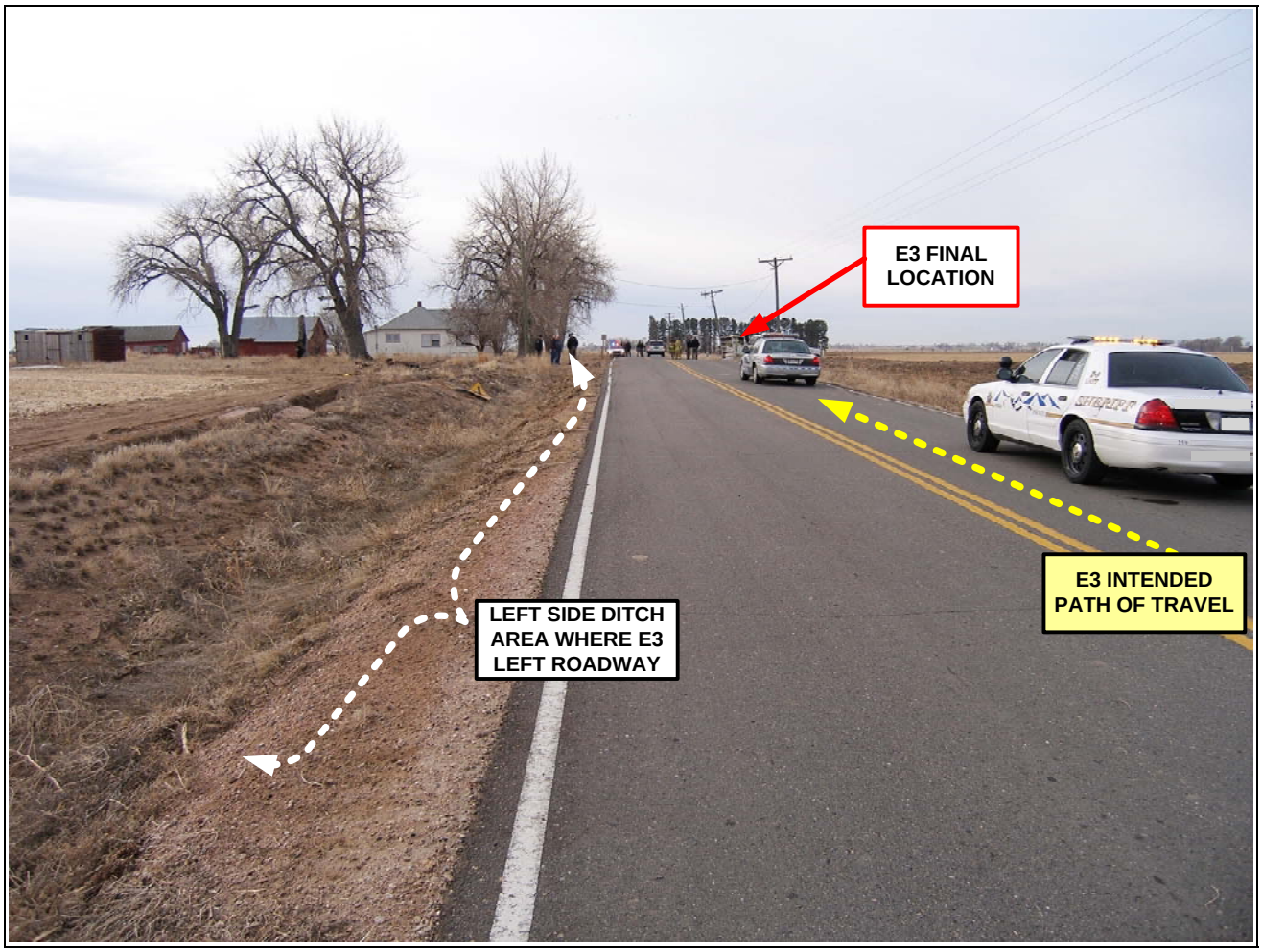

Photo 3. View of the roadway where the incident occurred.
(Photo courtesy of the State Patrol)