C10 Misinterpretation of Data From Linear Accelerometers in Dynamic Vehicle Testing

Matthew A. Ivory, BS, Biodynamics Engineering, Inc., 3720 East LaSalle Street, Phoenix, AZ 85040; Russell L. Anderson, MS*, PO Box 7185, Tempe, AZ 85281; and Carley C. Ward, PhD, Biodynamics Engineering, Inc., 3720 East LaSalle Street, Phoenix, AZ 85040*

After attending this presentation, attendees will understand what an accelerometer is and how it is used in testing; will understand the difference between linear and angular acceleration; and will know the difference between a vehicle's fixed coordinate system and a world coordinate system.

This presentation will impact the forensic community by informing attendees about the proper use and limitations of linear accelerometers and the proper technique for analyzing the data from tests.

This presentation examines data from linear accelerometers collected during dynamic vehicle testing. Currently, there is an ongoing problem with opinions being made from linear accelerometer data where the effects of angular accelerations and gravity are neglected.

Linear accelerometers are used in dynamic automotive testing, including crash testing and dynamic handling tests. SAE J211 is the standard that dictates the proper use of accelerometers and data recording in these tests. SAE J211 assigns a vehicular origin that is assigned near the vehicle's center of mass. This is defined as the vehicle's fixed coordinated system, where all measurements are made relative to the vehicle's center of gravity. For a world coordinate system, measurements are made relative to a point fixed to the earth.

Linear accelerometers do not measure angular acceleration. Because linear accelerometers can only measure in one direction, the accelerometers go off axis and produce questionable data if the vehicle experiences any angular acceleration. This is due to the fact that the origin (the vehicle's center of gravity) is rotating with the vehicle and, therefore, any rotation cannot be accounted for relative to the world coordinate system. Thus, linear accelerometers experiencing angular accelerations will record erroneous results. This is especially relevant if the recorded acceleration is integrated for change in velocity. Change in velocity for a body decelerating is the difference between an initial velocity and a final velocity. With a vehicular origin, it is not known where the change in velocity originates or stops.

In order to use linear accelerometers for data acquisition in dynamic testing with angular acceleration, certain parameters must be met. First, an outside reference must be established to coordinate the vehicle and world coordinate systems. Next, to account for angular accelerations, two linear accelerometers must be set at a known distance. The angular acceleration can then be obtained by calculating the difference between the two accelerometers and multiplying times the distance between them.

Accelerometers measure acceleration in terms of gravity (G's). This makes them susceptible to errors introduced when they go off axis and pick up accelerations due to gravity. This is not significant in a dynamic crash test where there are extremely high G loads. However, in dynamic handling tests, where one is dealing with very low G-loads, the effects of gravity can have a very significant effect. Therefore, a single linear accelerometer cannot be used in dynamic handling tests. To compensate and correct for gravity, rate gyros that measure roll and pitch must be used for accurate data.

An examination of two cases studies was performed. In these cases, data recorded from linear accelerometers mounted at the CG of a vehicle was misinterpreted and flawed opinions were formed. In the first case, use of the wrong coordinate system combined with a disregard for angular accelerations resulted in a 26% error in calculated velocity for a 62 mph vehicle into barrier test. In the second case, the effects of gravity were disregarded when there was pitch or roll of the accelerometer. The second case involved vehicle handling tests where recorded values from accelerometers are typically less than 1 G. The additional acceleration gained or lost by acceleration due to gravity resulted in readings one and a half to two times what they should have been. A static test was conducted to demonstrate this error. A stationary accelerometer was tilted off axis so that gravity was acting on the measured axis. In this demonstration, gravity made it appear that the stationary accelerometer was actually moving.

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