C2 Minivan, School Bus, and Pickup Crash Analysis: A Case Study

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After attending this presentation, attendees will learn how post collision spin in yaw affects calculations of dynamics of vehicles and of occupants. They will also follow calculations for force-velocity- displacement during impact with short time duration.

Overly simplified and incomplete analyses can lead to significant errors in an accident reconstruction. This presentation will impact the forensic science community by demonstrating how some, if not most, accident reconstruction software either does not include effects of spin at all or they do so with questionable accuracy of the polar moment of inertia. Slow spins might be satisfactorily handled by applying an appropriate averaging method to calculate an effective drag factor. Fast spins are better handled by calculations based on numerical integrations with short time steps.

An eastbound minivan "blew" through a stop sign and crashed into the right side of a southwest bound school bus in an intersection with unrestricted visibility. The school bus went out of control, continued moving southwest while rotating clockwise such that its rear end occupied most of the opposite lane. A northeast bound pickup crashed into the rear left side of the school bus. The school bus came to rest on its left side in the northeast bound lane southwest from the intersection facing southwest. Its rear axle was separated, and it came to rest near the rear end of the school bus. The pickup came to rest upright on the northeast bound shoulder facing northwest with its front end beneath the school bus left side. The minivan came to rest upright in the southwest bound lane facing northeast about 1½ car lengths southwest from the intersection. The movements of the minivan and of unbelted front seat occupants during collision are desired in order to determine who was the driver.

As in most crash analyses, the first interval of motion to be analyzed is the last interval in time to occur. This is from the instant of separation between the minivan and the school bus until the minivan reached its final rest. The initial conditions are determined for this interval which are equated to the final conditions for the preceding interval. The collision becomes the next interval of motion to be analyzed which is from the instant of initial contact to the instant of separation. The vehicles are assumed to be approximately following their respective roadways before collision, but the speeds are initially unknown and must be determined. Unbelted occupants will travel in the same direction at the same speed as that of the minivan at the instant of initial contact with the school bus. The minivan c.m. (center of mass) velocity will abruptly decelerate in its original travel direction while it accelerates in the original travel direction of the school bus; the relative angle between which is called the PDOF (principal direction of force). Coincidentally, the minivan orientation will undergo an abrupt acceleration in a clockwise spin in yaw. This means that initially all points forward from the c.m. will move to the right relative to the c.m. while the c.m. itself moves to the right from its original travel direction. Unbelted occupants will thus strike deploying airbags and parts of the dash or firewall that had been to their left prior to the collision. Deployed airbags will restrict the occupant's torso motion toward the dash in front of them, but only slightly affect motion toward the left side of the vehicle. Legs and lower abdomen motion will experience only little effect from the airbags until stretching is induced between body parts.

Spin in yaw during the collision and post-collision both acted to make unbelted front seat occupants move to the left relative to their positions prior to the collision. The unbelted passenger moved toward the driver's seat, and the unbelted driver moved toward the driver's door which according to witnesses flew open during the collision.

Engineering analyses also show that the second crash with the pickup was several times more severe than the first crash with the minivan. Thus, the second crash with the pickup most probably caused the severe injuries and fatalities to the students on the school bus. Post- collision spinning in yaw by the minivan accounted for about 2.5 times as much kinetic energy as that due to linear translation. Thus, any analyses that do not account for the spinning effects are subject to significant errors in the post collision dynamics.

Accident Reconstruction, Post Collision Spin, Relative Motion of Vehicle Occupants

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