Transport Canada
Road Safety

Transports Canada
Sécurité routière

COLLISION INVESTIGATIONS

SPECIAL INVESTIGATION V

ASF5-1210

1997 Ford E 350 Super Club XLT Van

Vs.

2005 Mack CXN613 "Vision" tractor *towing a*
2007 Great Dane Super LT reefer semitrailer

SIDE IMPACT

ENQUÊTES SUR DES COLLISIONS

Technical Report
Rapport technique

Canada

CASE VEHICLE SUMMARY
1997 Ford E 350 Super Club XLT passenger van
VIN: 1FBJS31S3VHxxxxxx
CDC: 01RZAW5
0110: 53 yr, M, lap/torso, front airbag, MAIS-0
0130: 51 yr, F, torso (misuse), front airbag, FATAL
0230: 15 yr, F, lap only (misuse), MAIS-3
0310: 17 yr, M, unrestrained, MAIS-5
0320: 17 yr, M, lap only, MAIS-4
0330: 16 yr, M, lap/torso, FATAL
0410: 15 yr, M, unrestrained, FATAL
0420: 17 yr, M, unrestrained, FATAL
0430: 17 yr, M, unrestrained, FATAL
0510: 17 yr, M, unrestrained, FATAL
0530: 17 yr, M, unrestrained, FATAL
0540: 17 yr, M, unrestrained, FATAL

KEYWORDS: Ejection
Incompatible
Tires

COLLISION EVENTS

This collision occurred on a straight and level rural section of a two-lane, two-way arterial highway with a legal speed limit of 100 km/h. It was dark and there was no artificial illumination at the scene. There was precipitation in the form of freezing rain. The asphalt surface was covered in snow and slush at the time of the collision.

A northbound 1997 Ford E 350 Super Club XLT 15-seat passenger van was travelling at a driver-estimated speed of 75 to 80 km/h. In a statement to police, the driver of the E350 said that he saw an approaching transport. The centreline was covered with snow so he reportedly attempted to stay to the far right side of the travel lane. The driver also stated that he thought that the E350 had travelled onto the shoulder and then he "… corrected to get back on the road". The E350 subsequently crossed the centreline, entering the path of the southbound tractor-semitrailer. According to the driver of the E350, he steered to the left in an attempt to reach the shoulder of the southbound lane and avoid a collision.

The approaching vehicle was a 2005 Mack CXN613 "Vision" conventional day cab highway tractor towing a 53 foot long 2007 Great Dane Super LT tandem reefer semitrailer. The semitrailer was partially loaded with wooden pallets. The Provincial Motor Vehicle Accident (MVA) report indicates that the tractor-semitrailer was southbound at a driver-estimated speed of 80 km/h. In a statement to police, the driver of the tractor-semitrailer said that he began slowing the vehicle when he noticed an oncoming vehicle. He further stated that the tractor-semitrailer was travelling 65 km/h when the E350 crossed into the path of his vehicle. The driver of the tractor stated that there was no warning or indication prior to the E350 entering his lane and that he did not have sufficient time to avoid a collision. The right front corner of the tractor collided with the right side of the E350. This impact deployed the dual front airbags in the E350. It also tore a swath through the E350 from the right B-pillar, across the vehicle to the left rear corner of the van.

The E350 was rotating clockwise as it travelled to the northwest after impact. The E350 came to rest facing east on the shoulder / roadway embankment adjacent to the southbound lane of the highway.

Figure 1: E350 & tractor-semitrailer at FRP

Figure 2: Right side of E350 at FRP

The tractor semitrailer travelled to the southwest onto the shoulder of the southbound lane after impact. The tractor came to rest facing west and was furrowed in the snow on the roadway embankment, approximately 40 metres from the point of impact. The semitrailer was intact and had remained connected to the tractor after the crash. The semitrailer was facing southwest, with the rear of the unit resting diagonally across the southbound lane and encroaching into the northbound lane. Wreckage from the rear and right side wall of the E350 was on the embankment near the right side of the tractor at final rest.

Figure 3: Front of tractor-semitrailer at FRP

Seven of the twelve occupants were ejected from the E350 through the opening created by the impact with the tractor. All seven of these occupants were fatally injured during the crash. Occupant 0130 was partially ejected from the vehicle and was fatally injured during the crash.

CASE VEHICLE (E350)

The tractor unit initially contacted the right wall of the E350 just behind the B-pillar. The entire rear wall and the portion of the right wall that is rearward of the B-pillar were completely separated from the E350. The right front corner of the roof was displaced rearward and downward. The roof deformation severed the connection between the roof and the top of the right A-pillar. It also extensively cracked the entire windshield and tore the laminated windshield horizontally from the top of the right A-pillar to the top of the left A-pillar. All of the remaining window glazing was shattered, with the exception of the window in the driver's door and the left side cargo window. The mount for the passenger side mirror was broken. The right rear tire was punctured and deflated. The right rear wheel rim was broken and deformed. The bolts were sheared off that hold the front spring shackle for the right rear suspension to the vehicle frame. The right rear wheel assembly was displaced 16 cm rearward. The mount holding the spare tire failed, allowing it to separate from its storage location at the rear underside of the vehicle.

Figure 4: Right front of E350

The front of the tractor penetrated approximately 110 cm into the right side of the E350, intruding the right wall and rear right side doors of the E350 into the occupant compartment just before they were torn from the vehicle. The front passenger seatback

was twisted clockwise from loading by occupant 0230. A detachable seatbelt anchor assembly, used to attach the lower portion of the seatbelt webbing to the right side of seat 0230, was contacted by the intruding right side wall. This contact damaged the buckle and released the latchplate for the anchor. The seatback for the floor mounted bench seats in row two was deformed forward by occupant loading. The last three rows of seats, also floor mounted bench type seating, were broken from the floor by intrusion. The last three rows of seats were ejected out of the vehicle during the crash.

Figure 5: Right rear of E350

Figure 6: Right side of E350 with ejected seats

Occupant 0110

The 53 year-old male driver was 168 cm (5'-6") in height with a mass of 84 kg (185 lb). The driver was properly wearing the three-point seatbelt at the time of the collision. Striations from the seatbelt webbing were observed on the seatbelt tongue and the seatbelt D-ring. The driver's front airbag (1st generation) and the driver's seatbelt pretensioner (buckle type) deployed during the collision. The driver's seat cushion was found adjusted to the middle position at the time of the vehicle examination. The driver was not injured during the collision.

Occupant 0130

Occupant 0130 was a 51 year-old female with a height of 168 cm (5'-6") and a mass of 104 kg (230 lb). Seat cushion 0130 was found adjusted to the middle position at the time of the vehicle examination. The passenger front airbag (2nd generation) and the front passenger seatbelt pretensioner (buckle type) deployed during the collision. Occupant 0130 was wearing the three-point seatbelt with the lap portion of the webbing behind her back at the time of the crash – a misuse of the restraint. This allowed her lower body to forcefully contact the front right side door in response to the impact with the tractor-semitrailer. The striker plate for this door pulled out of the B-pillar during the collision. Occupant 0130 was found partially ejected from the vehicle and hanging from the torso portion in the front right side door opening. The seatbelt webbing was tight against the right side of her neck, across the upper part of her chest and under her left arm. EMS personnel cut the seatbelt webbing to remove occupant 0130's body from the restraint. She had been fatally injured during the collision.

The cause of occupant 0130's death, as stated by the pathologist in the final autopsy report, was "Multiple organ damage secondary to motor vehicle accident".

Occupant 0230

Occupant 0230 was a 15 year-old female with a mass of 59 kg (130 lb). Her height is unknown. Occupant 0230 told police that she was wearing the three-point seatbelt with the torso portion of the webbing behind her back – a misuse of the restraint. Friction loading from the torso portion of the webbing was observed on the top of the seatback at the left side of seat position 0230, confirming the misuse of the restraint. Occupant 0230 moved forward in response to impact and was ejected from the seat after the detachable seatbelt anchor released. This anchor is located at the right side of seat 0230. It was damaged by the intrusion of the right wall of the vehicle. Occupant 0230 loaded the left side of seatback 0130 before coming to rest on the floor between the front seats. Occupant 0230 was injured during the collision (MAIS-3).

Occupant 0310

Occupant 0310 was a 17 year-old unrestrained male with a height of 185 cm (6'-1") and a mass of 77 kg (170 lb). Occupant 0310 told police that he was not wearing the three-point seatbelt at the time of the crash. No evidence of occupant loading was found on the restraint. It was found unbuckled after the crash. Occupant 0310 was ejected from the seat, loading and deforming forward the seatback directly in front of him. Occupant 0310 remained in the vehicle during the crash. He was injured during the collision (MAIS-5).

Occupant 0320

Occupant 0320 was a 17 year-old male with a height of 170 cm (5'-7") and a mass of 68 kg (150 lb). Occupant 0320 told police that he was wearing the manual lap belt at the time of the crash. The seatbelt webbing was cut by vehicle debris as the right side of the vehicle was intruded at impact, allowing occupant 0320 to be thrown forward and ejected from the seat. The tongue for seatbelt 0320 was found buckled during the vehicle examination, indicating that occupant 0320 was using the restraint at the time of impact. Loading marks from the seatbelt tongue on the seatbelt webbing appear to confirm seatbelt use. Occupant 0320 was injured during the collision (MAIS-4).

Occupant 0330

Occupant 0330 was a 16 year-old male with a height of 185 cm (6'-1") and a mass of 77 kg (170 lb). The tongue for seatbelt 0330 was found buckled during the vehicle examination. Deep striations from the seatbelt webbing were found on the seatbelt tongue, indicating that occupant 0330 was wearing the restraint at the time of impact. It could not be determined if occupant 0330 was wearing the restraint properly. He was completely ejected from the vehicle and was fatally injured during the collision.

The cause of occupant 0330's death, as stated by the pathologist in the final autopsy report, was "Transection of thoracic aorta and brain lacerations secondary to multiple diminuted skull fractures, secondary to motor vehicle accident".

Occupant 0410

Occupant 0410 was a 15 year-old unrestrained male with a height of 183 cm (6'-0") and a mass of 80 kg (176 lb). No evidence of occupant loading was found on the seatbelt and it was found unbuckled after the crash. He was completely ejected from the vehicle and was fatally injured during the collision.

The cause of occupant 0410's death, as stated by the pathologist in the final autopsy report, was "Multiple organ injuries secondary to motor vehicular accident".

Occupant 0420

Occupant 0420 was a 17 year-old unrestrained male with a height of 183 cm (6'-0") and a mass of 77 kg

(170 lb). No evidence of occupant loading was found on the seatbelt and it was found unbuckled after the crash. He was completely ejected from the vehicle and was fatally injured during the collision.

The cause of occupant 0420's death, as stated by the pathologist in the final autopsy report, was "Multiple organ damage secondary to motor vehicular accident including multiple skull fractures".

Occupant 0430

Occupant 0430 was a 17 year-old unrestrained male with a height of 183 cm (6'-0") and a mass of 125 kg (276 lb). No evidence of occupant loading was found on the seatbelt and it was found unbuckled after the crash. He was completely ejected from the vehicle and was fatally injured during the collision.

The cause of occupant 0430's death, as stated by the pathologist in the final autopsy report, was "Multiple organ injuries secondary to motor vehicular accident".

Occupant 0510

Occupant 0530 was a 17 year-old unrestrained male with a height of 175 cm (5'-9") and a mass of 74 kg (163 lb). No evidence of occupant loading was found on the seatbelt and it was found unbuckled after the crash. He was completely ejected from the vehicle and was fatally injured during the collision.

The cause of occupant 0510's death, as stated by the pathologist in the final autopsy report, was "Blunt trauma leading to multiple fractures and rupture of vital organs from motor vehicular accident".

Occupant 0530

Occupant 0530 was a 17 year-old unrestrained male with a height of 165 cm (5'-5") and a mass of 68 kg (150 lb). No evidence of occupant loading was found on the seatbelt and it was found unbuckled after the crash. He was completely ejected from the vehicle and was fatally injured during the collision. The cause of occupant 0530's death, as stated by the pathologist in the final autopsy report, was "Multiple organ injuries secondary to motor vehicular accident".

Occupant 0540

Occupant 0540 was a 17 year-old unrestrained male with a height of 195 cm (6'-5") and a mass of 95 kg (209 lb). No evidence of occupant loading was found on the seatbelt and it was found unbuckled after the crash. He was completely ejected from the vehicle and was fatally injured during the collision.

The cause of occupant 0540's death, as stated by the pathologist in the final autopsy report, was "Multiple organ injuries secondary to motor vehicular accident". In the autopsy report summary, the cause of death was given as, "… blunt trauma to vital organs and multiple fractures to bones (left humerus, left ribs, left leg and right thigh)".

NON-CASE VEHICLE (Tractor –semitrailer)

Mack Tractor

The front-end of the tractor was crushed rearward, involving the front bumper, the hood, and the right and left front fender. A maximum crush of 27 cm rearward was measured to the left of the centre of the front bumper beam, corresponding to the point of impact with the right rear wheel assembly of the E350. The bumper fascia was almost completely separated from the tractor. The left side of the steering axle was displaced 16 cm rearward. The right side of the steering axle was displaced approximately 66 cm rearward. The front of the right side diesel tank was crushed rearward from contact with the displaced right front wheel. The damaged fuel tank broke from its mounts and completely separated from the vehicle during the

crash. The fibreglass engine cowl and fender assembly was shattered, with the damage concentrated on the right side of the assembly. The radiator core was crushed and punctured. The windshield was extensively cracked from the contact with vehicle debris. The cab was twisted clockwise on the vehicle frame. A TDC of 12FZEW6 was determined for the tractor's impact with the E350.

Figure 7: Right front of Tractor with attached semitrailer

Great Dane semitrailer

The semitrailer was undamaged during the collision.

Figure 8: Right rear semitrailer

Occupant 0110 (Tractor-semitrailer)

The driver was a 68 year-old male. His height and weight are unknown. His seatbelt use during the crash is unknown. No loading evidence was observed on the restraint. Driver was not injured during the collision.

VEHICLE IMPACT

VEHICLE ORIENTATION AT IMPACT

RCMP and Team investigators placed the E350 and the tractor together to help confirm vehicle orientation at impact. Direct contact on the E350 extended rearward along the right side of the vehicle from the right front passenger's door, just ahead of the B-pillar, to the rear corner of the vehicle. Investigators noted gouges at the lower rear corner of the front passenger's door which appears to be the result of contact with the studs from the right front wheel of the tractor. Fibreglass from the tractor's shattered right front fender was found embedded in the punctured lower rear corner of the window frame on the E350's front passenger door. Damage to the right frame rail of the E350 was matched to the right corner of the tractor's bumper beam. Crush damage to the left of the centre of the tractor's front bumper beam was matched to the right rear wheel assembly of the E350. By matching vehicle damage, investigators concluded that the tractor collided with the right side of the E350 at an angle of roughly +30 degrees to the centerline of the E350.

EXTRACTED CRASH DATA

E350

An EDR was removed from the E350 and was sent to Ford Motor Company for data retrieval. A total of 70 ms of recorded data was extracted. A plot of the recovered data shows a maximum longitudinal acceleration of -50 g and a maximum longitudinal ΔV of -35 km/h. The acceleration had not returned to zero at the end of the recording, indicating that the actual maximum longitudinal ΔV for the crash was greater than the recorded value of -35 km/h. A PDoF of +30 degrees was estimated for the E350 based on the collision related damage. Based on this PDoF, a lateral ΔV of -20 km/h was estimated for the E350. The total maximum ΔV was calculated to be -40 km/h at 1 o'clock.

Tractor

The Mack engine in the tractor has an electronic control system known as the V-MAC III. This system includes two modules: A VECU (Vehicle Electronic Control Unit) and EECU (Engine Electronic Control Unit). A V-MAC III can contain two stored 'incidents'. A decrease in wheel speed of 10 miles per hour per second is the normal threshold for triggering the recording of an event. A rapid increase in wheel speed can also trigger an event. Mack incidents record event data at 0.2 second intervals for 15.8 seconds before the incident and 16.0 seconds after the recording of incident. Speed is reported to the nearest whole mile per hour. Mack incident reports include wheel speed, engine speed, and the status of up to eight 'switches'.

These switches normally include cruise control (on/off), service brake (on/off), and key switch (on/off). Mack Trucks have not provided public access to their incident data. Mack ECUs must be physically removed from the truck and sent to Allentown, Pennsylvania.

A VECU and an EECU were removed from the tractor and sent to Mack Trucks Inc. for data extraction. A Data Extraction & Incident Report was prepared by Mack Trucks Inc. Two "incident" logs were present in the recovered data. The VECU recorded "Vehicle Speed" (mph) and "RPM" (rpm) for each log. The status of seven switches (ON /OFF) was also recorded: "Service Brake"; "Park Brake"; "Clutch Pushed"; "Engine Brake Low"; "Engine Brake High"; "Cruise Control"; and "Key Switch".

The second "incident" log appears to correspond with this crash; however the "Incident Date and Time" data indicates that this incident occurred roughly five days earlier than the crash. The time discrepancy could be the result of the date and time being entered improperly when the system was setup. It could also be a factor of data corruption/loss. According to the tractor manufacturer, the tractor's "Gregorian clock" data ("Incident Date & Time") is "…notoriously inaccurate" because of its inherent susceptibility to data write errors, often caused by such things as voltage spikes, power interrupts, etc. Furthermore, the manufacturer has examined "Gregorian clock" data for numerous known recorded events and has determined that less than 1.5 percent of all the "Incident Date & Time" entries were accurate. The manufacturer also stressed that "Gregorian clock" timing is independent from how the computer times values for the other incident log data and that it has no affect on the accuracy of the other recorded data. The manufacturer stresses that the relative timings of the vehicle switches status, engine RPM and vehicle speed are impeccably accurate.

The V-MAC III Data Extraction and Incident Report established a 'time zero' for the crash related incident log and labeled it "Incident Occurred". "Vehicle Speed" was recorded as being 1.6 km/h (1 mph) at 'time zero' and was zero for the entire "after incident" portion of the record. It is obvious that the tractor was not stopped when the impact with the E350 occurred, given the post impact travel of the vehicle. Vehicle speed values provided in the incident report are a function of the rotational speed of the transmission output shaft in conjunction with the selected transmission gear, the tire size (circumference) and the rear axle ratio. Based on an examination of tractor, it appears that the wheels on the drive axles and the drive train were capable of turning after the impact with the E350. It appears unlikely that the tires on the tractor's drive axles would lock-up, given that the vehicle is ABS equipped. Given the above, it appears that a zero speed value would likely not have occurred until the tractor was close to, or at, it's final resting position.

Acceleration calculations were performed on the extracted vehicle speed and time data. From these calculations, it was observed that the tractor experienced two periods of significant negative acceleration during the incident log, one beginning roughly three seconds before 'time zero' and one occurring roughly one second before 'time zero'. In each case, the calculated acceleration values peaked at -1.14 g's - values too large to be explained by braking alone. The first period of rapid negative acceleration, occurring at roughly 3.0 to 2.6 seconds prior to 'time zero', was attributed to the impact with the E350. The second period of significant negative acceleration, occurring at roughly 1.0 seconds prior to 'time zero', was attributed to the impact with snow along the shoulder and the roadway embankment.

It was observed that the tractor's "Key Switch" status changed from "ON" to "OFF" at 3.2 seconds prior to 'time zero'. It appears improbable that the driver turned off the tractor's engine at, or just before, impact. A more plausible conclusion is that the electrical circuit for the key switch sensor was broken by the impact as a result of vehicle damage, changing the "Key Switch" status to "OFF". Both the acceleration calculations and the "Key Switch" status data indicate that the tractor's time of impact with the E350 occurred at roughly 3.2 seconds before 'time zero'.

Using speed and distance data from the ECU, it was calculated that the tractor would have traveled roughly 36 to 40 metres during the 3.2 seconds immediately prior to 'time zero', which is roughly the same distance measured from the apparent point of impact between the tractor and the E350 and the final resting position of the tractor. Based on an examination of the downloaded data, it was concluded that 'time zero' occurred at about the same time as when the tractor came to final rest on the roadway embankment.

The extracted data indicates that the tractor was travelling 80 km/h (50 mph) at 15.8 seconds before 'time zero'. This was approximately 12.8 seconds before the impact with the E350, assuming that this impact took place at 3.2 seconds before 'time zero'. The tractor speed steadily increased to 84 km/h (52 mph) until roughly 1.4 seconds before impact with the E350. The "Engine Brake Low" status changed to "ON" at 4.4 and 4.2 seconds before 'time zero'. It appears that the driver removed his foot from the fuel feed pedal at this point, triggering the engine brake (low) one second before impact with the E350. This status reverted to "OFF" 0.2 seconds later. The "Clutch Pushed" status was "ON" at 3.6 seconds before 'time zero' and remained on for one second, indicating that the driver was clutching as the impact took place. Based on the available data, it was concluded that the speed of the tractor was around 72 km/h at impact with the E350. The driver of the tractor told police that he thought that the tractor was traveling around 65 km/h when the impact occurred.

The "Service Brake" status changed to "ON" at 4.4 seconds before 'time zero' and remained in this status *almost* continuously until 3.0 seconds after time zero. There was only one data element recorded during this 7.4 second period where the status was "OFF". It occurred at 3.0 seconds before 'time zero', at roughly the time of impact with the tractor. The "Service Brake" data indicate approximately 1.4 seconds of pre-impact braking by the tractor.

The "Park Brake" status changed to "ON" at 3.0 seconds before 'time zero', again, at roughly the apparent time of impact. It could not be determined if the driver applied the parking brake or if the status of this switch changed as a result of collision related damage.

The incident data from 3.0 seconds after incident to the end of the data record appears to be unrelated to this crash. The last thirteen seconds of data appears to be a remnant from a previous 'incident' that was not overwritten due to a loss of electrical power. The manufacturer stated to a Team investigator that the V-MAC III system typically stops recording six seconds after the loss of electrical power. The "Key Switch" status indicator changed to "OFF" at 3.2 seconds before 'time zero', making a total time of six seconds between the status change and the start of the unrelated date.

PERFORMANCE OF VEHICLE SAFETY SYSTEMS

Seatbelts

Five of the twelve occupants in the E350 were wearing seatbelts at the time of the crash. The belted occupants were the driver, right front passenger (occupant 0130), occupant 0230, occupant 0320 and occupant 0330. Of these belted occupants, two were wearing their seatbelts improperly. The right front passenger had the lap portion of her three-point seatbelt behind her back. Seatbelt misuse likely contributed to the injuries received by the front passenger and allowed her to be partially ejected from the vehicle when her door opened during the crash. Occupant 0230 was wearing the three point restraint with the shoulder portion of the restraint behind her back. The failure to use the torso portion of the restraint likely allowed her upper body to move significantly further forward during initial stages of the crash. The detachable lower seatbelt anchorage for seat 0230 released as the crash progressed, allowing occupant 0230 to be ejected from the seat. One of the seven occupants that were completely ejected from the vehicle was wearing a seatbelt.

Seatbelt use was likely of minor significance regarding the fatal outcome for the seven completely ejected occupants given: (1) the extensive intrusion into the occupant compartment by the right wall of the E350 and front of the tractor and (2) the resulting ejection of the seat benches for rows three, four and five.

Airbags

The dual front airbags (first generation) deployed in the E350 as a result of the impact with the tractor-semitrailer. Both airbags appear to have deployed properly. No injury was associated with the deployment of the airbags. The deployment of the driver's front airbag likely offered some additional safety benefit to the properly belted driver in this crash. It could not be determined if the deployment of the passenger front airbag affected occupant 0130's injury outcome.

Antilock Brake System (ABS)

Sales information indicates that the 1997 Ford Econoline Club Wagon was built with a 4-Wheel Antilock Brake System (4WABS) as a standard feature. The driver of the E350 did not mention to police that he applied the brakes prior to impact with the tractor-semitrailer. To determine if the driver was applying the brakes of the E350 as the crash occurred, the bulbs from the left taillight of the E350 were examined and documented. The brake bulb filament was significantly stretched (hot shock), indicating that the brake lamp was illuminated at the time of the impact. The extent of pre-impact braking could not be determined, so it could not be determined if the presence of a 4WABS system on the E350 had any affect on the collision. The mechanic's post-crash inspection report of the E350 indicates that the left rear brake was out of adjustment at the time of the crash and had a broken brake adjuster cable. This may have affected the overall braking capacity of the E350.

Electronic Stability Control (ESC)

Team investigators have determined that the E350 was not equipped with Electronic Stability Control (ESC),

nor was this feature available for this vehicle in the year it was manufactured. A modern ESC system, as can be found on newer 15-passenger vans, has been shown to improve the stability and handling of similar type of vehicles. These systems are effective in reducing the likelihood of rollover events.

To avoid any confusion regarding the dynamics of the collision, readers should be aware that E350 did not overturn at any time during the collision. There is insufficient evidence to conclude whether ESC would have prevented or significantly affected the outcome of this collision.

ACTS, REGULATIONS & SAFETY STANDARDS

FIFTEEN-PASSENGER VANS

Commercial Vehicle Status

Under Section 1 of the Provincial Motor Vehicle Act (M-17), a 'commercial vehicle' is defined as "… a motor vehicle designed or adapted for the carrying of freight, goods, wares or merchandise, but does not include a private passenger vehicle." A 'private passenger vehicle' is defined by the Act as "… a motor vehicle designed and used primarily for the transportation of persons without remuneration and does not include a bus or taxicab." Part IV.1 of the Act, which deals with commercial vehicle safety, further defines a commercial vehicle as to include a vehicle defined as a '*bus*' under Section 1. In this section, a 'bus' is defined as "…any motor vehicle designed for carrying ten or more passengers and used for the transportation of persons". The E350 had a designed seating capacity of 15 persons, including the driver. It was also designed for the transportation of people. Receiving compensation for transport activities is not a qualifier for determining if a vehicle is a commercial vehicle. Based on the provincial Motor Vehicle Act, the E350 is considered a bus and a commercial vehicle.

As a commercial vehicle, the E350 must be operated in compliance with applicable regulations including Commercial Driver Hours of Service, Trip Inspection Reports & Records and Carrier Profile Compliance.

Vehicle Ownership & Registration

The E350 was registered to an incorporated unit. This organization was reportedly formed as a non-profit entity that purchased and operated the van for school sport related travel. In the case of the E350, it appears that the organization was acting as the 'carrier'. Under the Provincial Motor Vehicle Act, a 'carrier' means "a person who owns, is the lessee of, or is otherwise responsible for the operation of, a commercial vehicle for the purpose of transporting passengers or goods".

The E350 was licensed and plated under Provincial Regulation 8342 Section 10.5 of the Motor Vehicle Act as

"… a community service bus, being a passenger bus registered in the name of a bona fide community service organization used without remuneration and solely for the purpose of carrying out the aims and objects of such an organization."

COMMERCIAL DRIVERS - HOURS OF SERVICE REGULATIONS

In Regulation 2007-39, the Province adopts the federal Commercial Vehicle Drivers Hours of Service (CVDHS) regulations, with exceptions. One of these exceptions is the definition of 'commercial vehicle'. The Provincial definition of commercial vehicle, as defined previously, is used and enforced in this Regulation.

Logbook Requirements

CVDHS regulations require commercial drivers to fill out a *driver's daily log* to account for all of the driver's on-duty time and off-duty time for that day. A daily log must be filled out *unless*:

(a) the driver operates a commercial vehicle within a radius of 160 km of the home terminal;
(b) the driver returns to the home terminal each day to begin a minimum of 8 consecutive hours of off-duty time;
(c) the motor carrier maintains accurate and legible records showing, for each day, the driver's duty status and elected cycle, the hour at which each duty status begins and ends and the total number of hours spent in each status and keeps those records for a minimum period of 6 months after the day on which they were recorded; and
(d) the driver is not driving under a permit issued under these Regulations.

The E350 traveled outside of a radius of 160 km from its origin (home terminal) on the day of the crash; therefore, the driver was required to fill out a driver's daily log. Before beginning the journey on the day of the crash, the driver reportedly wrote down his name, his intended use of the van, the group involved and the mileage for the start of the journey in a notebook, instead of recording his activities in a driver's daily logbook. A driver's daily logbook was found in the E350 after the crash. The most recent entry in this logbook, made almost nine months prior to the crash, was completed by another driver - not the person driving the E350 at the time of the crash. The driver of the E350 was also required to carry a record of his duty status for the previous fourteen days. He was not carrying a summary of his daily activities for the previous fourteen days in the vehicle at the time of the crash. The driver of the E350 was in *violation* of the logbook requirements of CVDHS regulations by failing to properly record his daily activities.

The driver of the tractor-semitrailer was in possession of a driver's daily logbook at the time of the crash. The employer of this driver provided to police copies of the logbook pages for the day of the crash and for the previous fourteen days. A detailed summary of the stops made by the tractor during the fourteen days leading up to the crash were also obtained by police. Based on the logbook entries, it appears that the driver of the tractor semi-trailer was in compliance with the logbook requirements of CVDHS regulations.

Hours of Service Limits

CVDHS regulates the number of hours a driver's 'daily driving' time and 'on-duty' time. No driver is permitted to drive after:

(a) the driver has accumulated 13 hours of driving time in a day*;
(b) the driver has accumulated 14 hours of on-duty time in a day*; and
(c) after 16 hours have elapsed between the conclusion of the most recent period of 8 or more consecutive hours of off-duty time

** A "day" is defined by Provincial regulation as a 24-hour period.*

This driver of the E350 had arrived at work almost sixteen hours before the collision. He was 'on-duty' from the time he arrived at work to the time of the crash. The driver did not exceed the maximum permitted 'driving time', having driven just over six hours. He was in *violation* of the *hours of service* limits set by CVDHS regulations because he was driving almost two hours after he had reached the limit set for accumulated on-duty time. He was also within roughly five to ten minutes of exceeding the limit of sixteen hours since the last consecutive eight hour period of off-duty time.

The driver of the tractor-semitrailer complied with the *hours of service* limits set by the CVDHS regulations. According to the driver's logbook records, he was continuously on-duty from the time he arrived at work to the time of the crash. His on-duty time that day was almost nine hours, which is less than the fourteen hour maximum permitted for *on-duty time*. This driver drove almost six and a half hours while on-duty that day, within the maximum number of hours permitted for *driving time.* It was less than sixteen hours since the driver had his last consecutive eight hour period of off-duty time.

The driver of the tractor-semitrailer elected to work and fill out his daily log based on a 120 hour / 14 day cycle (cycle 1). According to CVDHS regulations, no driver who is following 'cycle 1' shall drive after this driver has accumulated 70 hours of on-duty time during any period of seven days or, if the driver has reset the cycle in accordance with section 28, during the period of the cycle that was ended. Lacking records for the fourteen days prior to the crash, Team investigators were unable to determine whether the driver of the tractor-semitrailer complied with the 70 hour maximum hours of service limit.

Trip Inspection Reports & Records

Under Provincial Regulation 94-77 "Trip Inspection Report and Records", the driver of a commercial vehicle is required to inspect the vehicle before the vehicle's first trip of the day for the purpose of preparing a trip inspection report. A trip inspection report must include:

(a) the date and time of the inspection;
(b) the odometer reading at the time of the inspection;
(c) the licence plate or unit number of the commercial vehicle;
(d) the licence plate or unit number of any trailer or semi-trailer towed by the commercial vehicle;
(e) the name of the carrier for whom the driver is working at the time the report is made;

(f) a list of the items required to be inspected as set out in Schedules A (exterior) and B (interior);
(g) any safety defects as disclosed in the inspection of the items listed in Schedules A and B; and
(h) the name and signature of the person who carries out the inspection.

The driver E350 *violated vehicle inspection* requirements by failing to perform a complete 'pre-trip' inspection of the vehicle prior to the start of the journey. The carrier for the E350 violated Regulation 94-77 by failing to maintain vehicle inspection reports. One of the items for inspection, listed in Schedule A of the regulations, is the tires of the vehicle. Tire condition was not inspected by the driver of the E350 on the day of the crash. The worn treads and under-inflation of the tires on the E350 appear to have been significant contributing factors in the loss of control that resulted in the collision. This matter is further addressed later in this report.

The driver of the tractor-semitrailer complied with vehicle inspection requirements, based on copies of inspection records provided to police by the driver's employer (motor carrier).

Carrier Profile and Compliance

Under Provincial Regulation 2004-6 "Carrier Profile and Compliance", motor carriers having addresses in the Province shall maintain records so that they may be given a safety rating for their transport operations. The safety rating is based on a demerit system. Demerits can be incurred for the driver of a commercial vehicle that is part of a carrier's fleet if they are convicted of: driving related offenses under the Criminal code of Canada and for 'moving violations' and/or 'hours of service violations' under the Provincial Motor Vehicle Act. Demerits can also be incurred by vehicles in the motor carrier's fleet for violating provisions of the Motor Vehicle Act regarding equipment, mechanical fitness requirements, vehicle dimensions or mass, records keeping violations, and a number of miscellaneous requirements. Carriers also incur demerits for dangerous goods violations under the Transportation of Dangerous Goods Act.

The Provincial Registrar never conducted a carrier profile safety audit for the carrier of the E350. Although a carrier can comply with the Regulation 2004-6 even if unaudited, it appears that the carrier for the E350 was in violation of the regulation by failing to maintain adequate records.

It appears that the carrier for the E350 was in compliance of the regulations regarding carrier compliance and profile. The carrier had an 'unaudited-complaint' status at the time of the crash.

SCHOOL BUS RELATED STANDARDS & REGULATIONS

A school bus is defined in Canada by the Canadian Standards Association (CSA) document D250-07 "School Buses". The CSA first established a voluntary standard for school buses in 1971 in response to a request by provincial authorities. This standard had been revised several times to address the adoption of improved mirror requirements, crossing arms, roof hatches, etc. The current CSA definition of a school bus is "a

specially constructed vehicle that is designed to carry more than ten persons (primarily children) to and from school related events and is *National School Bus Yellow*." Section 4.1 of document D250-70 states, "School buses must meet all applicable standards under the government of Canada's Motor Vehicle Safety Regulations (MVSR) in effect at the date of manufacture of the chassis or the basic vehicle."

The 15-passenger E350 is considered a *bus* by both Provincial and Federal Motor Vehicle Regulations but it is *not a school bus* with respect to Canadian standards and regulations - even though it was carrying students for travel to and from a school sports activity. The E350 was not painted National School Bus Yellow. The E350 was not designed to comply with Canadian Motor Vehicle Standards (CMVSS) that are applicable for school buses (e.g. CMVSS 217 Bus Window Retention and Emergency Exits, CMVSS 221 School Bus Body Joint Strength & CMVSS 222 School Bus Passenger Seating and Crash protection) and was not required to follow these standards.

CANADIAN MOTOR VEHICLE SAFETY STANDARDS

Door Locks and Door Retention Components (CMVSS 206)

The front right side door of the E350 opened during the crash as a result of the striker assembly being pulled out of the B-pillar. This allowed occupant 0130 to be partially ejected from the vehicle.

CMVSS 206 covers requirements for vehicle door locks and door retention components, including latches, hinges, and other supporting means, to minimize the likelihood of occupants being ejected from a vehicle as a result of impact. Technical Standards Document 206 states that the door latch and striker assembly, when in the fully latched position, shall not separate when a longitudinal load of 11 000 N (2500 lb) is applied.

CMVSS 206 did not apply to the E350 at the time it was manufactured and it does not apply to similar vehicles presently being manufactured. CMVSS 206 will apply to a bus with a GVWR of 4536 kg or less that is manufactured on or after September 1, 2009.

Anchorage of Seats (CMVSS 207) & Seat Belt Anchorages (CMVSS 210)

There were multiple seat anchorage failures in the E350 associated with this collision. According to Technical Standards Document 210, vehicle seats are required to withstand (a) a force equal to 20 times the weight of the seat applied in both the forward and rearward directions and (b) a rearward force that produces a 377 N·m (3,300 lb·in) moment about the seating reference, individually. Seating units are currently required to withstand an additional loading of 20 times the weight of the seat *simultaneously* with loading required for each of the attached seatbelt installations, as outlined in "Strength Requirements" of CMVSS 210. It appears that the seats in the E350 were loaded in excess of that required by CMVSS 207 and CMVSS 210.

COLLISION CONTRIBUTING FACTORS

An attempt was made to determine contributing factors in this collision. Areas of investigation have been divided into three categories: (1) Human Factors, (2) Environmental Factors and (3) Vehicle Factors.

HUMAN FACTORS

E350 Driver Background

The driver of the E350 had adequate driving qualifications to operate a 15-passenger van. He held a valid Class 4 drivers licence at the time of the crash. A Class 4 licence allows the holder to operate any two-axle vehicle (including an ambulance, a taxi or a bus), any towed vehicle less than 4500 kg gross vehicle mass, any three-axle motor home and any three-axle motor vehicle that is not designed for the construction, maintenance or repair of highways. A driver is required to meet medical standards to obtain and to hold a Provincial Class 4 license. The driver of the E350 stated to police that he has no medical conditions that might affect his ability to drive a 15-passenger van.

It appears that the driver of the E350 had significant experience driving 15-passenger vans. In a statement to police, the driver said that he has held a Class 4 licence for 28 years. This claim could not be verified by documentation because the driver obtained his Class 4 license before the Province began recording the date and year a driver is first certified. The driver further stated that he has been driving 15-passenger vans for 28 years. When asked by police about his familiarity with the E350 involved in the crash, the driver estimated that he had driven the vehicle roughly 50 to 100 times since it was purchased in 1998 and that 10 to 15 of these times had involved winter driving conditions. According to the driver's abstract, a record of a driver's last seven years of driving, the driver of the E350 had no record of driving offences, suspensions or collisions in the Province.

The driver of the E350 was familiar with the highway and the area of the collision. He lived and worked in a community close to the area of the crash.

E350 Driver Activities

The driver of the E350 was employed as a school teacher and was the coach of a school sport team at the time of the crash. He arrived at work and attended to school related duties, including teaching, for almost six hours before he started on the fatal journey. The purpose of this journey was to transport players on a school sports

team to a game in another city and then return home the same day.
The driver told police that he had checked the windshield wipers and headlights of the E350 before departing on the journey. The driver then drove approximately 450 km in total, with four reported stops, during a period of a little over ten hours just prior to the crash. He was the only person that drove the E350 for each leg of the journey. His total driving time was just over six hours. He did not rest during any of the stops. He ate three meals that day. The crash occurred approximately one hour after the last stop and almost sixteen hours after the driver had arrived at work. The E350 was approximately ten minutes away from its destination, the start of the day's journey, when the crash occurred.

E350 Travel Speed

The statements given by the surviving occupants of the E350 were used to develop a time line for the day's activities. According to the survivors of the crash, the E350 was returning home when the collision occurred. Only one stop, of ten minutes duration, was reported for the return journey. No other stops or periods travelling significantly below the legal speed limit were reported. The two legs of the return travel were 145 km and 73 km in length, respectively. There is no evidence suggesting that traffic congestion would have impeded the progress of the E350 during its return journey. No other activities were identified that would have significantly impeded the progress of the E350 as it travelled home (e.g. construction zones, intersections, etc.). The time of the '911 call' was recorded on the police report. The 911 call was reportedly made immediately after the collision by the driver of the E350, making it a reasonably accurate time estimate for the collision event.

Available data indicates that the travel time of the E350 for the each leg of the return travel was 1.92 hours and 1.00 hour, respectively. The average speed calculated for this each leg was the 76 km/h and 73 km/h, respectively. Based on speed zone and chainage data provided by the Province, it was calculated that a vehicle travelling at the posted speed limit would require 1.51 hours to complete the first leg of the return trip and that it would have an average speed of 96 km/h. If travelling at the posted speed limit, the second leg of the trip would require 0.75 hours to complete with an average speed of 97 km/h. Therefore, it appears that the E350 was travelling at an *average speed* that was *less* than was *normally* permissible by law while returning to its destination – roughly 21 percent less for the first leg and 25 percent less for the second leg of the return travel.

The Provincial Motor Vehicle Act states, "No person shall drive a vehicle on a highway at a speed greater than is reasonable and prudent under the conditions and having regard to the actual and potential hazards then existing." It appears that the prevailing road and weather conditions at the time of the crash would have made the legal speed for the roadway less than the posted legal speed limit, given the wording of the Act. What the reasonable and prudent speed would have been at the time of the crash is beyond the scope of this report.

The driver of the E350 stated to police that his vehicle was travelling between 75 and 80 km/h at the time of the collision. The legal speed for the area was 100 km/h.

E350 Vehicle Control

The E350 was improperly positioned in the travel lane just before the driver lost control of the vehicle. Tire marks evidence, recorded by the RCMP, indicates that the right side wheels of the E350 were just to the *right* of the northbound white edge (fog) line and to the *right* of the asphalt portion of the shoulder when the vehicle was approximately 80 metres south of the impending point of impact with the oncoming tractor-semitrailer. The asphalt portion of the northbound shoulder is approximately 0.60 metres wide at this point, so roughly one third of the vehicle would have been to the right of the white edge line. In his statements to police, the driver stated that he thought the E350 was on the right shoulder so he steered to the left to return the vehicle to the travel lane. The driver said that the E350 did not respond when he subsequently steered to the right so he steered towards the left shoulder in an attempt to avoid a collision with the oncoming vehicle.

Tractor-Semitrailer Driver Background

The driver of the tractor-semitrailer had adequate driving qualifications to operate this type of vehicle. He held a valid commercial drivers Class 1-E licence at the time of the crash. A Class 1 licence allows the holder to operate all motor vehicles covered under the Provincial Motor Vehicle Act, with the exception of a motorcycle and vehicles equipped with air brake systems. An "E" endorsement on a driver's license permits a driver to operate vehicles equipped with air brake systems. A driver is required to meet medical standards to obtain and to hold a Provincial Class 1 license.

It appears that the driver of the tractor-semitrailer has significant experience driving tractor-semitrailers. In a statement to police, the driver said that he has been a truck driver for all of his working life. This claim could not be verified by documentation because the driver obtained his Class 1-E license before the Province began recording the date and year a driver is first certified. According to the driver's abstract, a record of a driver's last seven years of driving, the driver of the tractor-semitrailer has had one motor vehicle conviction. It was for failing to display a valid certification of inspection and it occurred almost seven years prior to the day of the crash. There is no record of this driver having any other driving offences, suspensions, or collisions in the Province. The driver told police that he has worked for his current employer for five to six years, driving a regular delivery route, and that he is accustomed to driving at night as part of his normal work. He also stated that he normally drove the tractor involved in the crash but that he sometimes drove other tractors for his employer. The site of the crash is on a section of highway that is a part of his regular delivery route.

Tractor-Semitrailer Driver Activities

Police obtained logbook records for the driver of the tractor-semitrailer. According to the logbook entries, the driver came on duty just over nine hours prior to the crash, after eleven hours of off-duty time. He drove approximately 350 km in total with two stops prior to crash. He had been driving for approximately 90 minutes since last stop when the crash occurred. There was approximately five hours left in the driver's work day at the time of the collision.

ENVIRONMENTAL FACTORS

Light Conditions

It was dark at the time of the collision. There was no artificial illumination to illuminate the roadway in the area of the collision, other than light from vehicle headlights.

Traffic

No other vehicles were reported in the immediate vicinity of the scene at the time of the collision. The first vehicles began arriving on scene minutes after the crash.

Weather

The police report recorded the weather condition for the time of the crash as being "sleet/hail/freezing rain". According to the Environment Canada, precipitation in the form of freezing rain was falling on the site at the time of the collision. A temperature of -0.6ºCelcius was recorded at a nearby weather monitoring station for this time. It had been precipitating for eleven hours prior to the crash. This precipitation for this period reportedly included snow, ice pellets, snow grains and freezing rain. The temperature when the precipitation began was -3.0ºCelcius.

Roadway

The collision occurred on a straight rural undivided two-lane, two-way section of an arterial highway. The point of impact is at the crest of a slight vertical curve. The yellow centerline was broken for southbound traffic only, beginning roughly 22 metres north of the point of impact and continuing south through the collision scene. The centerline was solid for northbound traffic throughout the collision scene. The southbound lane was 3.94 metres wide and the northbound lane was 3.75 metres wide, measuring from the centre of the solid yellow centreline. There is a two percent crown on the traveled portion of the roadway. The asphalt surface was in good condition. There are visible rutting of both travel lanes. According to the RCMP, the road surface was covered by 3 cm of snow and slush at the time of the collision. Lane markings were present but were partially obscured by the snow and slush. The depth of the snow and slush on the shoulders was not recorded.

Each shoulder of the roadway had a total width of roughly 3.00 metres. Over an 80 metre long section in the immediate area of the collision, the asphalt portion of the shoulder adjacent to the southbound lane had an average width of 0.77 metres. The remaining portion of this shoulder was gravel with a thin top coat of chipseal. The asphalt portion of the shoulder adjacent to the northbound lane had an average width of 0.64 metres. The remaining portion of this shoulder was gravel with a thin top coat of chipseal.

Road Maintenance Activities

Both travel lanes at the scene of the collision scene were plowed, salted and sanded full width three times in the six hour period immediately prior to the crash by the same plow and operator. The last of these three

passes was completed roughly one hour and twenty minutes prior to the crash. Salt application was reportedly 125 to 150 kg/km on the hills and curves and 75 kg/km on straight sections and significantly greater salt application on bridges and certain hills. At roughly one hour prior to the crash, an additional pass was made by the snowplow as it headed south to plow, salt and sand the centerline. The snowplow operator stated, in a detailed report of his work schedule on the night of the crash to the Provincial Department of Transportation, "… there was about an inch of wet snow (sleet) on the right side of the road and the temperature seemed favourable for melting, since it had stopped snowing, but freezing drizzle was still falling and it was foggy" while he completed the final pass on the highway. The temperature was reported by the plow operator as being -2 degrees Celsius with fog.

A grader plowed the shoulder adjacent to the southbound lane in the area of the collision approximately 5.6 hours before the crash. This same grader and operator plowed the shoulder adjacent to the northbound lanes in the area of the collision approximately 0.75 to 1.0 hour before the collision.

Shoulder of Northbound Lane

In a statement to police, the driver of the E350 said that he thought that his vehicle had travelled onto the shoulder as he neared the oncoming tractor-semitrailer. The driver of the E350 responded to this perceived shoulder incursion by steering to the left. The E350 subsequently returned to the northbound lane and then crossed the centreline before entering the path of the southbound tractor-semitrailer.

Tire mark measurements, recorded by the RCMP on the night of the crash, indicate that the right side tires of the E350 were travelling on the gravel/chipseal portion of this shoulder when the vehicle was roughly 80 metres south of the point of impact. Tire mark evidence also indicates that the E350 began to rotate (yaw) counter-clockwise a point roughly 60 metres south of the point of impact.

A fifteen metre long section of the shoulder adjacent to the northbound lane was examined and documented by Team investigators. This examined section began roughly 80 metres south of the point of impact and ended roughly 65 metres south of the point of impact. The average width of the asphalt portion of the shoulder was 0.60 metres along this section. The remaining portion of the shoulder, to the immediate right of the asphalt, was found to be eroded. This erosion passed through a thin chipseal top coat, used to stabilize the surface and limit erosion, into the gravel below. The drop from the surface of the asphalt to the gravel surface was measured at one metre increments along the asphalt edge. Drop-off values ranged from 57 mm (2 ¼") to 74 mm (2 7/8") along the examined section. The shape of the drop-off face in the examined sections ranged from 'vertical' to slightly 'rounded'. It should be noted that Team investigators measured the edge drop-off after melting had cleared the shoulder of snow and ice. RCMP scene photography, taken on the night of the crash, shows a build-up of snow against the face of the asphalt shoulder edge. The RCMP measured the edge drop at multiple locations along the east side of the road surface on the night of the crash. An edge drop of 50 mm (2'-0") to 60 mm (2'-3/8") was recorded in the RCMP Technical Traffic collision Investigation Report (TTCI), indicating that a build-up of snow and ice reduced the effective edge drop-off heights along the shoulder roughly 12 to 20 percent. The exact locations of the measured edge drop-off were not recorded. The investigating officer states that the measurement took place in the area where the tire track was found on

the shoulder of the roadway.

A study of pavement edge drops entitled "Effects of Pavement/Shoulder Drop-offs on Highway Safety: A Synthesis of Prior Research" was prepared for the Transportation Research Board by J.C. Glennon in 1985 in an attempt to develop practical guidelines for the treatment of pavement 'edge drops' when repaving roadways. This study suggests that:

- tolerable edge drop heights decrease with increasing vehicle speed and as the edge shape approaches vertical;
- successful recovery of a vehicle from a shoulder encroachment decreases as edge drop height and/or vehicle speed increase; and
- the exit angle and the return angle steered, traveled by the vehicle with respect to the pavement edge, is a factor affecting recovery success.

According to J.C. Glennon, on page 216 of "Roadway Defects and Tort Liability", many US roadway agencies have adopted a 76 mm (3") maximum allowable edge drop height. Roads with edge drop heights higher than this value would require maintenance to reduce the drop-off height.

Tire mark evidence indicates that the E350 was traveling with its right side wheels parallel to and immediately adjacent to the edge of the pavement for a minimum of 25 metres. The right front tire subsequently tracked over the edge of the asphalt in an apparent response to the driver steering to the left. By steering to the left, the driver increased the angle of the tire with respect to the edge of the asphalt. This steer angle could not be determined. The right rear tire travelled another 15 to 20 metres along the shoulder before tracking over the edge of the asphalt. During this travel, tire track evidence indicates that E350 rotated roughly 10 to 20 degrees counter-clockwise about the right rear wheel. The driver of the E350 stated that he steered to the right as the vehicle encroached into the oncoming lane and that the vehicle failed to respond to this steering input. The slippery road surface would have increased the risk of the driver losing control the E350 and of the vehicle failing to respond to steering inputs. According to the driver, the E350 was travelling approximately 80 km/h when the E350 traveled onto the shoulder of the northbound lane.

VEHICLE FACTORS

E350 Mechanical & Maintenance Condition

The E350 was examined after the collision Team investigators and by an RCMP investigator. Team investigators recorded tire pressures of 43 psi for the left front tire, 42 psi for the right front tire of the E350 and 34 psi for the left rear tire. The right rear tire was punctured and deflated. According to the 1998 Tire Guide, published by Tire Guides Inc., the recommended tire pressure for an E350 Super Van is 55 psi in the front tires and 80 psi in the rear tires. An RCMP collision investigator measured tread depth at four points across each tire of the E350. The average tread depth of the left front tire was 6 mm (min. depth 5 mm). The average tread depth of the right front tire was 6.5 mm (min. depth 6 mm). The average tread depth of the left rear tire was 5 mm (min. depth 4 mm). The average tread depth of the right rear tire was 5 mm (min. depth 4

mm). The tread wear bars are at a depth of 3 mm. The four tires used on the E350 are of the same make, model, size, service description and load range. According to the tire manufacturer's website, these tires had a tread depth of 13 mm at the time of manufacture. The Province of New Brunswick Official Vehicle Inspection Station Manual issued by the Department of Public Safety at page 2.10.2 requires rejection of a vehicle for inspection when: "The tire is worn so that less than 1.6 mm. (2/32") tread remains when measured in any two adjacent major grooves at three locations spaced approximately equally around the outside of the tire."

The E350 underwent an inspection by a certified mechanic after the crash. The front-end was found to be out-of-alignment, resulting in scalloping of the inside edge of the front tire treads. All four of the E350's 'all-season' tires were noted as being badly worn. Inadequate tire pressure was noted in the front tires and the left rear tire. The right rear tire had been punctured and deflated during the crash. The front upper and lower driver's side ball joints were found to be loose but, according to the mechanic's report, "not critically so". The right front wheel bearing was out of adjustment. The front brake shoes were found to be almost new and the rear brake shoes and drums were new. The left side rear brake self-adjuster cable was found to be broken. The left rear brake adjuster was not working and the brake was out of adjustment. The body condition was stated to be "getting bad". The front of the left rear quarter-panel was "rusted bad (holes)". He concluded that the E350 would not have passed a Provincial Motor Vehicle Safety Inspection (MVSI) given the problems that were identified. The E350 had passed a Provincial MVSI approximately two months before the crash, according to the MVSI sticker on the windshield of the vehicle.

Team investigators noted significant corrosion of the seams along the roof, especially at the rear of the vehicle. The seams along the right and rear edges of the roof failed as the rear and right sides of the E350 were torn from the vehicle.

Tractor & Semitrailer Mechanical & Maintenance Condition

The tractor had passed a Provincial MVSI approximately seven months before the crash, according to the MVSI sticker on the windshield of the vehicle. A sticker on the trailer indicates that the semitrailer had its last preventative maintenance roughly three months prior to the crash. The certified mechanic who inspected the tractor found no evidence of a mechanical problem or maintenance issue that would have contributed to this collision. The semitrailer was undamaged during the collision. This unit was put back in service.

CONCLUSIONS

It appears that both vehicles were *travelling below the legal speed limit* immediately prior to the crash.

Poor weather and a slippery road surface were major contributing factors in this crash. Despite being plowed and salted repeatedly during the hours leading up to the crash, the ongoing precipitation had accumulated a deposit of roughly 30 mm of slush and snow on the roadway. This snow/slush covering partially obscured the roadway markings, making it more difficult for drivers to maintain proper vehicle placement in their lanes.

Driver error appears to be a major contributing factor in the crash. The driver of the E350 oversteered to the left when the vehicle travelled onto the right shoulder. This steering manoeuvre initiated the counter-clockwise rotation that resulted in a loss of vehicle control, travel into the oncoming lane and a collision with an oncoming vehicle. The fact that the E350 was not properly positioned in its lane immediately prior to the driver losing control of the vehicle also indicates driver error, possibly as a result of driver fatigue. The driver of the E350 was approaching sixteen hours of on-duty activity when the collision took place. The last three hours of driving took place as weather and driving conditions steadily deteriorated - increasing the workload for the driver. It should also be noted that the crash occurred near midnight, which would be when most people would be asleep if they worked a normal work day.

Poor mechanical condition of the E350 resulting from *inadequate vehicle maintenance* appears to be a major contributing factor in the crash. There were multiple mechanical issues, ranging from loose front ball joints to a broken rear brake cable. The most critical maintenance issue with respect to this crash was that the E350 was equipped with misaligned, worn and improperly inflated *all-season tires*. The handling of the E350 on the slush and snow covered road would have been significant better had the vehicle been equipped with properly inflated and aligned winter tires that had adequate tread depths.