National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: February 2, 2009

In reply refer to: H-08-15 and H-01-6 and -7
(Reiterations)

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Between 1:58 a.m. and 1:59 a.m. on Sunday, October 16, 2005, an accident comprising two events occurred on Interstate Highway 94 (I-94) near Osseo, Wisconsin.[1] The first event was the single-vehicle rollover of a truck-tractor semitrailer combination unit. The second event occurred when a motorcoach collided with the wreckage from the first event.

About 7:30 p.m. on October 15, 2005, a 22-year-old truck driver departed Munster, Indiana, on an approximately 436-mile-long trip to Minneapolis, Minnesota, driving a truck-tractor semitrailer operated by Whole Foods Market, Inc. (Whole Foods). By 1:58 a.m., the truck driver had completed about 323 miles of his trip. The combination unit was traveling westbound on I-94 near milepost 85, at a police-estimated speed of 63 to 69 mph, when the unit departed the right-hand travel lane and paved shoulder at an approximate 3-degree angle. The unit left the roadway and entered the earthen, sloped roadside. The driver steered to the left, and the combination unit reentered the pavement and overturned onto its right side, sliding to a stop so that it blocked both westbound lanes and shoulders of I-94. The truck driver said that following the overturn, he turned off the ignition and was then thrown into the sleeper berth area by another impact.

About 3 hours before this accident, a group of marching band members from Chippewa High School left the University of Wisconsin near Whitewater on an approximately 225-mile-long trip back to Chippewa Falls, Wisconsin. The group was traveling in four motorcoaches and had completed about 195 miles of the return trip. The accident vehicle, a 1993 Motor Coach Industries DL-3 55-passenger-capacity motorcoach owned by

[1] For more information, see *Truck-Tractor Semitrailer Rollover and Motorcoach Collision With Overturned Truck, Interstate Highway 94, Near Osseo, Wisconsin, October 16, 2005*, Highway Accident Report NTSB/HAR-08/02 (Washington, DC: NTSB, 2008), available on the National Transportation Safety Board's website at <http://www.ntsb.gov/publictn/2008/HAR0802.pdf>.

Chippewa Trails, Inc., was in the lead. It was traveling westbound in the right-hand lane of I-94 at an estimated speed of between 64 and 78 mph when it collided with the bottom of the overturned combination unit about 1:59 a.m.

The motorcoach driver and four passengers were fatally injured. Thirty-five passengers received minor-to-serious injuries, and five passengers were not injured. The truck driver received minor injuries.

The National Transportation Safety Board determined that the probable cause of the truck-tractor semitrailer rollover, the precipitating event in the accident sequence, and the motorcoach's subsequent collision with the truck, was the truck driver's falling asleep at the wheel, drifting from the roadway, and losing control of his vehicle. The truck driver was most likely fatigued because he did not take full advantage of adequate rest opportunities provided to him during his off-duty time and, as a result, obtained inadequate and disrupted sleep prior to the accident. The motorcoach collided with the overturned truck because there were insufficient visual cues to permit the driver to identify the truck wreckage in time to avoid the collision.

Among the issues raised by this accident was the effectiveness of collision warning systems (CWS) in preventing and mitigating crashes. The Safety Board's investigation indicated that the second event in the Osseo accident sequence—the motorcoach's collision with the overturned truck—might have been mitigated, or possibly prevented, had the Osseo motorcoach been equipped with a CWS with active braking capability.

On the night of the accident, it would have been difficult for any driver to identify the overturned truck in the highway because there was no highway lighting in the vicinity, the truck's lights were off, and its retroreflective markings were invisible to approaching traffic. No skidmarks were found at the accident site, but examination of the indicator panel light bulbs in the motorcoach and motorcoach occupant recollections strongly indicate that the driver was applying the brakes at the time of the collision with the overturned truck. It is not known how long the motorcoach brakes were applied.

During the postaccident inspection, two of the six brakes on the motorcoach were found to be defective and out of adjustment. Both of these out-of-adjustment brakes were on the drive axle of the motorcoach and had automatic slack adjusters that dated to the motorcoach's original manufacture, indicating that they had been in use for over 12 years. The out-of-adjustment condition would have placed the motorcoach out of service, according to Commercial Vehicle Safety Alliance (CVSA) criteria.

At a 100-psi brake application, the motorcoach would have decelerated at a rate of 0.369 *g*, given the condition of the brakes. If all the brakes had been within adjustment and adjusted to achieve the maximum amount of brake force, the preimpact deceleration rate would have been 0.587 *g*. Assuming that the motorcoach was traveling at a speed of 70 mph and that the brakes were in the condition they were at the time of the accident, the motorcoach would have needed approximately 442 feet in which to come to a complete stop. If the brakes had been in ideal adjustment, the motorcoach would have needed approximately 278 feet in which to stop.

The Wisconsin Department of Transportation placed this motorcoach out of service 4 months before the accident because the drive axle brakes were out of adjustment. The motorcoach company attempted to solve the problem by manually adjusting the automatic slack adjusters. However, automatic adjusters should be manually adjusted only as a temporary measure to correct the adjustment in an emergency, because this procedure usually does not fix the underlying problem, making it probable that the brakes will soon be out of adjustment again. In this case, the motorcoach's brakes most likely went out of adjustment shortly after the manual adjustment and remained so until the accident. The Safety Board concludes that improper maintenance of the brake system on the part of the motor carrier Chippewa Trails resulted in two out-of-adjustment drive axle brakes, which diminished the braking force available to slow the motorcoach, but this condition likely did not contribute to the accident. The Safety Board is concerned that brakes with automatic slack adjusters are still being manually adjusted. Drivers and motor carriers need to be reminded that automatic slack adjusters should only be manually adjusted at installation or under emergency conditions and that manually adjusting the slack adjusters does not fix the underlying problem with the brakes. Therefore, the Safety Board will draft an article for inclusion in the CVSA's quarterly publication *Guardian* on the dangers associated with manually adjusting automatic slack adjusters.

CWSs are designed to warn the driver of slowed or stopped objects in the vehicle's forward path. Commercially available systems sound an initial alert at 350 feet of the detected obstacle. Additional alerts are given as the time to collision decreases. For a stationary or stopped vehicle ahead, the highest warning level is given within 220 feet of the object.

Table 1 shows the change in speed that the motorcoach could have achieved if a CWS warning had been given and the driver had begun to take action at 220 feet. The table shows the impact speeds possible given a reaction time of 1.5 seconds;[2] a brake rise time of 0.5 second; and an initial motorcoach speed of 70 mph, based on the Wisconsin State Patrol's estimate of the motorcoach's speed. The calculations used to create the table also considered the condition of the brakes on the motorcoach at the time of the accident and brakes in ideal condition.

Table 1. Estimated change in Osseo motorcoach's velocity, assuming CWS warning was given and heeded at 220 feet.

Driver's reaction time (seconds)	Brake rise time (seconds)	Brake condition	Initial speed (mph)	Final speed (mph)	Speed reduction (mph)
1.5	0.5	At the time of the accident	70.0	68.8	1.2
1.5	0.5	Ideal	70.0	68.1	1.9

As can be seen, the reduction in speed possible, given the factors that must be considered, would have been less than 2 mph, even had the Osseo motorcoach's brakes been in ideal condition.

[2] M. Green, "How Long Does It Take To Stop? Methodological Analysis of Driver Perception-Brake Times," *Transportation Human Factors* 2(3), (2000): 195-216.

If the Osseo motorcoach driver had been cued and had responded to an initial CWS warning at 350 feet rather than 220 feet, the possible reduction in speed would have been greater. (See table 2.)

Table 2. Estimated change in Osseo motorcoach's velocity, assuming CWS warning was given and heeded at 350 feet.

Driver's reaction time (seconds)	Brake rise time (seconds)	Brake condition	Initial speed (mph)	Final speed (mph)	Speed reduction (mph)
1.5	0.5	At the time of the accident	70.0	57.5	12.5
1.5	0.5	Ideal	70.0	48.5	21.5

Nevertheless, given the existing condition of the Osseo motorcoach's brakes, the impact speed could still have been as high as 57.5 mph, even with a 350-foot warning distance. This is mainly because the CWS only alerts the driver to the hazard; the driver still needs time in which to detect and react to the hazard.

Some CWSs are equipped with an automatic braking system that will actively brake the vehicle if a collision is imminent. To date, active braking has not been coupled with CWS for commercial vehicles. Instead, the active safety systems are part of the adaptive cruise control (ACC). Hypothetically, if the Osseo motorcoach had been equipped with a CWS that included an active braking system, the driver's reaction time would not have been a factor—only the brake rise time would have contributed to the distance traveled before maximum braking was achieved. (See table 3.)

Table 3. Estimated change in Osseo motorcoach's velocity, assuming CWS warning was given at 350 feet and CWS had active braking system.

Brake rise time (seconds)	Brake condition	Initial speed (mph)	Final speed (mph)	Speed reduction (mph)
0.5	At the time of the accident	70.0	40.0	30.0
0.5	Ideal	70.0	0.0	70.0

In this circumstance, with an active braking activation at 350 feet, if the Osseo motorcoach's brakes had been in ideal condition, the motorcoach would have had sufficient distance to stop before impact, and the second event of the Osseo accident sequence—which resulted in multiple fatalities—would have been prevented. Therefore, the Safety Board concludes that a CWS with active braking might have prevented, or at least lessened the severity of, the Osseo motorcoach's impact with the overturned truck.

CWS technology could also have assisted the driver in another accident about which the Safety Board has recently issued its findings—the Lake Butler, Florida, accident.[3] In this accident, a tractor-trailer collided with a Pontiac Bonneville and a school bus, killing all seven occupants of the passenger car and injuring the nine bus passengers and bus driver. This accident occurred on January 25, 2006, at 3:25 p.m. Reconstruction of the truck driver's work/rest history showed the truck's Qualcomm[4] signal was lost at 8:23 p.m. on January 23 and resumed about 9 hours later, the next morning, January 24, about 34 hours before the accident. This was the last opportunity the driver had for an extended sleep period before the accident. With the exceptions of a 2-hour sleep period beginning around 1:00 a.m. on January 25 and 1 to 2 hours of rest a few hours later, about 7:00 a.m., the truck driver was awake for about 30 hours during this 34-hour period. The Safety Board determined that the probable cause of the accident was the failure of the truck driver to maintain alertness due to fatigue from obtaining inadequate rest. Contributing to the accident was the failure of the motor carrier to exercise proper oversight of the driver's hours of service.

Although it is probable that the truck driver whose truck collided with the passenger car and the school bus in that accident was asleep, or at least driving in a state of reduced alertness due to fatigue, a CWS could have alerted the truck driver that vehicles were in the roadway ahead. Analysis shows that had a hard brake application been made to the Lake Butler combination unit at a speed of 60 mph, it would have been able to come to a complete stop in approximately 265 feet. Thus, had the Lake Butler truck been equipped with a system that sounded a warning at 350 feet of detection and had the driver been alert enough to comprehend a CWS alarm notifying him that the school bus and passenger car were stopped ahead, he could have stopped his vehicle in 265 feet. This would have left the driver with 85 feet, which he would have needed to perceive and react to the warning. For the truck traveling at 60 mph, 85 feet would have afforded about 1 second of reaction time. Thus, a CWS might not have provided the fatigued or asleep Lake Butler driver with sufficient time to react to the warning, brake the vehicle, and prevent the accident, but it might have provided enough time for him to react, brake, and lessen the severity of the accident, or enough time to avoid the collision through steering inputs.

In 1995, the Safety Board investigated a multiple-vehicle rear-end collision that occurred during localized fog on Interstate 40 near Menifee, Arkansas.[5] As a lead vehicle entered the fog, it slowed from 65 mph to between 35 and 40 mph; then, it was struck in the rear. Subsequent collisions occurred as vehicles drove into the wreckage area at speeds varying from 15 to 60 mph. Eight loaded truck-tractor semitrailer combination units and one light-duty delivery van were involved. Three truck drivers, one passenger, and the van driver were killed. One truck driver received a minor injury and four truck drivers were not injured. As a result, the Safety

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[3] National Transportation Safety Board, *Rear-End Chain-Reaction Collision, State Route 121, Near Lake Butler, Florida, January 25, 2006*, Highway Accident Brief NTSB/HAB-08/05 (Washington, DC: NTSB, 2008).

[4] The Qualcomm Qtracs system uses a transmitter/receiver that allows objects to be continually tracked through global positioning satellites. The system identifies the location of each truck every hour, as well as the corresponding time and date and whether the truck engine is running.

[5] National Transportation Safety Board, *Multiple-Vehicle Collision with Fire During Fog Near Milepost 118 on Interstate 40, Menifee, Arkansas, on January 9, 1995, Special Investigation of Collision Warning Technology*, Highway Accident Report NTSB/HAR-95/03 (Washington, DC: NTSB, 1995).

Board issued Safety Recommendation H-95-44 to the U.S. Department of Transportation (USDOT), asking it to do the following:

> Sponsor, in cooperation with the Intelligent Transportation Society of America, fleet testing of collision warning technology through partnership projects with the commercial carrier industry. Incorporate testing results into demonstration and training programs to educate the potential end-users of the systems.

At the time the recommendation was issued, the USDOT had no plans for conducting operational testing of CWS. The Safety Board classified Safety Recommendation H-95-44 "Closed—Unacceptable Action" in 1999, based on the length of time that had elapsed without positive result since the recommendation was issued.

The Safety Board published a special investigation report concerning CWSs in 2001[6] that contained the following recommendations to the USDOT:

> Complete rulemaking on adaptive cruise control and collision warning system performance standards for new commercial vehicles. At a minimum, these standards should address obstacle detection distance, timing of alerts, and human factors guidelines, such as the mode and type of warning. (H-01-6)
>
> After promulgating performance standards for collision warning systems for commercial vehicles, require that all new commercial vehicles be equipped with a collision warning system. (H-01-7)

Although the recommendations were originally issued to the USDOT, further communication with the USDOT indicated that the National Highway Traffic Safety Administration (NHTSA) was the most appropriate agency to implement the recommendations.

The Safety Board reiterated Safety Recommendations H-01-6 and -7 to NHTSA as a result of its investigation of a 2003 multivehicle collision at a toll plaza near Hampshire, Illinois.[7] The Board determined that the probable cause was a truck driver who was driving too fast for conditions and failed to slow for traffic. The Board concluded that the driver did not detect the slowing traffic ahead of his vehicle and that, had his vehicle been equipped with a CWS, the accident might have been prevented.

In its responses to the Safety Board concerning these recommendations, NHTSA reported that the USDOT had established the intelligent vehicle initiative and was undertaking studies to collect the field operational test data needed to establish performance standards. These studies have been completed.[8] Further, in 2005, the Federal Motor Carrier Safety Administration

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[6] National Transportation Safety Board, *Vehicle- and Infrastructure-based Technology for the Prevention of Rear-End Collisions*, Special Investigation Report NTSB/SIR-01/01 (Washington, DC: NTSB, 2001).

[7] National Transportation Safety Board, *Multivehicle Collision on Interstate 90, Hampshire-Marengo Toll Plaza, Near Hampshire, Illinois, October 1, 2003*, Highway Accident Report HAR-06/03 (Washington, DC: NTSB, 2006).

[8] (a) Volvo Trucks North America, Inc., *Volvo Trucks Field Operational Evaluation of Advanced Safety Systems for Heavy Truck Tractors*, prepared for USDOT/FHWA, Cooperative Agreement No. DTFH61-99-X-00102 (2005). (b) Battelle, *Final Report Evaluation of the Volvo Intelligent Vehicle Initiative Field Operational Test*

(FMCSA) published voluntary performance standards for CWSs for commercial vehicles, which address functional, data, hardware and software, driver vehicle interface, and maintenance and support requirements.[9]

The Safety Board added the prevention of rear-end collisions through the use of CWSs and ACC to its Most Wanted List of Transportation Safety Improvements in November 2007. NHTSA has been working consistently, though slowly, on this issue. It has recently published its report on the field operational test conducted by Battelle and Volvo Trucks North America, showing a reduction in rear-end crashes.[10] The Safety Board has not received any information on NHTSA's interpretation of the commercial vehicle testing or a timeline for future NHTSA actions to mandate use of this technology. Rulemaking as requested in Safety Recommendation H-01-6 is needed to ensure uniformity of system performance standards, such as obstacle detection, timing of alerts, and human factors guidelines on commercial vehicles. Safety Recommendations H-01-6 and -7 are currently classified "Open—Acceptable Response."

A CWS with active braking might have prevented or lessened the severity of the impacts in the Osseo and Lake Butler accidents. In both cases, even if the driver had not reacted to the CWS, either because he was asleep or driving while impaired from fatigue (Lake Butler) or because he did not see the object in the roadway (Osseo), a system with active braking could have stopped or slowed the vehicle before it collided with the stationary vehicle in its path. If a collision is deemed imminent, an active braking CWS does not wait for the driver to react. Braking is applied automatically in this critical situation to reduce the severity of the impending collision.

It should be noted that the Safety Board is aware of some limitations of CWS with active braking. For instance, a radar system can detect the speed differential between two moving vehicles, but it has more difficulty distinguishing a stopped object, such as debris in the road or a stalled vehicle. Industry representatives have indicated that they are cautiously moving ahead in this area of technology.

CWSs alert the driver to hazardous situations and often require the driver to take evasive action, such as hard braking or rapid steering. In the case of a CWS with active braking, application of maximum braking occurs when a collision is imminent. When evasive actions are taken either by the driver or the system (such as through active braking), the stability of the vehicle is critical, especially for commercial vehicles, because they are typically large and heavy, and have relatively high centers of gravity. Such vehicles may become unstable when hard braking is applied in slippery conditions or if the driver steers rapidly to avoid a collision. Actions taken to avoid a rear-impact collision or a collision with a fixed object may result in a directional loss of control of the vehicle or in a rollover, which could be even more hazardous than the collision the driver is attempting to avoid. Therefore, the Safety Board concludes that

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Version 1.3 (2007), prepared for USDOT/FHWA, Cooperative Agreement DTFH61-96-C-00077, task order 7721, <www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14352_files>, accessed January 22, 2008.

[9] Federal Motor Carrier Safety Administration, *Concept of Operations and Voluntary Operational Requirements for Automated Cruise Control/Collision Warning Systems (ACC/CWS) On-board Commercial Motor Vehicles*, FMCSA-MCRR-05-007 (Washington, DC: FMCSA, 2005).

[10] Volvo (2005) and Battelle (2007).

because commercial vehicles, which typically have high centers of gravity, are prone to become unstable when they are hard-braked or steered suddenly to avoid a collision, CWS-equipped commercial vehicles should also be equipped with an electronic stability control (ESC) system addressing both roll and directional stability.

Both active braking and ESC technologies represent opportunities for significant enhancement of CWSs' capabilities to prevent (or mitigate) commercial vehicle accidents. Therefore, the Safety Board recommends that NHTSA determine whether equipping commercial vehicles with CWSs with active braking and ESC systems will reduce commercial vehicle accidents. If these technologies are determined to be effective in reducing accidents, NHTSA should require their use on commercial vehicles. In addition, the Safety Board reiterates Safety Recommendations H-01-6 and -7 to NHTSA, which recommend that NHTSA complete rulemaking on ACC and CWS performance standards for new commercial vehicles (H-01-6), and once the CWS standards have been developed, that NHTSA require that all new commercial vehicles be equipped with a CWS (H-01-7).

Therefore, the National Transportation Safety Board makes the following safety recommendation to the National Highway Traffic Safety Administration:

> Determine whether equipping commercial vehicles with collision warning systems with active braking and electronic stability control systems will reduce commercial vehicle accidents. If these technologies are determined to be effective in reducing accidents, require their use on commercial vehicles. (H-08-15)

Further, the National Transportation Safety Board reiterates the following previously issued safety recommendations to the National Highway Traffic Safety Administration:

> Complete rulemaking on adaptive cruise control and collision warning system performance standards for new commercial vehicles. At a minimum, these standards should address obstacle detection distance, timing of alerts, and human factors guidelines, such as the mode and type of warning. (H-01-6)

> After promulgating performance standards for collision warning systems for commercial vehicles, require that all new commercial vehicles be equipped with a collision warning system. (H-01-7)

The Safety Board also issued two safety recommendations to the Federal Motor Carrier Safety Administration and one safety recommendation to Whole Foods Market, Inc.

In response to the recommendations in this letter, please refer to Safety Recommendations H-08-15 and H-01-6 and -7. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our Tumbleweed secure mailbox procedures. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Acting Chairman ROSENKER and Members HERSMAN, HIGGINS, SUMWALT, and CHEALANDER concurred in these recommendations. Member HIGGINS filed a concurring statement, which is attached to the highway accident report.

[Original Signed]

By: Mark V. Rosenker
Acting Chairman