Analysis of EDR Data

Figure 1 shows plots of all the pre-crash accelerometer data obtained from the EDR report of 2019/07/25 22:44:10 (UTC), along with the plotted vehicle speed data. Analysis of the data provides three major conclusions:

1) The steering wheel angle data and the yaw rate data are not consistent with each other.
2) If the sign of the steering wheel angle data is changed, then all the accelerometer data become consistent with each other, showing that the vehicle veered to the left as shown in Figure 2, in agreement with the driver's testimony and with the damage to the right front corner of the vehicle as supported by repair records.
3) All accelerometer data plots show a change in the sign of the acceleration at around -1.0 seconds before the final crash, indicating possible contact with a crushable object before contact is made with a more impenetrable wall at 0.0 sec.

These conclusions will now be discussed in more detail.

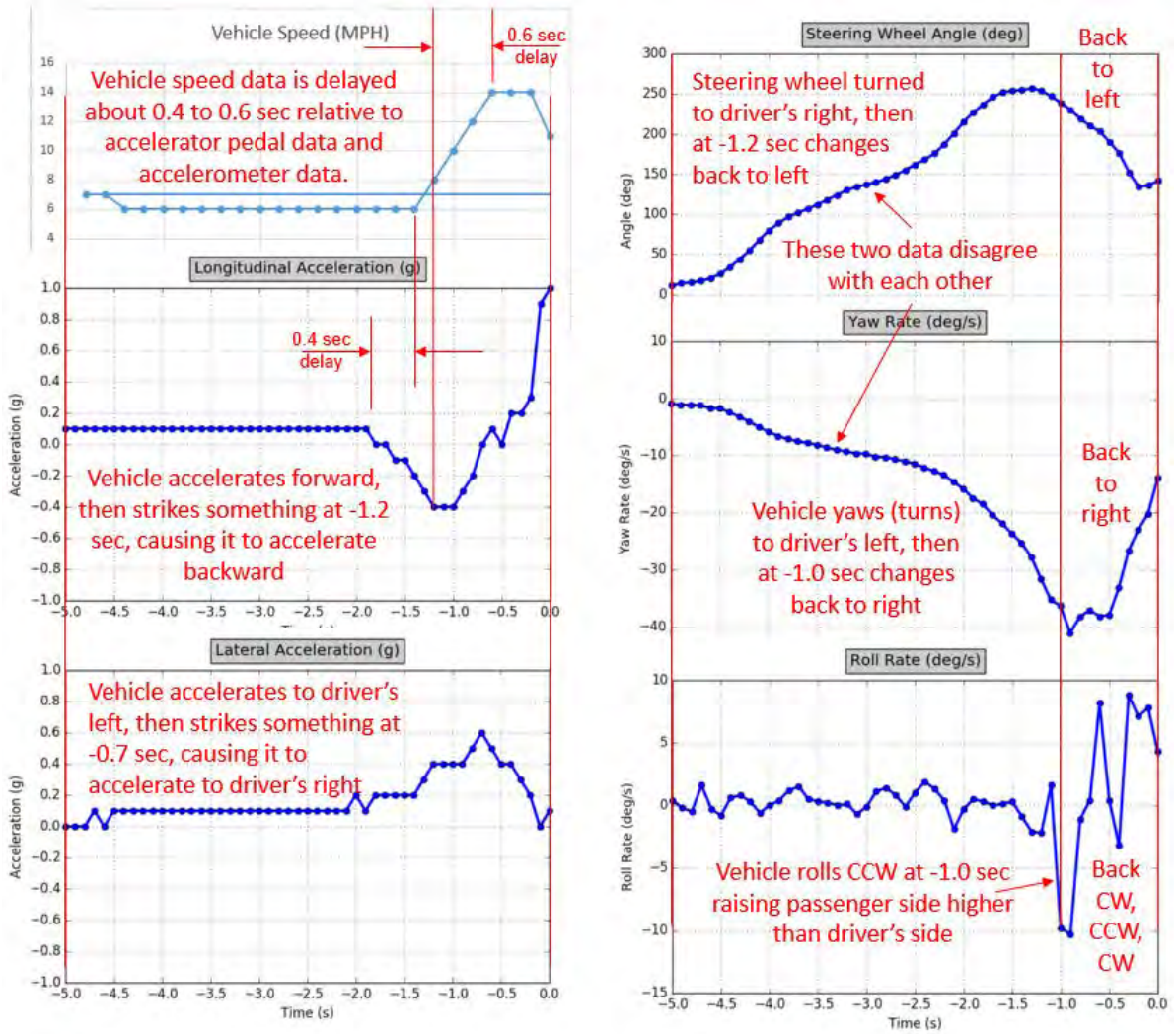
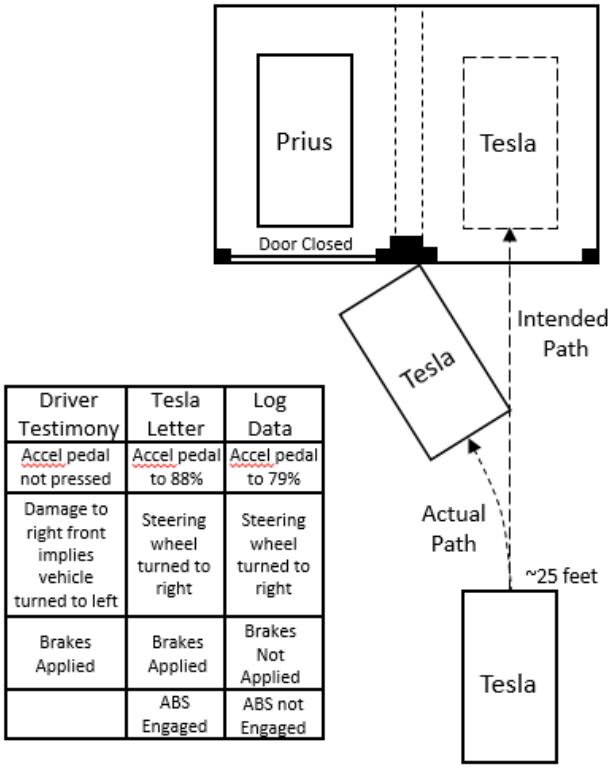


Figure 1. Pre-crash accelerometer data plots

1. Steering wheel angle data and yaw rate data are not consistent with each other. By definition, yaw is the rotation of a vehicle about a vertical axis, with positive yaw values indicating a rotation to the driver's right. Therefore, the negative yaw values in the yaw rate data of Figure 1 indicate a rotation of the vehicle to the driver's left with the rate of rotation increasing with time, and then decreasing again. This is incompatible with the steering wheel angle data, which shows positive values indicating a turn of the steering wheel to the right and then back to the left. What this means is that one of these plots has the wrong sign, indicating that one of the plots does not conform to the SAE 211 / SAE J670 standards mandated by NHTSA in its Part 563 EDR rule dated Sept 2012. Why this wrong sign exists is unknown, and may indicate a mistake by Tesla when designing the EDR system.
2. If the sign of the steering wheel angle data is changed, then all the accelerometer data become consistent with each other, showing:
    a. the vehicle accelerated forward as shown by the longitudinal acceleration data showing a forward acceleration followed by a rearward acceleration caused by crashing into an object. The acceleration caused by the crash reached a value of 1g, triggering the recording of the EDR data, but not the excitation of the air bags.
    b. the vehicle veered to the left before the crash as shown in Figure 2. This is supported by:
        1) the revised steering wheel angle data now agreeing with the yaw rate data,
        2) the lateral acceleration data showing that the vehicle accelerated first to the left and then to the right, and
        3) the driver's testimony,
    c. the vehicle struck an object with the right front fender as supported by:
        1) the lateral acceleration data showing that the vehicle first accelerated to the driver's left and then back to the driver's right,
        2) the roll rate data, showing that the vehicle first rolled counter-clockwise (CCW), raising the passenger side higher than the driver's side, and then back clock-wise (CW) again, followed by an additional CCW and CW rotation,
        3) the driver's testimony,
        4) repair records indicating damage to the right front fender area.
3. The vehicle may have made contact initially with a crushable object (like a garbage can, a planter, or something similar) before final contact was made with a more impenetrable object like the garage structure between the two garage doors. This is inferred from the observation that all accelerometer data plots show a change in the sign of the acceleration values at around -1.0 seconds before the final crash, with the reverse accelerations reaching their highest values at 0.0 seconds.



Driver Testimony	Tesla Letter	Log Data
Accel pedal not pressed	Accel pedal to 88%	Accel pedal to 79%
Damage to right front implies vehicle turned to left	Steering wheel turned to right	Steering wheel turned to right
Brakes Applied	Brakes Applied	Brakes Not Applied
	ABS Engaged	ABS not Engaged

Figure 2. Vehicle path for the incident along with a table showing inconsistencies between the driver's testimony, the EDR data as interpreted by Tesla, and Tesla's letter to the driver. This report shows the EDR data is consistent with the driver's testimony.

Figure 3 shows plots of the pre-crash data values of accelerator pedal depression (%), rear motor speed (RPM), and vehicle speed (MPH). One can make the following three inferences from these plots:

1. The maximum in the accelerator pedal data at -1.0 seconds corresponds roughly to the maxima in all the accelerometer data at about -1.0 seconds. This appears to show that the driver released the accelerator pedal after the vehicle initially made contact with a crushable object, but before the vehicle finally came to rest at 0.0 seconds. But this inference is merely an assumption until Tesla can prove that the recorded accelerator pedal data is actually obtained by storing the accelerator pedal sensor voltage values, and not some signal derived from the voltage data but possibly affected by other events occurring in the vehicle. Therefore, the dropping of the accelerator pedal data to a zero value may also imply that an accelerator-related signal derived from the accelerator pedal voltage stopped as a result of the shock caused by the vehicle hitting an object, which changed a related event. This possibility allows for events other than the accelerator pedal sensor value to influence the vehicle motion.
2. The rear motor speed (RPM) and the vehicle speed (PMH) are offset from the accelerator pedal (%) data by 0.2 seconds and 0.6 seconds, respectively. While some delay in these two responses may be expected, a delay of 0.2 seconds

between the accelerator pedal and the motor speed is quite large and should be detectable by the driver as a noticeable lag in accelerator response. It is not known if this is a normal lag value for the Tesla motor, or if this large value indicates that some non-normal process is at work in this incident. It is known, however, that in vehicles with internal combustion engines this delay is kept as far below 100 milliseconds as possible (typically about 30 to 70 milliseconds) to avoid the driver experiencing a lag in accelerator response.

3. The rear motor speed (RPM) plot shows that the motor RPM continued at about 1500 RPM for about 0.4 seconds after the accelerator pedal data went to zero. This is not a result of the 0.2 second delay of the motor RPM relative to the pedal data, but is in addition to the delay. The cause of this continuation in motor RPM is unknown at this time. It may imply that some other process is in control of the motor RPM in addition to the accelerator pedal data.

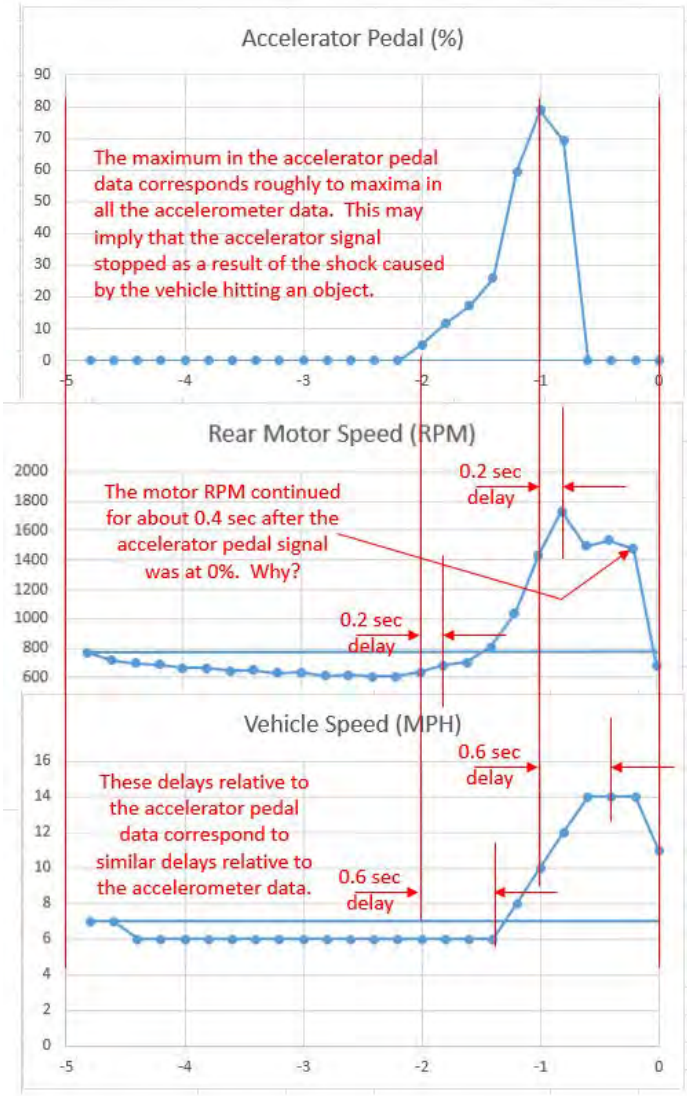


Figure 3. Plots showing recorded pre-crash values of accelerator pedal depression (%), rear motor speed (RPM), and vehicle speed (MPH)