

MOTOR VEHICLE HANDLING AS IT RELATES TO VEHICLE COLLISIONS

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Motor vehicle handling is a crucial factor in the engineering discipline of accident reconstruction, in particular vehicle dynamics during a crash event. Vehicle handling is a control process in which the driver, the vehicle and the roadway form a closed loop. It is the ability to transmit drive, steering and braking forces as a result of driver input, to the road, through the tires. Handling usually refers to the vehicle properties that allow a driver to negotiate manoeuvres successfully.

The tires, brakes, steering and suspension systems are the most critical variables for vehicle handling and hence accident avoidance dynamics, as follows:

- Tires are the primary source of the forces and torques, which provide the control, and stability of the vehicle.
- The braking system utilizes friction to slow the vehicle by changing the kinetic energy into thermal energy.
- The steering system produces forces between the tire and the road that guide the vehicle in the desired path and contribute to the directional stability of the vehicle at higher speeds.
- The wheel suspension system components and geometry position the wheels and their movement relative to the body and control the transmission of forces between the tires, wheels and the vehicle to optimize handling and ride dynamics.

A complete or partial failure of any of the above must be identified, documented and further analyzed. This is performed to scientifically relate the failure to the degraded vehicle handling and possibly an accident. There are numerous additional variables that affect handling, including the chassis or frame design and geometry, the location of the centre of gravity and the drive axle.

When defining handling, optimum dynamic performance of a particular vehicle and actual dynamic driver input characteristics must be distinguished. This is due to the fact that drivers' perceptions and reactions and skills vary even to a common hazard.

To quantify a specific vehicle's optimum handling characteristics, without the aid of the manufacturer, the variables must be obtained primarily through testing. For example automotive journalists and writers attempt to do this by:

- Determining the maximum acceleration from 0 to 15, 30 and 60 mi/hr and the maximum speed attained at the end of a ¼ mile;
- Determining the minimum stopping distance on dry pavement;
- Determining the maximum lateral acceleration on a skid pad; a flat pavement with a painted circle to measure the vehicle's maximum lateral grip/acceleration;
- Measuring the maximum speed in a slalom, in which a vehicle is manoeuvred in an extremely compact course, usually marked with pylons; and,
- Assessing a vehicle's degree of understeer/oversteer or tendency of the front end of the vehicle to plough or push or the rear end of the vehicle to slip or "break loose" to the outside of a curve.

To quantify the actual vehicle dynamics or the utilization of the available coefficient of friction in an accident situation, the following information is required:

- A thorough review of the reported information including police information and witness statements;
- A detailed scene and involved vehicle(s) examinations to document the physical evidence, especially the road character and tire marks and the pre accident mechanical condition of the vehicle and the damage sustained as a result of the accident;
- Research on the specific make and model to obtain physical data and relevant recalls;
- Testing using a similar vehicle and the incident area of impact if required; and,
- Analysis using engineering methods including force and energy analysis as well as motion formulae.

Numerous techniques for performing handling analysis can be implemented, including traditional and advanced computer models. In an accident situation where pre-impact and post impact dynamics must be analyzed, the specific handling of every involved vehicle must be considered in order to determine how the accident occurred and how it may have been avoided. For example a tractor-trailer is not as efficient as a passenger vehicle in utilizing the available road surface/tire coefficient of friction.

One of the most argued variables in the field of accident reconstruction is the road surface/tire coefficient of friction and the involved vehicle's ability to utilize it. Published literature including sources from SAE (Society of Automotive Engineers) and other accident reconstruction textbooks and organizations recommend ranges for the coefficient of friction of various roadway surfaces. The ranges include values for dry and wet: cement, asphalt, gravel, snow and ice. In the absence of proper skid testing, the expert's choice for a reasonable range of the input variable of the coefficient of friction becomes, in many cases, critical. The expert's choice for the multitude of other input variables, including an involved vehicle's ability to utilize the available traction limits, is also crucial.

In a settled case, I had discovered that the opposing expert utilized a high lateral or sideways acceleration value (more than twice the value recommended in published literature) for a vehicle performing a passing manoeuvre. In this particular case, the invalid assumption decreased the passing distance and time proportionately. The expert then came to the flawed conclusion that the driver could not have avoided the accident in question. I was able to illustrate, through the use of appropriate assumptions, that the driver would have had sufficient time to avoid the accident. The driver had performed an unsafe passing manoeuvre and collided with a vehicle travelling in the opposite direction.

In summary, motor vehicle handling is quantified through analysis of many of a vehicle's systems and their interaction with the road surface. When assessing the performance of these systems for the purpose of an accident reconstruction, it is easy for the reconstruction to be incorrect when an expert uses extreme values or even variables outside of a reasonable range. In order to present a reconstruction in an unbiased fashion, the expert must use reasonable input variables that are, as per the Engineering Code of Ethics, "... founded on adequate knowledge and honest conviction".