NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering

Washington, D.C. 20594

May 22, 2012

Vehicle Dynamics Study

NTSB Case Number:

HWY-11-MH-005

A. ACCIDENT

LOCATION:	Interstate 95 (I-95) New England Thruway, at Mile Marker 3.2, in Westchester County, New York
VEHICLE:	1999 Prevost H3-45 Motorcoach
OPERATOR:	World Wide Travel of Greater New York, Ltd.
DATE:	March 12, 2011
TIME:	5:37 a.m. EST

B. AUTHOR

Dan T. Horak
NTSB
(202) 314-6664
dan.horak@ntsb.gov

C. ACCIDENT SUMMARY

On March 12, 2011, at about 5:38 a.m., a 1999 Prevost 56-passenger motorcoach, operated by World Wide Travel of Greater New York, headquartered in Brooklyn, New York, was traveling southbound on Interstate 95 near New York, New York. The motorcoach, en route from the Mohegan Sun Casino in Uncasville, Connecticut, to New York City, was carrying 32 passengers. While in the vicinity of mile marker 3.2, the motorcoach departed from the travel lanes to the right, driving over the rumble strips on the right shoulder edge. The motorcoach then crossed over the 10-foot-wide paved shoulder and struck a strong-post W-beam guardrail, traveling about 480 feet alongside and on the guardrail, before finally overturning 90° onto its right side and flattening the guardrail.

The front of the vehicle subsequently collided with an overhead highway sign support structure consisting of two vertical 8-inch-diameter steel tubular poles linked by cross-beam diagonal metal supports. The vehicle's front roof also collided with a steel electrical box mounted to the highway sign support structure. After the motorcoach struck this support structure and steel electrical box at the motorcoach windshield, the two poles making up the structure entered the passenger compartment along the base of the passenger windows as the motorcoach slid forward. The impact resulted in the vehicle's roof panel being torn from the bus body for almost the entire length of the bus.

As a result of this accident, 15 passengers were killed, 17 passengers received serious to minor injuries, and the bus driver received minor injuries.

D. DETAILS OF INVESTIGATION

The purpose of this investigation was to estimate the effect of the motorcoach speed on its propensity to roll over due to its impact with the 24 inches high roadside barrier. The speed of the motorcoach at the time of initial contact was recorded by the engine ECM as 64 mph. The motorcoach dimensions, CG height and inertial properties were accurately estimated based on manufacturer's data and the known number of passengers. This information was used to generate a TruckSim vehicle dynamics model of the vehicle and the road. The road model included the 5 inches high angled curb.

The roadside barrier was modeled as consisting of elastic springs that generated lateral forces on the motorcoach at the contact points between them. The springs were characterized by stiffness and the maximum lateral force that they could apply on the vehicle. It was not possible and practical to develop an accurate model of the forces developed by the roadside barrier as it was being flattened by the moving motorcoach. Therefore, the approach was to investigate the effects of various values of barrier stiffness and the maximum force it could apply and set their values high enough so that the motorcoach rolled over in simulated collisions with the barrier when its initial speed was 64 mph or higher. Further increases of stiffness and maximum force had only limited effect on the dynamics of the motorcoach as it collided with the barrier.

Once the parameters of the barrier were selected, the simulated motorcoach behaved similarly to the accident vehicle. Following the initial impact, it was slightly deflected but then impacted the barrier again, started rolling to the right, and eventually rolled 90 degrees and ended up on its right side. Since there was no information on the steering actions of the driver, the steering wheel angle was fixed at 0 degrees during the simulations.

Table 1 summarizes the rollover propensity of the motorcoach as a function of its longitudinal speed when it initially impacted the roadside barrier. The motorcoach rolls over at speeds above 62 mph, as indicated by the maximum roll angle of 90 degrees. When the maximum tabulated roll angle is less than 90 degrees, the motorcoach eventually returns to its upright position (i.e., roll angle of 0 degrees). At the speed of 55 mph, for example, the maximum roll angle of the motorcoach is 27 degrees and it is

only 20 degrees at the speed of 50 mph. This indicates that at or below the posted speed limit, the rollover and collision with the pole might have been preventable by steering the motorcoach away from the barrier after it returned to the upright position.

Table 1 Motorcoach Rollover Propensity vs. Speed at Time of Initial Barrier Impact (the tabulated maximum roll angles are of the suspended mass)

Motorcoach Speed (mph)	Maximum Roll Angle (degrees)
50 (posted speed limit)	**20**
55	**27**
60	**41**
61	**44**
62	**90 (rollover)**
63	**90 (rollover)**
64 (recorded by ECM)	**90 (rollover)**

TruckSim simulations compute detailed time histories of all the motions of the simulated vehicle. Simulations used in this study were used to output tables of positions, accelerations, orientation angles and angular accelerations of the suspended mass of the motorcoach. These tables are intended for use as inputs to simulations that can estimate occupant motions during this accident.

E. Conclusions

Simulations indicated that the motorcoach speed was only slightly above the value beyond which rollover was unavoidable. A speed lower by a few mph could have resulted in the motorcoach returning to its upright position, making it possible to steer it away from the barrier and the pole.

These simulations should not be viewed as exact representations of this accident. The differences between the simulations and the accident event are due to the unknown steering by the driver after the initial impact with the barrier, the limited information on the speed of the motorcoach as it was moving while in contact with the barrier, and the unavoidable inaccuracies in modeling the lateral forces between the barrier and the motorcoach as the barrier was being contacted and flattened by the moving motorcoach.