## ERRORS IN ACCIDENT RECONSTRUCTION

-- as seen by Joseph E. Badger

It has recently come to my attention that some police academies – for whatever reason(s) – limit their instruction regarding accident investigation to a two-hour segment on how to fill out the crash report form. Another statistic I heard was that – at least for the aforementioned recruit school – that out of approximately 100 basic students only 14-20 take a 5-day crash investigation course.

Trust me on this, even a 5-day course – nay, not even a 5-week course – makes a qualified accident reconstructionist. Neither does a 5-year physics or engineering course. It takes not only training in the mathematics and engineering principles involved, but also years of practical hands-on, in-the-field experience.

Some agencies mandate its officers to NOT take photographs unless there is a fatality. Yet we occasionally see reports of fatalities and serious bodily injury where only the standard crash report is completed. No photographs, no measurements.

We find that some officers, including those who have had no more than a couple of weeks of reconstruction instruction, are holding themselves out as accident reconstruction experts yet make grievous blunders. Sometimes without evening realizing it.

## YAWS

For instance, just because a tire mark is curved doesn't necessarily mean it is a yaw mark. (And while I'm on the subject, I'm forever seeing police reports and diagrams that mention "yawl" marks. A yawl is a two-masted fore-and-aft-rigged sailing vessel similar to a ketch but having a smaller jigger mast stepped abaft the rudder. Or it's a ship's small boat, crewed by rowers. *American Heritage Dictionary.*)

A yaw, on the other hand, is a whole other subject, described in Al Baxter's *Accident Investigation and Reconstruction Terminology* as "The rotational or oscillatory movement of an object about its vertical axis; a movement about the z-axis of the vehicle axis system." Yaws often occur when a driver makes a hurried steering maneuver (a) to avoid an object in the road or (b) to remain on the pavement while entering a curve too fast, or (c) while overcorrecting a previous situation. "A yaw mark is that physical mark on the roadway caused by the rotating tires of a vehicle slipping in a direction parallel to the axle of the wheel during a maximum rate change of direction (turn)."

Speed determinations may indeed be made by correctly measuring genuine yaw marks; however, if those are merely spin marks, created by one vehicle that is impacted by another vehicle, then it is inappropriate to use equations that assume the mark to be a real yaw. And for heaven's sake, you don't have to measure the length of a yaw mark –

unless you simply want to know how long it is. The length has no bearing in critical speed formulae.

For the critical speed equation to work, the vehicle in question must be both rolling in one direction and sliding in another; however one "expert" used a supposed yaw mark and came up with over 90 mph, but the front tires were both flat and the front wheels were crushed, not allowing them to roll.

## FLIPS, VAULTS AND FALLS

In one respect the yaw is a like a vault or flip – circumstances that may befall vehicles in certain accident scenarios. That is, a speed calculation determined from that action is final. Whatever the vehicle does subsequently doesn't matter. It can skid, crash into a tree, or rollover. Once you've computed the yaw (or fall or vault or flip) speed you must not combine the speed <u>following</u> any of those events with the speed calculated <u>in</u> the event. You may – and should – use data from circumstances following the yaw, fall, or vault to confirm the originally calculated speed. If a collision or skid occurs prior to a yaw (etc.), then fine, speeds may be combined.

In one case, the reconist actually ***added*** two airborne speeds together. Go ahead and calculate both (hopefully the second one will be less than the first one) but don't add, subtract, or combine them. Use the answer from the equation in which you have the best data.

## MISINTEPRETING EVIDENCE

Be careful when taking scene photos that you don't inadvertently create evidence that isn't there. Watch those shadows! Likewise, be careful when examining photographs taken at accident scenes. Shadows created by overhead utility lines have an uncanny way of appearing as yaws or curved tire marks on the pavement.

## COMBINING SPEEDS

Speaking of combining speeds, there's a particular way of doing that. "Combining" doesn't mean "adding." If a car, say, skids 50 feet on concrete, 25 feet on blacktop, then 40 feet on grass, and smashes into a 75-year-old oak tree, there's a reasonably easy way to determine how fast the car was going when the driver first applied the brakes. The not-quite-so simple part involves first a crush analysis, then backing things up wherein you compute the speed for each surface. But you don't add all those speeds together. It's like Pythagoras Plus. Square all the speeds, add those, then take the square root of the answer. That way, 36 mph and 23 mph and 24 mph and 20 mph doesn't equal 103 mph, it's 52 mph and some change.

In a motorcycle case, a Ph.D. testified that a motorcyclist's speed, based upon post-impact throw distance, was 30 to 35 mph. He then said that the speed of the motorcycle,

based upon post-impact sliding distance, was 30 to 35. Sounds great, right? No! He combined them and said that the speed of the motorcycle was approximately 46 mph.

## INCORRECT SCIENCE

Acceleration rates are interesting. Car magazines print data regarding how fast certain cars can accelerate from 0 to 60, or the fastest speed attainable in a quarter-mile. Be cautious using these data in intersection collisions. There's the case where an opposing expert used an acceleration rate for 0 to 10 mph to show how quickly it could accelerate from 55 to 65 mph.

## DRAG FACTORS

Much of the time, assigning a precise value for drag factor isn't necessary. In the overall scheme of things, there isn't a lot of difference between the speeds generated from a .65 drag factor as with a .75 drag factor. For one reason, you end up taking the square root of the value. As an example, if a car skids to a stop in 100 feet on a .65 surface, the slide-to-stop speed is around 44 mph. On a .75 surface, everything else being equal, the speed equates to about 47 mph. What's three miles an hour among friends?

Furthermore, if you perform a skid test (whether with a drag sled, bumper gun, or electronic accelerometer) on the surface where the accident skidding occurred and in the direction the skidding happened, you should not add or subtract the grade. The grade was "built in" when you completed the test.

But drag factors do make a difference when tractor-semitrailers are involved, and especially when bob-tail units skid. ("Bob-tails," by the way, are truck-tractors designed to pull semitrailers but which are traveling without one.) On a roadway surface that may be .80 for a car, may be only .20 for a bob-tail tractor. And for that same 100-foot skid the respective speeds would be 48 mph versus 24 mph.

Drag factors are different for heavy trucks for a number of reasons, including weight shift (no, not load shift, that's something else), tire pressure, and the idiosyncrasies inherent with air brake systems.

This was an actual case: An officer used a 0.7 for friction, because "all streets in the city have a 0.7." He then adjusted for the 0.03 grade. Next, he checked the striking vehicle and discovered that the rear brakes did not function. He determined the speed of the striking vehicle by using momentum, then combined the impact speed with the speed loss from pre-collision skid marks. He used the full friction (0.73) for both pre- and post-collision movement of both vehicles, even though he had determined that one vehicle did not have working brakes. He used the 0.73 for the post-impact movement of the other vehicle, even though it was going downhill on grass, with only one wheel locked from damage.

Similarly, there are officers who use the full drag factor – meaning 100% braking – for vehicles that are free-rolling from impact to final rest.

Then there are some who mishandle drag sleds (usually by pulling them way too slowly) and come up with drag factors of 1.20 on level blacktop surfaces. This may approach possibility on some brand new asphalt that has bits of embedded glass particles and a sled with really soft tire material, but beware anytime you come up with a factor of .95 or more.

**COMPUTER PROGRAMS**

Beware also of accident reconstructionists bearing software. Paraphrasing Charles Grosvenor, former Representative from Ohio, "Computers won't lie, but liars will compute." I'm acquainted with two engineers who on separate occasions used a particular program (with which I've had years of experience and special training), one to calculate that a vehicle was astraddle the centerline during a collision; the other who figured how two women pushed a car up a grade at over 10 miles an hour.

And I've seen police officers who have used sophisticated mapping and measuring software to calculate the departure angles of cars in intersection crashes based on the center of mass of the cars at final rest, rather than the angle at separation.

**ROUNDING DOWN**

They always tell you to "give the benefit of doubt to the violator," but wait, you don't need to give them the farm. Truncating the energy equation is one way to do that. Sure, round down, but wait till you're finished, then round down the final answer.

**MIXING UNITS**

This sort of error crops up in measuring critical speed scuffs or curved roadways. If you measure a chord in feet, measure the middle ordinate in feet also, not inches. Likewise, if you're dealing in feet per second, don't use miles an hour as formula input. Imperial and metric don't mix very well either.

Don't mix prices with pounds. This actually happened when an engineer checked a NADA book for the weight of a used vehicle and wrote down the retail price of a pickup truck instead of its weight. Then he entered that number in the momentum formula.

**BOTTOM LINE**

Before you hold yourself out as an accident reconstructionist, be sure you can back up your methodology. Such support is not simply saying you read it someplace or some teacher told you.

(About the author: Joseph E. Badger is an internationally known accident reconstructionist who has had over 100 articles published in such periodicals as *Law and Order* magazine, *Accident Reconstruction Journal*, *Accident Investigation Quarterly*, and others. Having retired after 20 years with the Indiana State Police, Mr. Badger resides in Bloomington, Indiana.)