Accelerometer Crash Test Investigation

Performed on 2 May 2011

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Created By: Darren Beams

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Executive Summary

A crash test investigation was undertaken to get a better understanding of the nature of vehicle impacts and, more specifically, the data expected from the accelerometer mounted on the Geotab GO4V3 and GO5 devices during these impacts. Two vehicles were used in the testing; both were fitted with Geotab GO devices. Several tests were performed at both 5km/h and 20km/h and included vehicle into vehicle collisions as well as vehicle collisions into a concrete median. Curves of the accelerometer data from both vehicles for each impact were plotted and are included in the report below along with observations based on the data.

Test Setup

Driven Vehicle	Chevrolet Cavalier
Stationary Vehicle	Ford E350 Bus
Geotab Test Team	Moussa Kfouri, Tom Walli, Darren Beams, Tony Partheniou, John Kyes, Victor Barreto
Geotab Audio Visual	Maria Sotra
Stunt Driver	Craig Snoyer
GO Device Firmware Versions	GO4V3 - 81.250.1 GO5 - 100.250.1

Both the Cavalier and the Ford bus were fitted with multiple GO devices. In Geotab standard firmware, devices auto-calibrate to transform the accelerometer to a known orientation. The devices in the test were running custom firmware that did not transform accelerometer data and were mounted in a known orientation. These devices saved every accelerometer log as long as it was different from the previously saved log by 54mg. The devices were configured to switch from 2g mode to 8g mode when any axis was above 1.9g and would return to 2g mode when all axes were below 1.6g.

Accelerometer Specifications

Type	STMicroelectronics LIS302DL
Description	MEMS motion sensor 3-axis - ±2g/±8g smart digital output “piccolo” accelerometer
Range	-2.286g to 2.286g in 2g Mode -9.144g to 9.144g in 8g Mode
Configured Sample Rate	100 Hz (100 samples per second)

List of Crash Tests

1) Vehicle driven into the back of the bus at 5km/h
2) Vehicle driven into a concrete median at 5km/h
3) Vehicle driven into the side of the bus at 20km/h
4) Vehicle driven into the wheel of the bus at 20km/h
5) Vehicle driven into the back of the bus at 20km/h
6) Vehicle driven into a concrete median at 20km/h

Figure 1: Vehicle driven into the side of the bus at 20km/h

Crash Test Results

Test 1: Moving Vehicle into the Back of the Bus at 5km/h

Event Time: 15:31:38

GPS Speed at time of impact: 5km/h

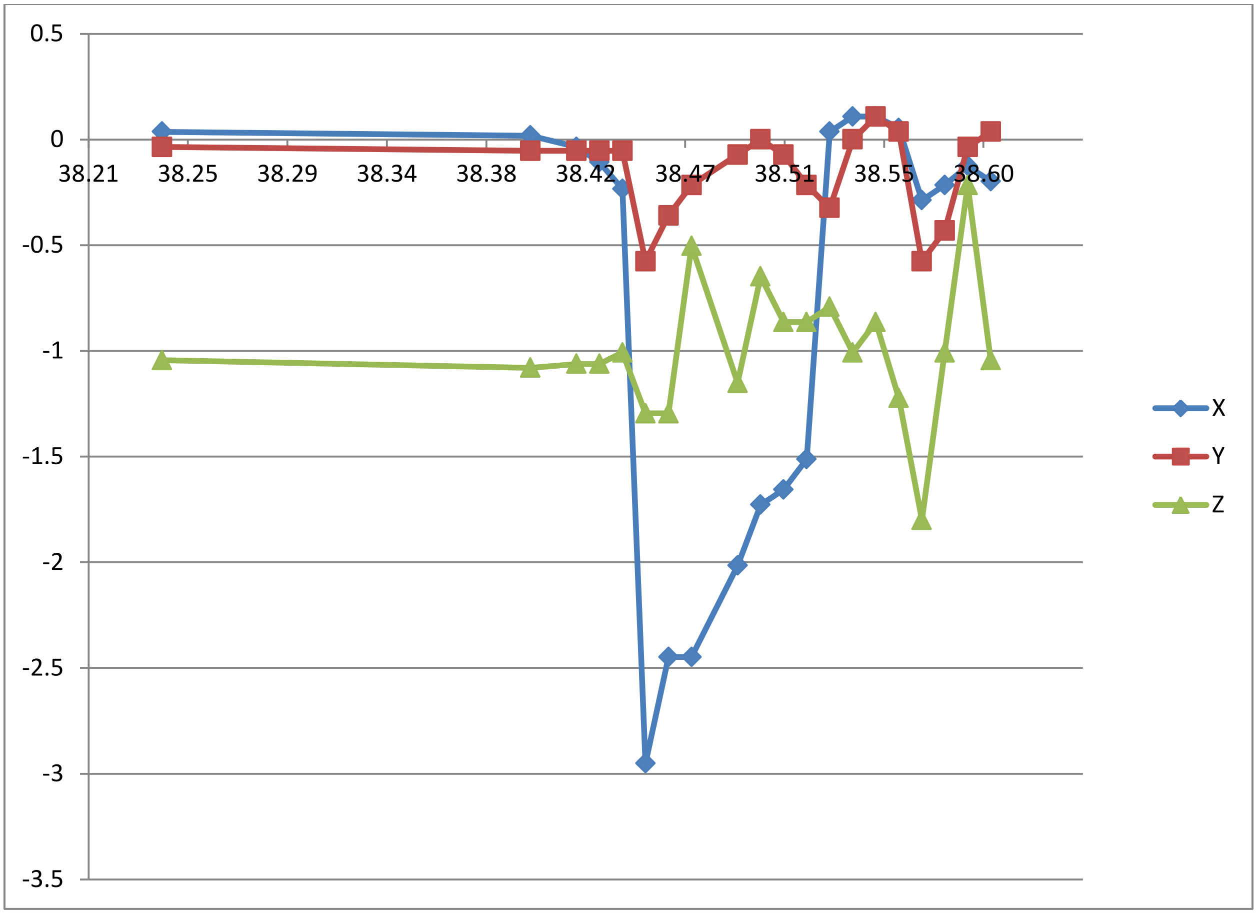

Chart 1: Vehicle device during 5km/h impact into the rear of the bus

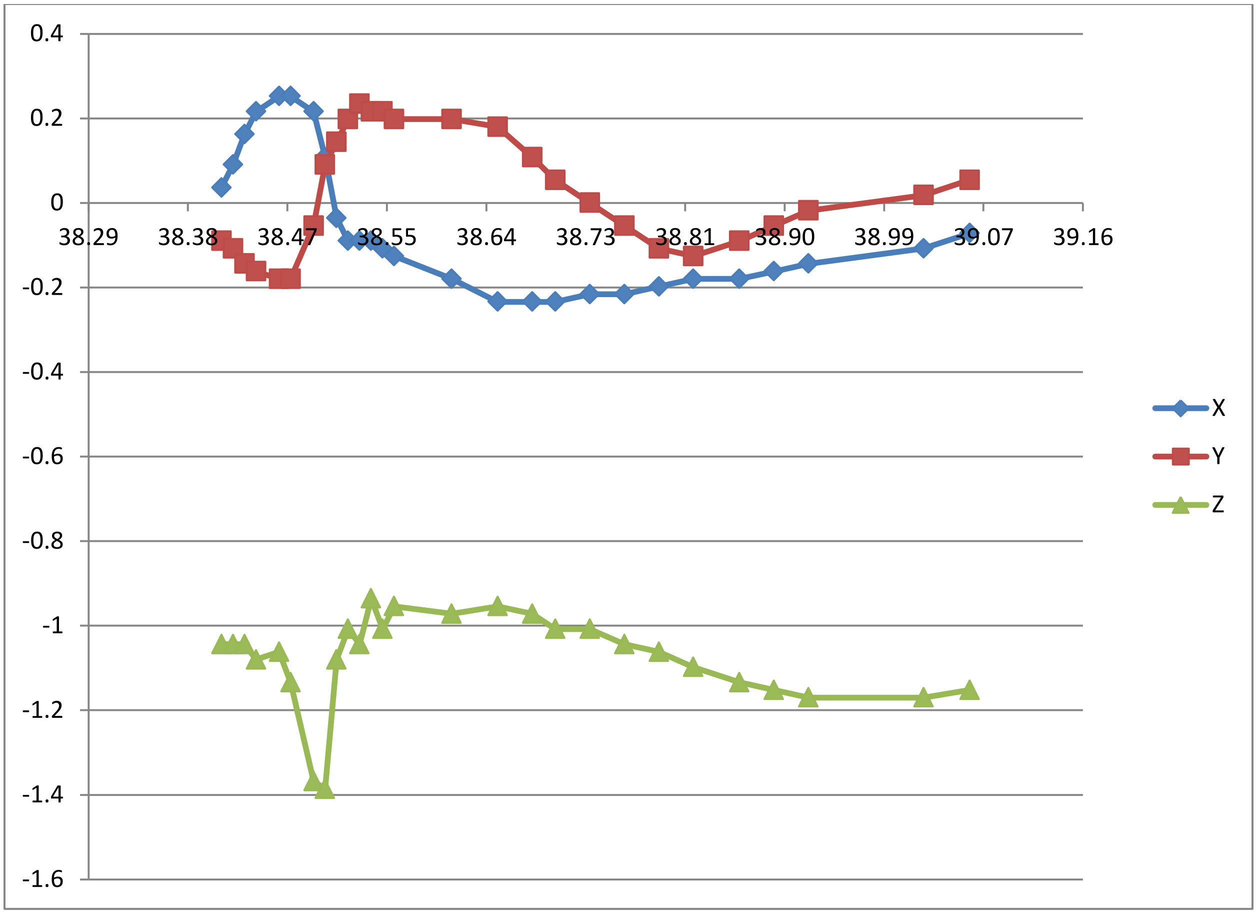

Chart 2: Bus device during 5km/h impact into its rear

Observations

- The 5km/h crash into the back of the bus caused a peak accelerometer reading of just under 3g on the vehicle reference device. (Chart 1)
- The bulk of the impact event occurred within 80ms. (Chart 1)
- The bus reference device experienced dramatically lower acceleration values compared to the vehicle although the event lasted considerably longer. (Chart 2)
- The forward swaying of the bus resulting from the impact can be clearly observed in the X axis plot (Chart 2). The bus then slowly sways backwards, and we see a negative x-axis value.

Test 2: Moving Vehicle into a Concrete Median at 5km/h

Event Time: 15:34:22

GPS Speed at time of impact: 5km/h

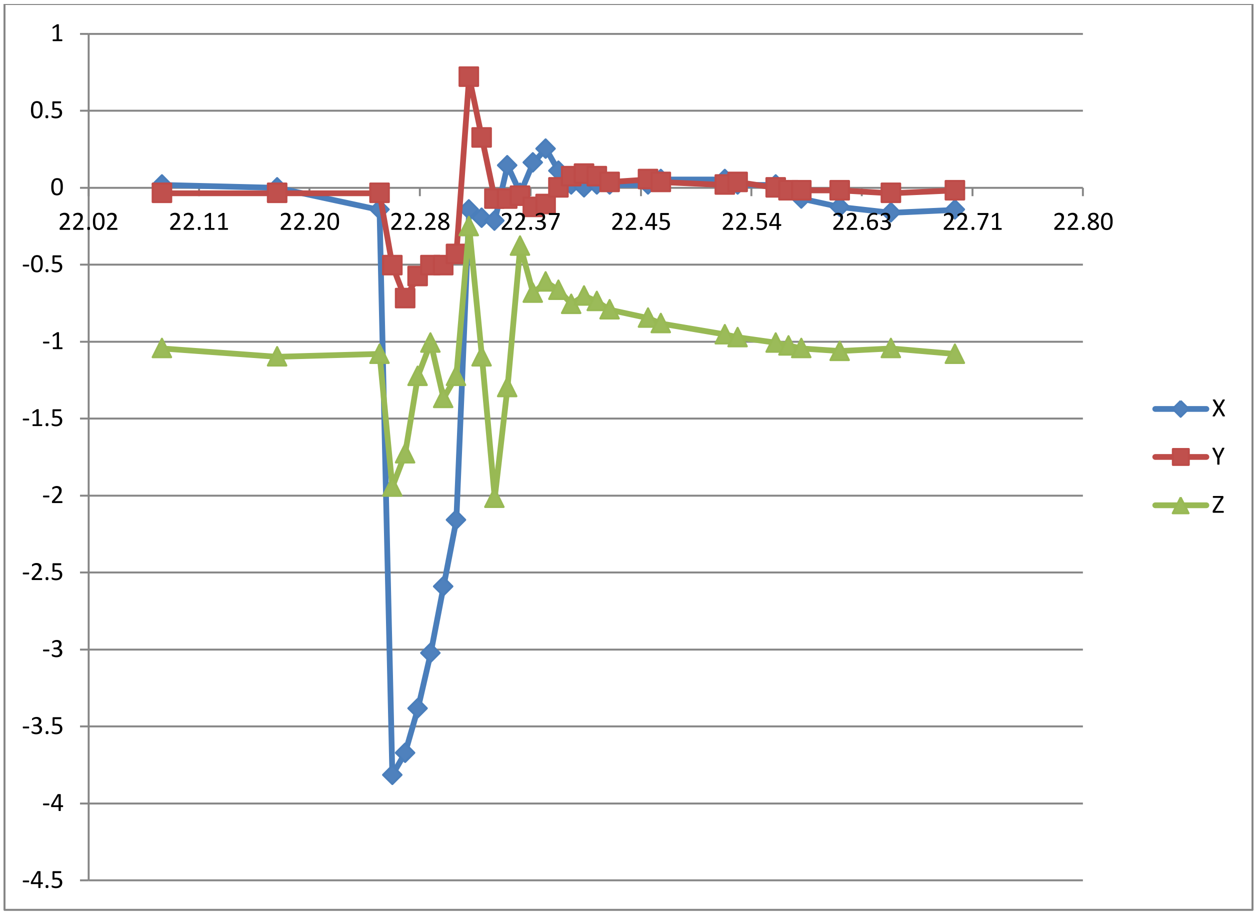

Chart 3: Vehicle device during 5km/h impact with a concrete median

Observations

- The 5km/h crash into the concrete median caused a peak accelerometer reading of just 3.8g on the vehicle reference device. (Chart 3)
- The bulk of the impact event occurred within 60ms. (Chart 3)

Test 3: Moving Vehicle into the Side of the Bus at 20km/h

Event Time: 15:44:12

GPS Speed at time of impact: 20km/h

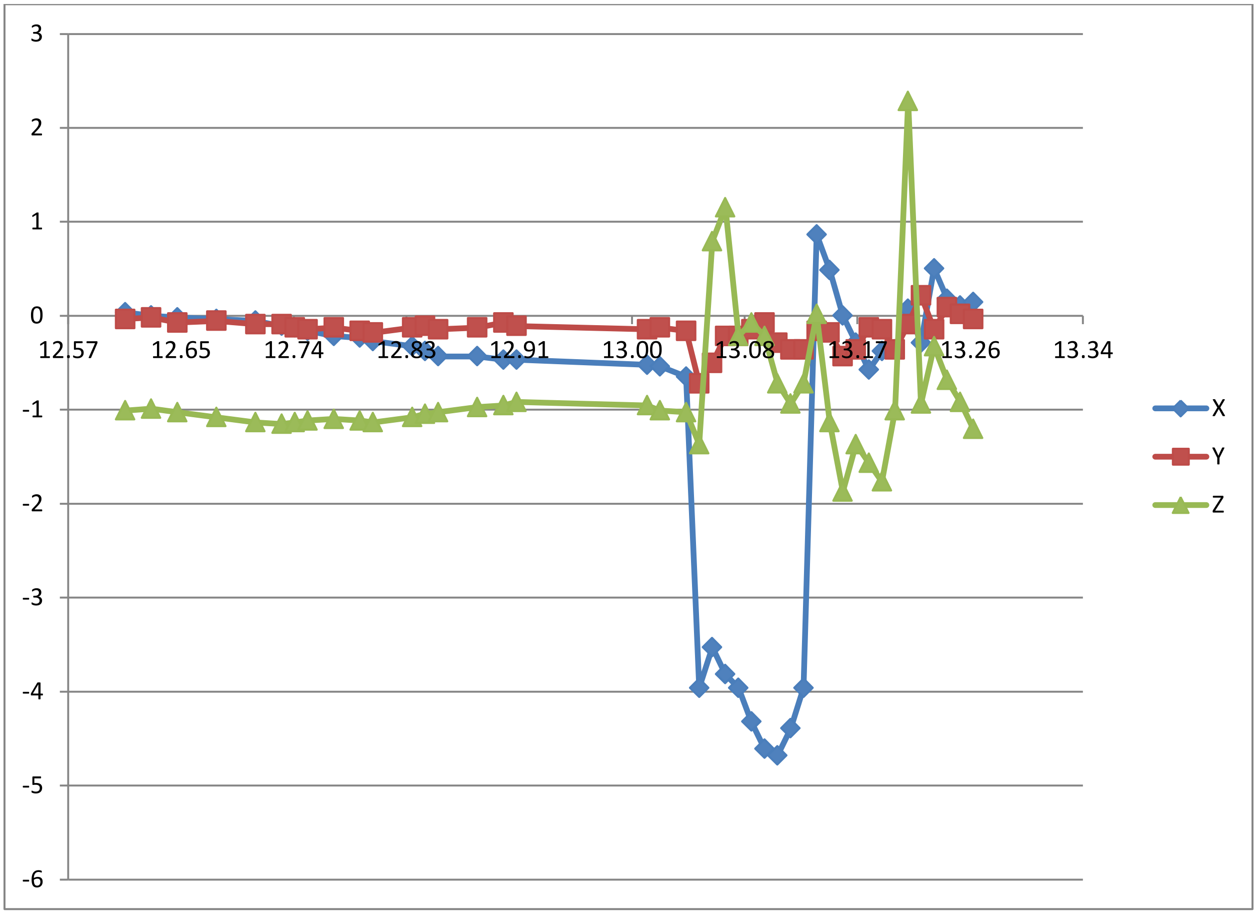

Chart 4: Vehicle device during 20km/h impact into the side of the bus

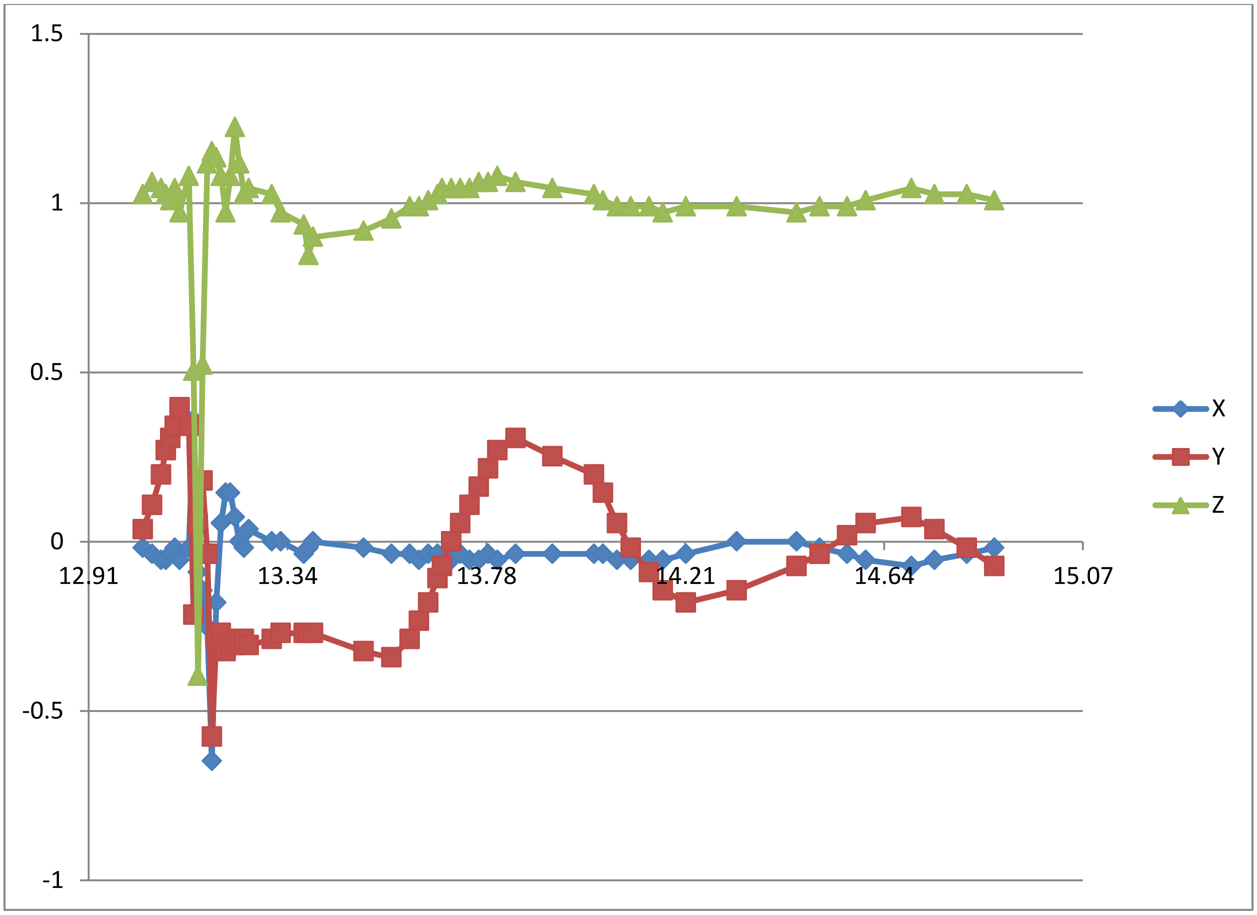

Chart 5: Bus device during 20km/h impact into its side

Observations

- The 20km/h crash into the side of the bus caused a peak accelerometer reading of 4.7g on the vehicle device. (Chart 4)
- The bulk of the impact event occurred within 100ms. (Chart 4)
- There was approximately 0.5g of deceleration prior to the impact. (Chart 4)
- The bus reference device experienced lower peak values but the event lasted longer. (Chart 5)
- The sideways swaying of the bus resulting from the impact can be clearly observed in the Y axis plot. (Chart 5)
- The Z axis spike on the bus at the time on impact may be due to the way the device was mounted. (Chart 5)

Test 4: Moving Vehicle into Wheel of Bus at 20km/h

Event Time: 15:53:43

GPS Speed at time of impact: 20km/h

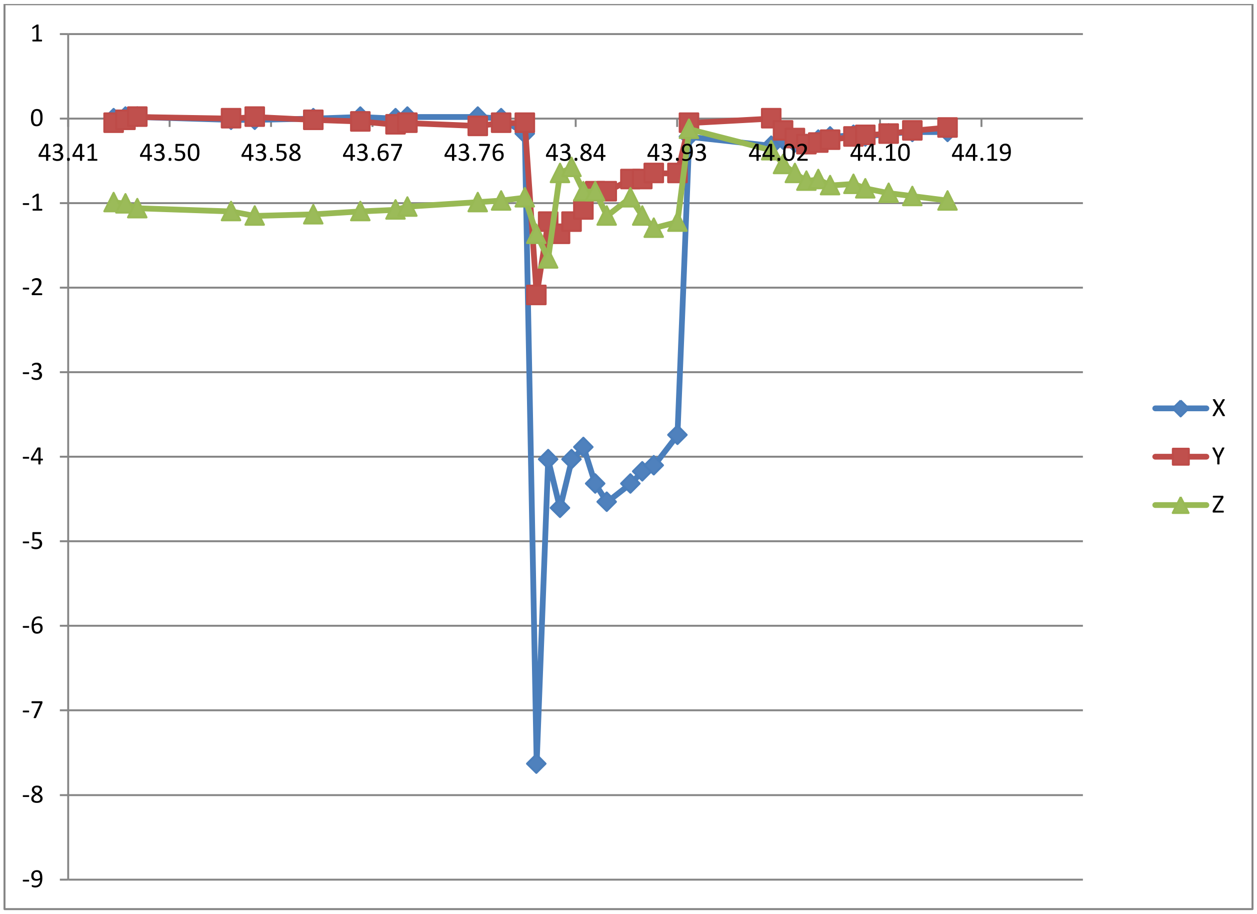

Chart 6: Vehicle device during 20km/h impact into the wheel of the bus

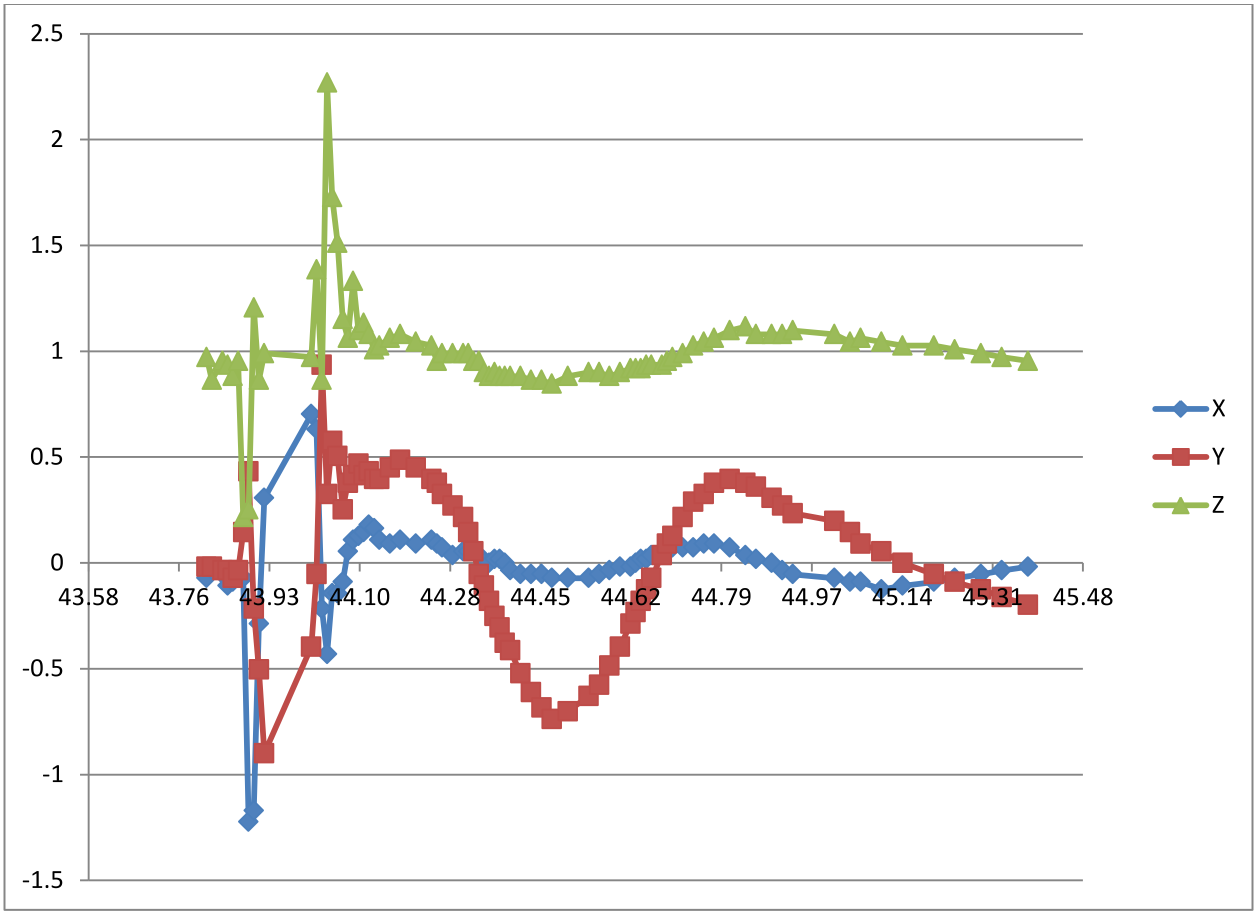

Chart 7: Bus device during 20km/h impact into its right-rear wheel

Observations

- The 20km/h crash into the wheel of the bus caused a peak accelerometer reading of just under 7.6g on the vehicle device. (Chart 6)
- The bulk of the impact event occurred within 140ms. (Chart 6)
- The bus reference device experienced lower peak values but the event lasted substantially longer. (Chart 7)
- The sway caused by the impact on the bus is also clearly evident in the Y axis data. (chart 7)

Test 5: Moving Vehicle into the Back of the Bus at 20km/h

Event Time: 16:05:08

GPS Speed at time of impact: 15km/h

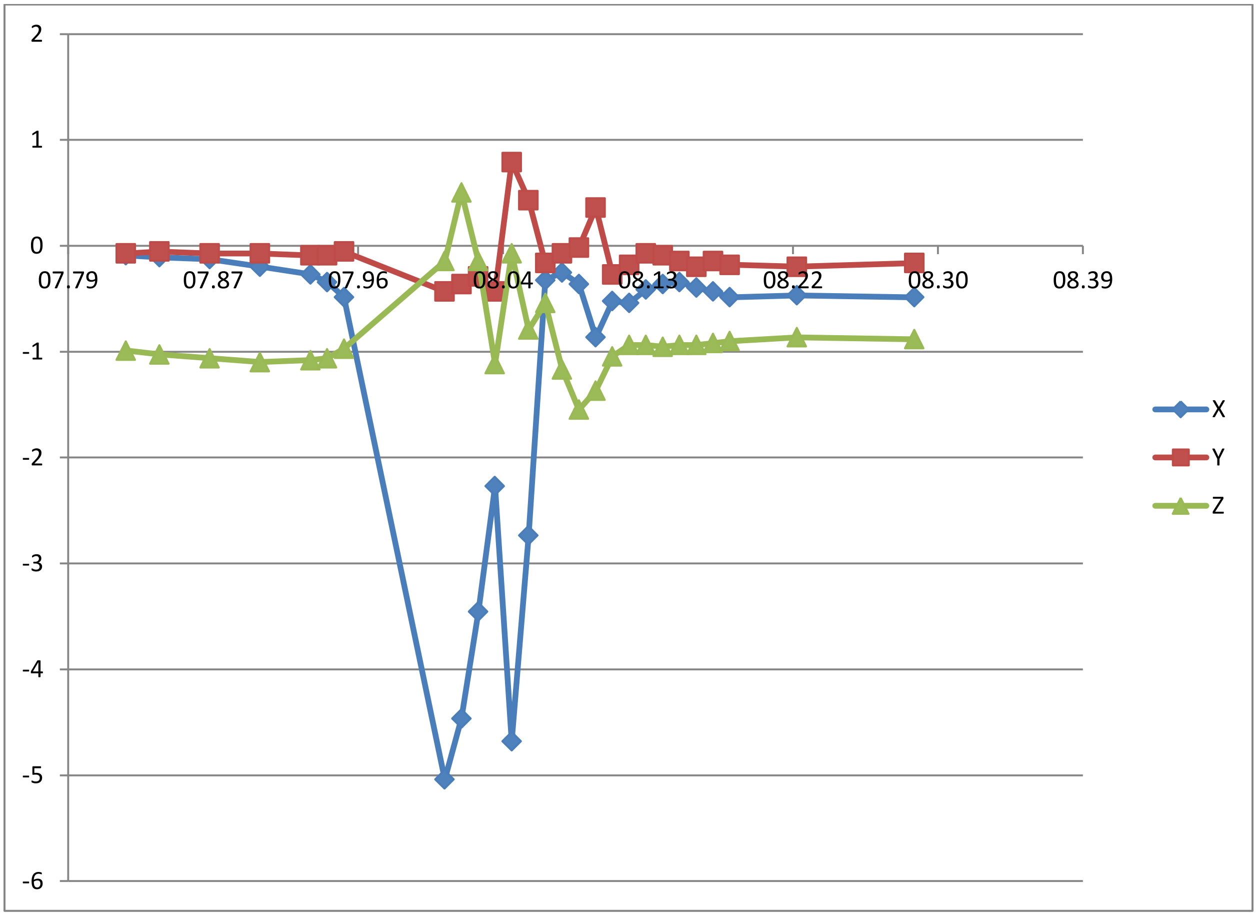

Chart 8: Vehicle device during 20km/h impact into the back of the bus

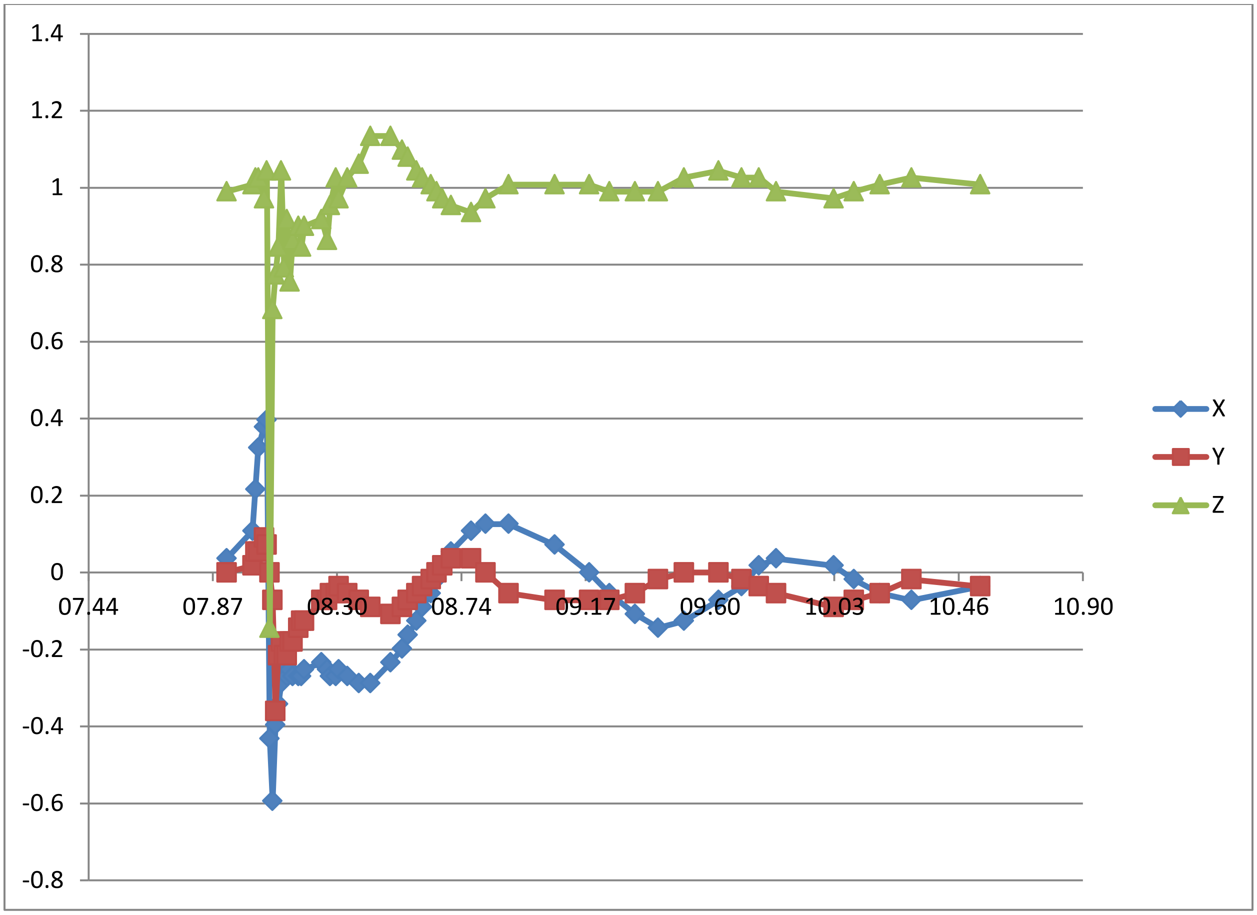

Chart 9: Bus device during 20km/h impact

Observations

- The 20km/h crash into the back of the bus caused a peak accelerometer reading of just 5g on the vehicle device. (Chart 8)
- The bulk of the impact event occurred within 120ms. (Chart 8)
- There was almost 0.5g of deceleration prior to the impact on the bus, the GPS speed reported around the time of impact was reported as at 15km/h which was lower than the planned 20km/h.
- The bus reference device experienced lower peak values but the event lasted substantially longer. (Chart 9)
- The rocking motion caused by the impact on the bus is evident in the X axis of the bus data. (chart 9)

Test 6: Moving Vehicle into Concrete Meridian at 20km/h

Event Time: 16:07:46

GPS Speed at time of impact: 22km/h

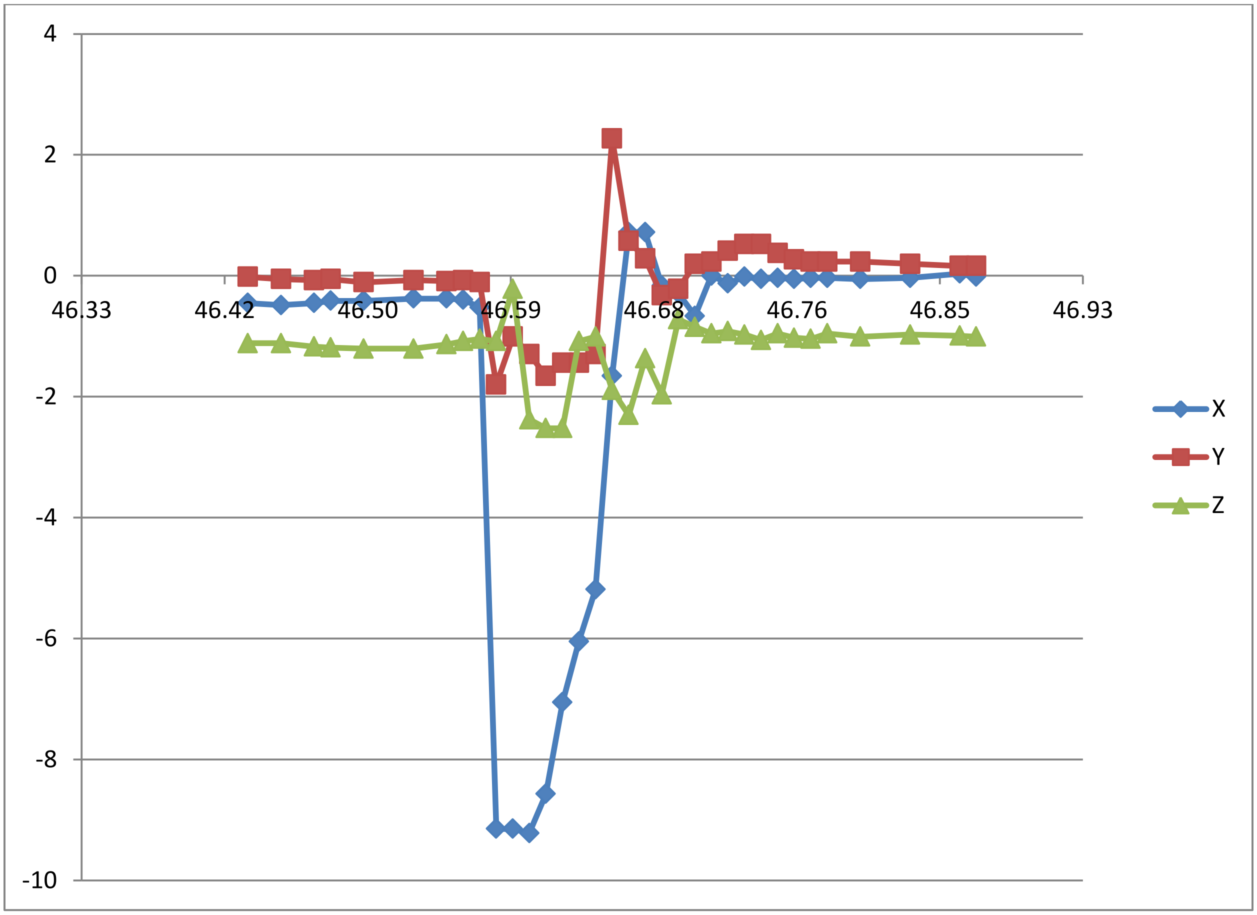

Chart 10: Vehicle device during 20km/h impact into concrete median

Observations

- The 20km/h crash into the concrete median caused a peak accelerometer reading of 9.2g on the vehicle reference device. (Chart 10)
- 9.2g is the max reading that can come from our accelerometer, so the actual value could have been higher.
- The bulk of the impact event occurred within 80ms. (Chart 10)

Observations and Conclusions

- A 5km/h impact is more of a large accelerometer event than originally thought, accident data thresholds will need to be carefully chosen to prevent false positives.
- The duration of an event is considerably shorter than originally thought; a moving average or periodic sampling of the data may be insufficient to capture the true nature of an event.
- A 22km/h event is enough to max out our accelerometer; higher speed collisions would probably be difficult to discern using the existing hardware.
- Looking at the range of peak values across the 20km/h events, a slight change in speed or acceleration vs deceleration prior to impact can have a discernable effect on the nature of the impact.
- The size, weight and suspension of the bus allowed it to relatively successfully absorb a substantial amount of each impact. This means that that different thresholds would be needed for small and large vehicles.

Figure 2: The front of the vehicle after a full days testing