EDR Case Studies

Presented by Richard R. Ruth, P.E.

2019 IPTM Symposium on Traffic Safety

Richard R. Ruth , P.E.

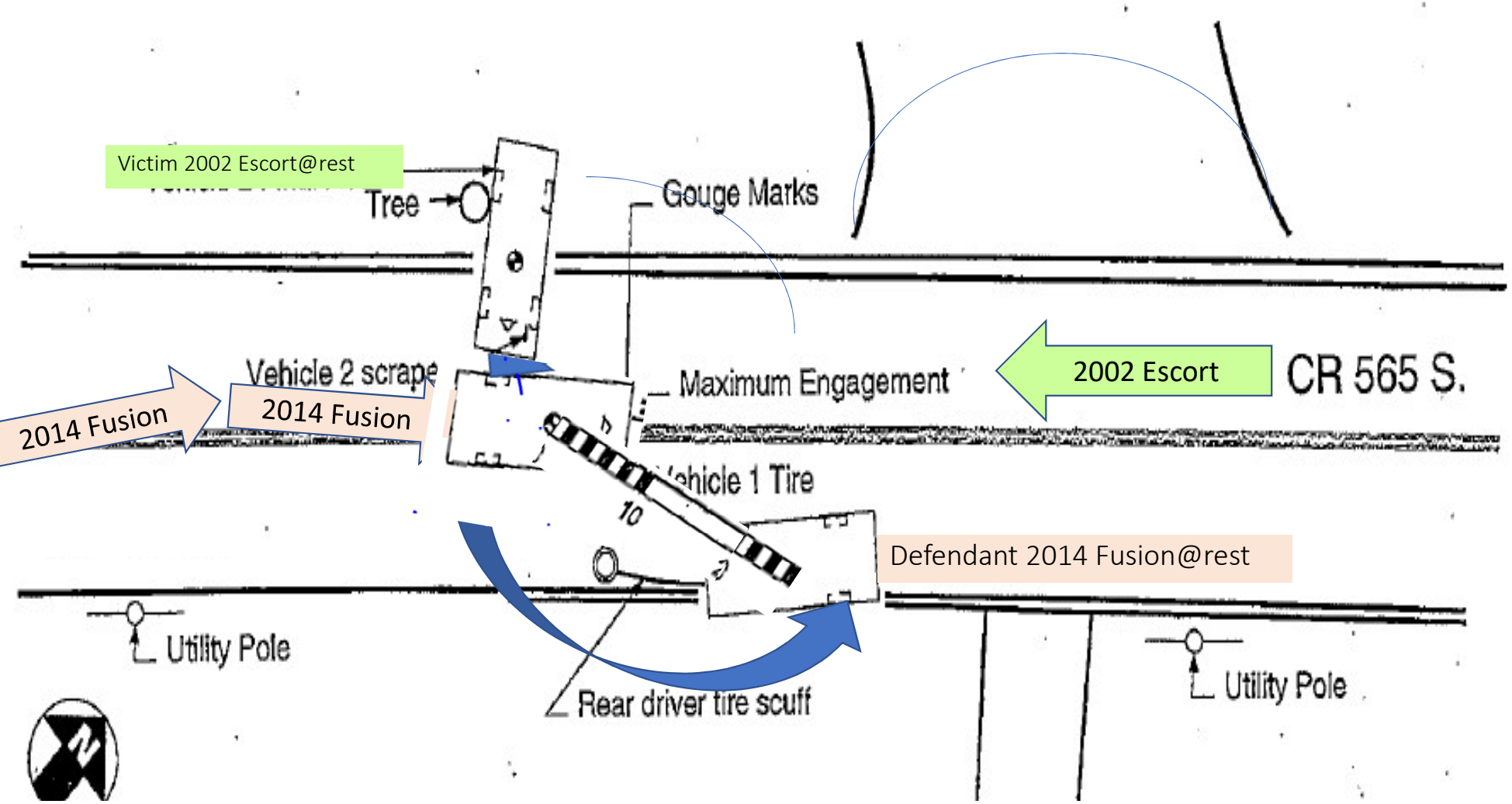
- Ford Motor Company 33 years – retired 2006
- Ford's lead field user of EDR's, EDR policy committee, Rep to SAE & EDR Committee, Rep to Bosch CDR
- 2007-present, Ruth Consulting LLC –Teaches EDR tech, EDR Analyst 1 & 2 classes for IPTM and EDR for SAE.
- Presents regularly at national and regional conferences on reconstruction, on EDR's.
- Does research on EDR accuracy – 19 publications
- Helps prosecutors and cops nationwide in EDR cases – mostly for free (charge for written reports and testimony).
- Takes civil cases in airbags and EDR aspect of Recon
- Bleeds Ford Blue

Rick Ruth

Case 1: Using Ford Stability Control Data

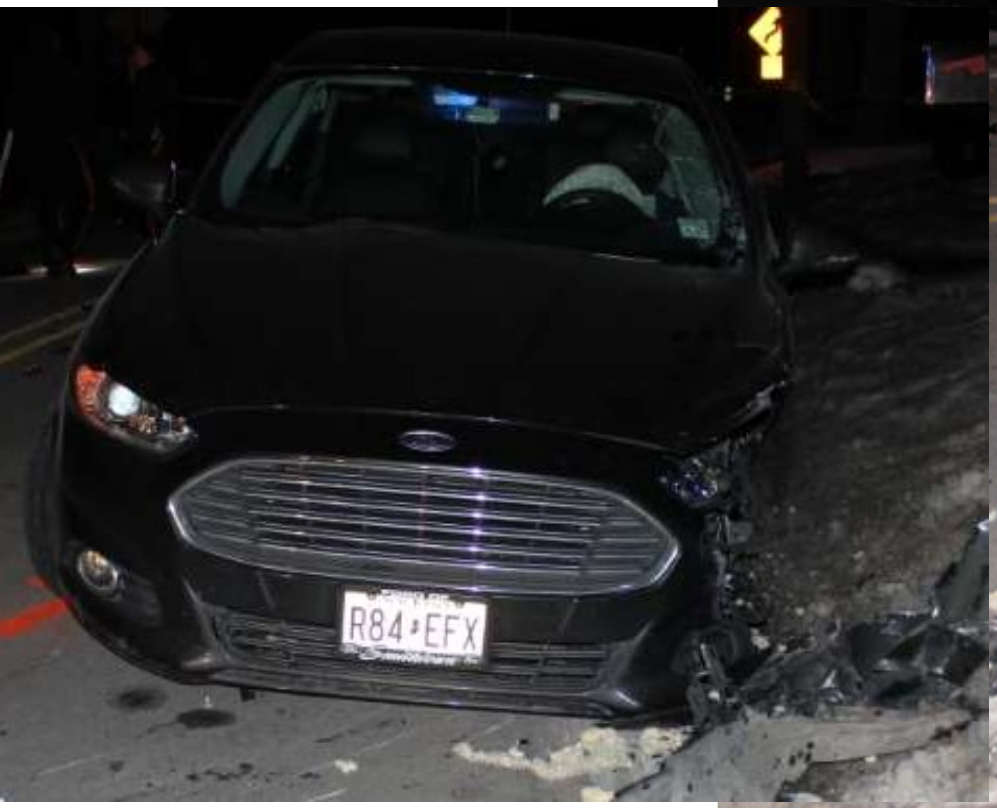
- Phasing in 2009-2012 Ford added stability control system data into its airbag control module EDR's
- The longitudinal acceleration data can help us get a more accurate speed at impact if the vehicle was going a nice steady speed before an emergency braking before impact
- The lateral acceleration and yaw rate data can help us understand lateral movement prior to impact

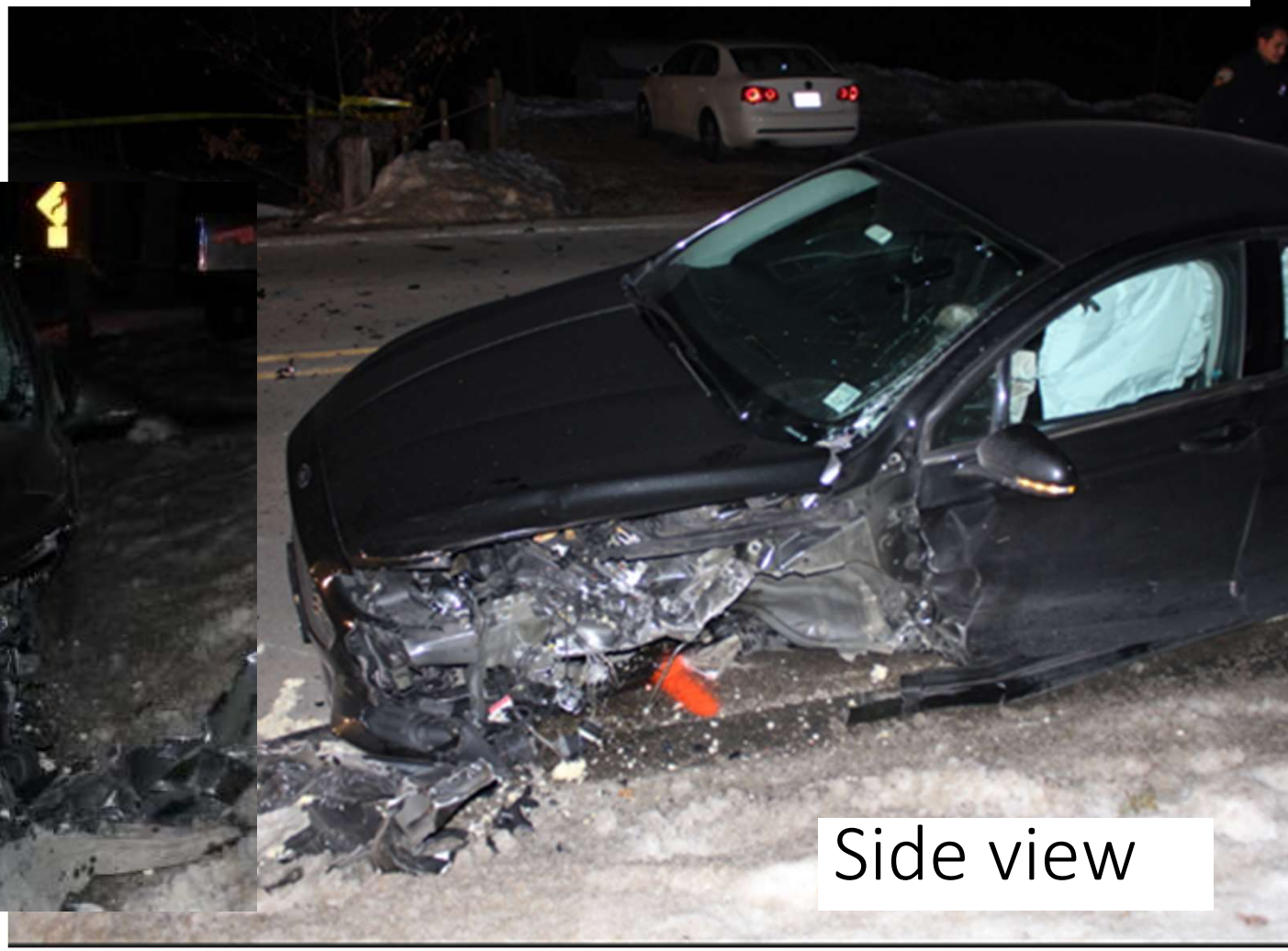
Cross centerline case: Peeking nose out or passing?



Defendant's 2014 Fusion at rest

Front view





Side view

Victim's 2002 Escort

2014 Fusion: Recording from my event?

Reported with CDR version	Crash Data Retrieval Tool 18.0.2
Reported with Software Licensed to (Company Name)	Ruth Consulting LLC
EDR Device Type	Airbag Control Module
ACM Adapter Detected During Download	Yes
Event(s) recovered	locked frontal event

Interp in latest software? YES

How many events? 1

System Status at Event (First Record)

Complete File Recorded (Yes,No)	Yes

1. Complete Recording?

Pre-Crash Data -1 sec (First Record)

Ignition cycle, Crash	4,789
Frontal Air Bag Warning Lamp, On/Off	Off
Occupant Size Classification, Front Passenger (Child size Yes/No [Hex value])	No [$00]
Safety Belt Status, Driver	Buckled

Key Cycles

System Status at Time of Retrieval

Ignition Cycle, Download (First Record)	4,790
Ignition Cycle, Download (Second Record)	N/A

2. Key Cycles Match? YES

Recording from my event continued

3. Delta V match physical crush? YES

Deployment Data (First Record)

Frontal Airbag Deployment, Time to First Stage Deployment, Driver (msec)	13.5
Frontal Airbag Deployment, Time to 2nd Stage, Driver (msec)	18.5
Pretensioner (Retractor) Deployment, Time to Fire, Driver (msec)	13.5
Side Curtain Airbag Deployment, Time to Deploy, Driver Side (msec)	17.0
Adaptive Steering Column Deployment, Time to Deploy, Driver (msec)	13.5
Inflatable Knee Bolster Deployment, Time to Fire, Driver (msec)	13.5
Pretensioner (Anchor) Deployment, Time to Fire, Driver (msec)	18.5
Maximum Delta-V, Longitudinal (MPH [km/h])	-24.9 [-40]
Time, Maximum Delta-V Longitudinal (msec)	170

4. Precrash From my crash? – (passing maneuver)

Pre-Crash Data -5 to 0 sec [2 samples/sec] (First Record)

Time (sec)	Speed, Vehicle Indicated (MPH [km/h])	Speed, Vehicle Indicated, Quality Factor	Accelerator Pedal, % Full	Accelerator Pedal, % Full, Quality Factor	Service Brake, On/Off	Service brake, Quality Factor	Engine RPM	ABS Activity (Engaged, Non-Engaged)
- 5.0	33.3 [53.6]	OK	99.9	OK	Off	OK	4512	non-engaged
- 4.5	36.2 [58.2]	OK	99.4	OK	Off	OK	4844	non-engaged
- 4.0	39.2 [63.1]	OK	28.3	OK	Off	OK	5118	non-engaged
- 3.5	40.8 [65.6]	OK	66.0	OK	Off	OK	5166	non-engaged
- 3.0	42.5 [68.4]	OK	99.9	OK	Off	OK	5516	non-engaged
- 2.5	44.6 [71.8]	OK	99.2	OK	Off	OK	4178	non-engaged
- 2.0	46.7 [75.2]	OK	98.2	OK	Off	OK	4262	non-engaged
- 1.5	48.5 [78.1]	OK	99.6	OK	Off	OK	4368	non-engaged
- 1.0	50.4 [81.1]	OK	99.9	OK	Off	OK	4264	non-engaged
- 0.5	49.5 [79.6]	OK	0.0	OK	On	OK	3890	engaged
0.0	40.8 [65.7]	OK	0.0	OK	On	OK	3360	engaged

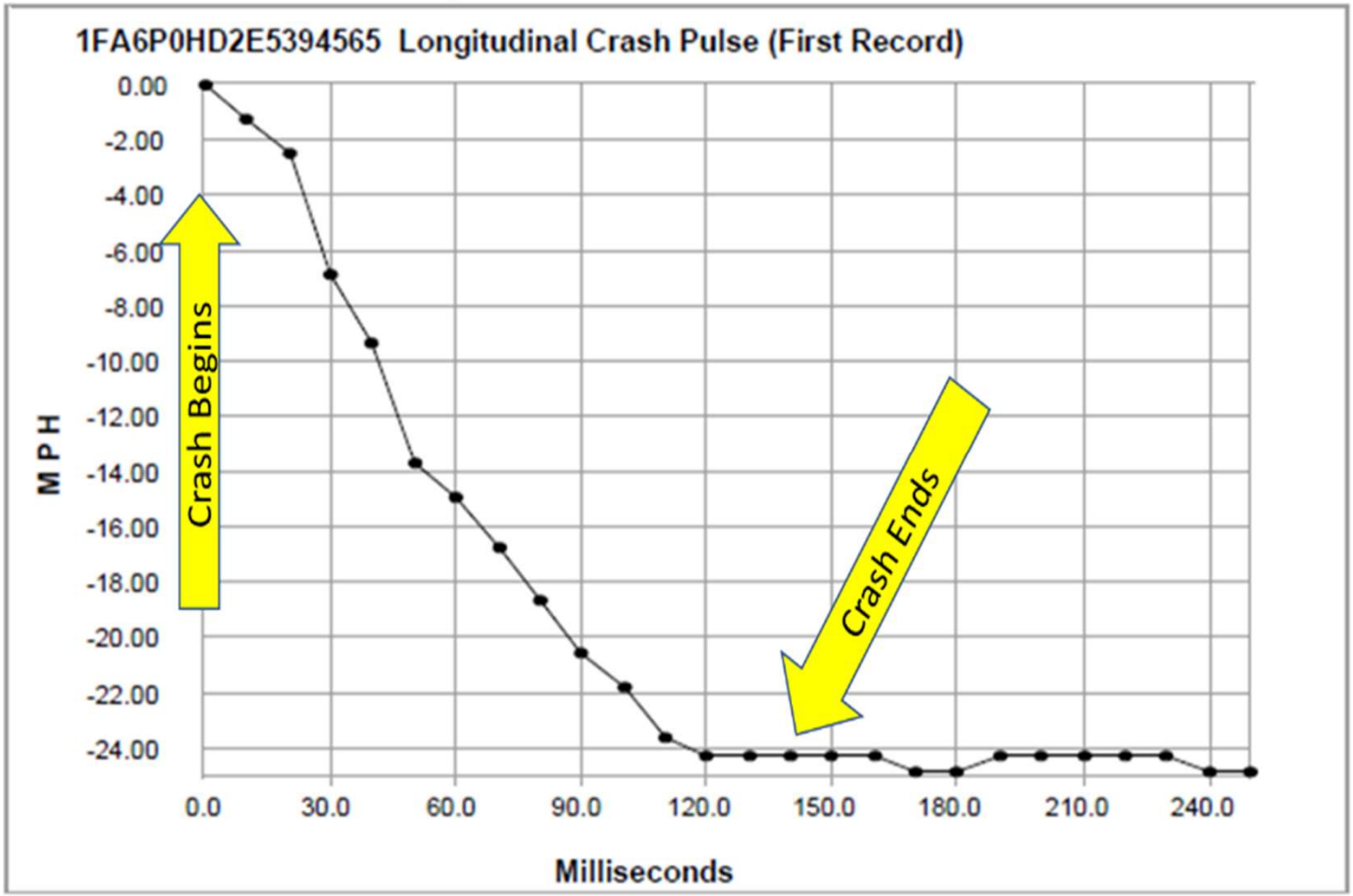
Increasing Speed

Heavy Acceleration

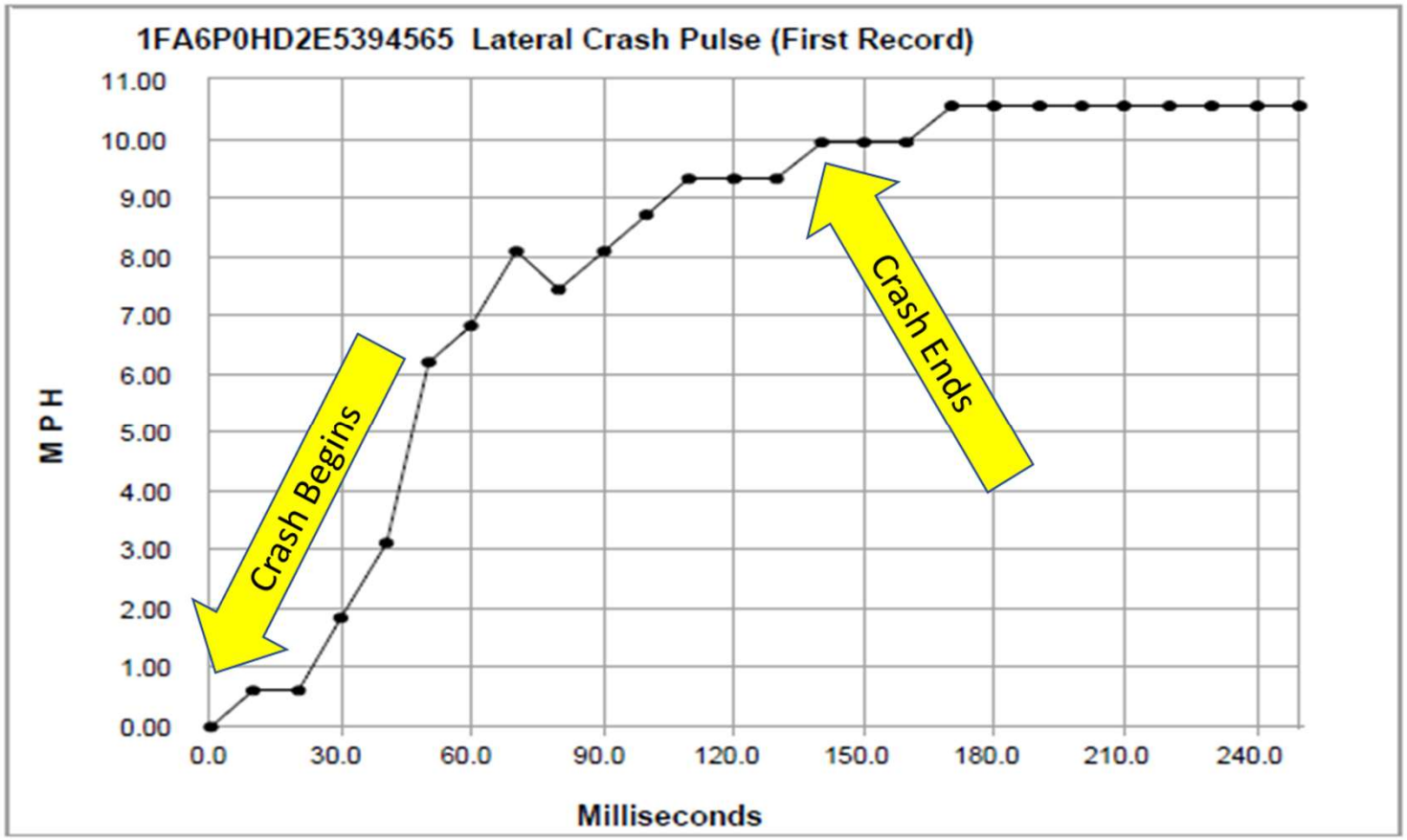
High RPM

Emergency!

Delta V curve shape and duration OK? YES



Lat Delta V curve shape and duration OK? YES

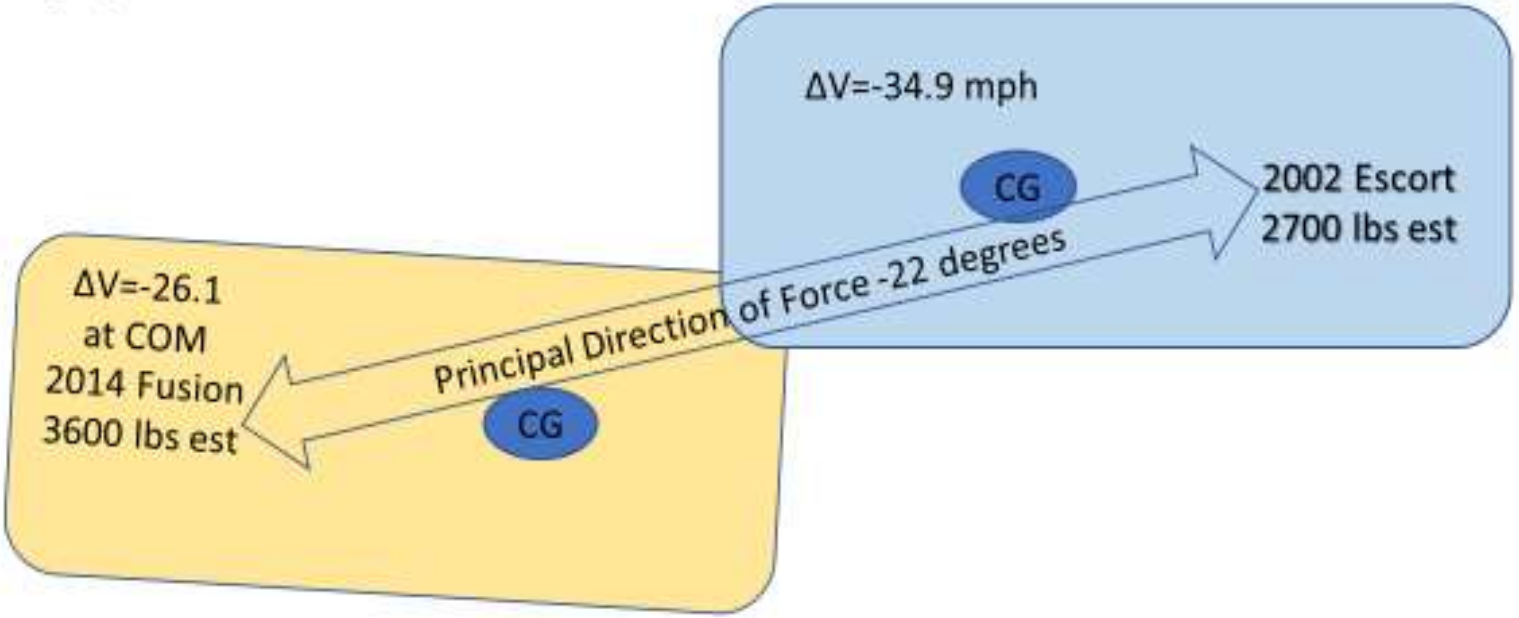


Total Delta V Magnitude and Direction

- Total Delta V $= \sqrt{x^2 + y^2} = \sqrt{24.1^2 + 10^2} =$ **$26.1\ mph$**
- Direction = atan-1$(\frac{10.0}{26.1}) =$ **$22\ degrees$**

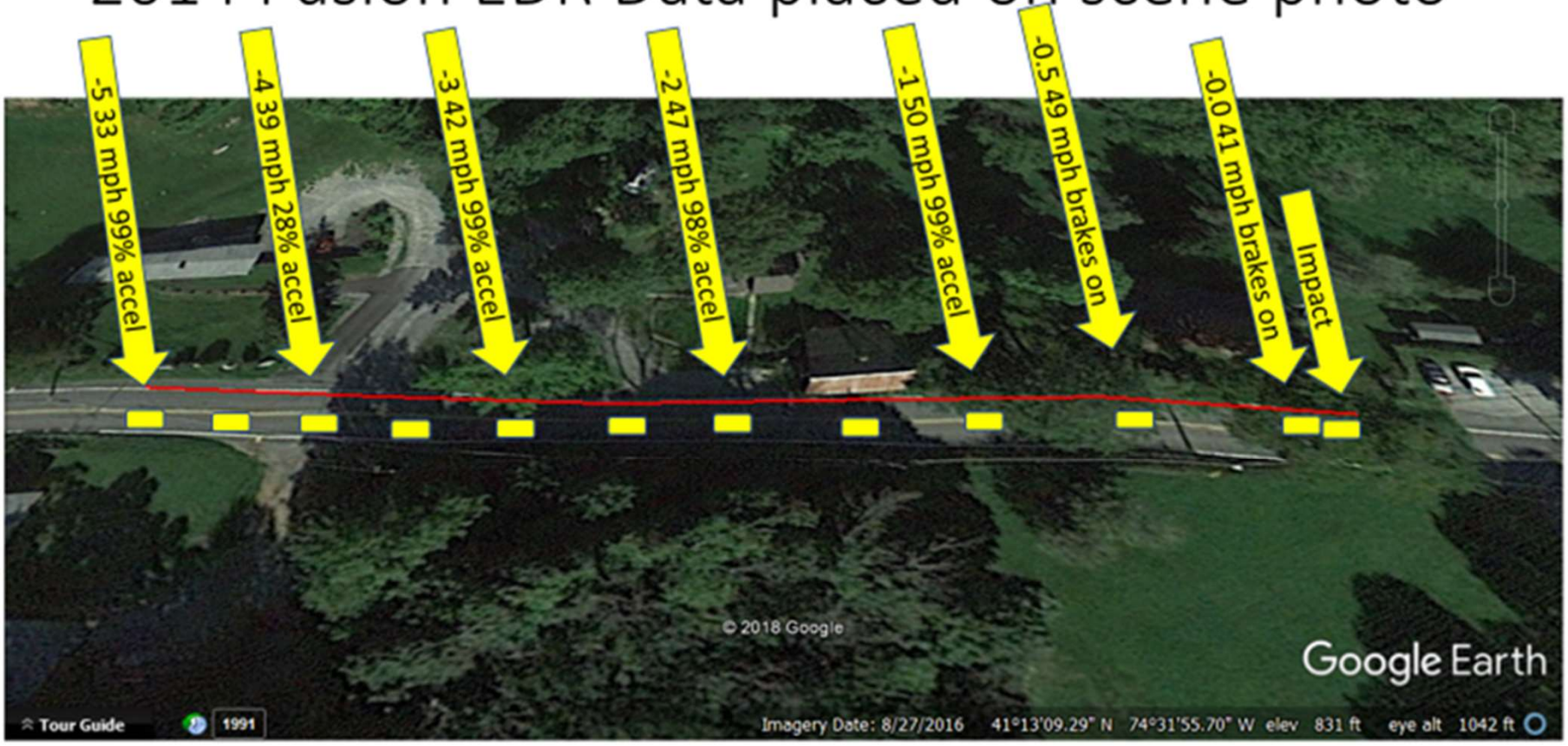
- Delta V of Escort = 26.1$\frac{3600\ lb\ fusion}{2700\ lb\ Escort}$ **=34.9 mph at ? degrees**

Approximate vehicle orientation at impact



Distance to Impact Calculations				Dist this	If 0=-0.0	If 0 = -0.5	
		MPH	FPS	interval	Min Dist	Max Dist	Midpoint
	-5	33.3	48.8	24.4	310.5	343.6	327.0
	-4.5	36.2	53.1	25.5	286.1	319.2	302.6
	-4	39.2	57.5	27.6	260.6	293.7	277.2
	-3.5	40.8	59.8	29.3	233.0	266.1	249.5
	-3	42.5	62.3	30.5	203.7	236.8	220.2
	-2.5	44.6	65.4	31.9	173.1	206.2	189.7
	-2	46.7	68.5	33.5	141.2	174.3	157.8
	-1.5	48.5	71.1	34.9	107.8	140.8	124.3
	-1	50.4	73.9	36.2	72.9	106.0	89.4
	-0.5	49.5	72.6	36.6	36.6	69.7	53.2
	0	40.8	59.8	33.1	0.0	33.1	16.5

2014 Fusion EDR Data placed on scene photo



Speed at Impact Worksheet taught by IPTM

	MIN	MAX	
Last reported Speed	40.8	40.8	
Speed change since last	-7.5	0.0	0.5 sec interval x 15mph/sec
ABS Wheel Slip adjust +5%	+2.0	+2.0	last speed underreported
Speedometer Error +/-4%	-1.6	+1.6	
	33.7	**44.4 mph**	

Confirm Speed at Impact, method 2
Start 50.4 at -1.0, use stability control data

Pre-Crash Data -5 to 0 sec [10 samples/sec] (First Record)

Time (sec)	Stability Control Lateral Acceleration (g)	Stability Control Longitudinal Acceleration (g)	Stability Control Yaw Rate (deg/sec)	Steering Wheel Angle (deg)
- 1.0	-0.15	-0.13	3.26	11.8
- 0.9	0.00	-0.15	0.82	3.7
- 0.8	0.16	-0.13	-4.53	-13.3
- 0.7	0.34	-0.10	-10.53	-35.0
- 0.6	0.43	0.02	-13.84	-52.7
- 0.5	0.36	0.39	-13.11	-51.2
- 0.4	0.54	0.34	-12.44	-48.3
- 0.3	0.44	0.52	-16.87	-47.2
- 0.2	0.39	0.49	-18.21	-37.4
- 0.1	0.39	0.42	-17.08	-31.2
0.0	0.38	0.49	-14.90	-32.4

Note this 2014 Fusion AB10P has ***backwards polarity*** for longitudinal accel, +=decel, - = accel (opposite of what is stated in data limitations)

Speed at impact from stability control long G's
Start from 50.4mph at -1.0 +/-4% (+/-2.0mph)

start time	start value	accel g's	interval time	mph this interval	final value
-1	50.4	0.13	0.1	0.29	50.69
-0.9	50.69	0.15	0.1	0.33	51.02
-0.8	51.02	0.13	0.1	0.29	51.30
-0.7	51.30	0.1	0.1	0.22	51.52
-0.6	51.52	-0.02	0.1	-0.04	51.48
-0.5	51.48	-0.39	0.1	-0.86	50.62
-0.4	50.62	-0.34	0.1	-0.75	49.87
-0.3	49.87	-0.52	0.1	-1.14	48.73
-0.2	48.73	-0.49	0.1	-1.08	47.65
-0.1	47.65	-0.42	0.1	-0.92	46.73
0	46.73	-0.49	0.1	-1.08	45.66
0.1	45.66	-0.47	0.1	-1.03	44.63

Range 42.6 tp 47.7

Speed at impact = V3 cos β - ΔV_x

- Rotation drag factor 70% of 0.7 = 0.49.
- $V3 = \pi\sqrt{30Df} = \sqrt{30 * 26 * 0.49}$ = 19.55 mph
- Estimate departure angle at <30 degrees
- 19.5*cos30-(-24.9 DVx) = 19.5*.866+24.9=16.93+24.9=41.83+/-2.5
- **Range 39.3 to 44.3**

Consider using Closing Speed?

- Offset collision – must adjust for Effective Mass Ratio

$$\text{ClosingSpeed} = \left[\frac{1}{1+e}\right]\left[\frac{|\Delta V_1|}{\gamma_1} + \frac{|\Delta V_2|}{\gamma_2}\right]$$

- Uncertainty if vehicles reached a common velocity at damage centroid
- No speed available for victim to get to speed of perpetrator

Therefore, not a good choice of ways to get speed at impact

Reconcile 3 Speed at Impact Calcs

33.7 ----------from last speed data ----------44.4

42.6 –from start of braking—47.7

39.3-----DV+post---------**44.3**

Consensus of all 3 methods is **42.6 to 44.3 at impact**

Review Stability Control Lateral Data

Note polarity shifts near -2.9 sec and -0.6 sec

Start calculations from -2.9 seconds

Pre-Crash Data -5 to 0 sec [10 samples/sec] (First Reco

Time (sec)	Stability Control Lateral Acceleration (g)	Stability Control Longitudinal Acceleration (g)	Stability Control Yaw Rate (deg/sec)	Steering Wheel Angle (deg)
-5.0	-0.07	0.17	-4.31	-16.6
-4.9	-0.08	0.20	-4.25	-15.9
-4.8	-0.07	0.21	-4.32	-15.4
-4.7	-0.11	0.21	-4.21	-14.9
-4.6	-0.09	0.21	-4.21	-14.2
-4.5	-0.11	0.22	-4.30	-14.2
-4.4	-0.08	0.20	-4.57	-14.2
-4.3	-0.10	0.23	-4.47	-14.2
-4.2	-0.12	0.21	-4.46	-14.0
-4.1	-0.12	0.21	-4.53	-14.0
-4.0	-0.08	0.20	-4.25	-13.3
-3.9	-0.07	0.10	-3.75	-12.2
-3.8	-0.06	0.05	-2.79	-9.8
-3.7	-0.03	0.10	-2.37	-8.4
-3.6	-0.06	0.13	-2.85	-8.4
-3.5	-0.07	0.13	-2.76	-8.4
-3.4	-0.04	0.14	-2.38	-8.2
-3.3	-0.03	0.12	-2.04	-6.6
-3.2	-0.04	0.11	-1.83	-5.2
-3.1	-0.03	0.12	-1.77	-4.9
-3.0	-0.02	0.12	-1.94	-4.9
-2.9	0.03	0.12	-1.61	-3.2
-2.8	0.02	0.13	-0.36	0.6
-2.7	0.09	0.13	1.07	6.0
-2.6	0.12	0.12	2.74	11.1
-2.5	0.13	0.13	3.21	12.4
-2.4	0.13	0.13	2.71	10.4
-2.3	0.07	0.14	1.93	8.0
-2.2	0.07	0.14	1.57	6.4
-2.1	0.08	0.14	1.69	6.9
-2.0	0.08	0.15	1.91	7.6
-1.9	0.09	0.14	2.10	8.4
-1.8	0.10	0.15	2.38	9.1
-1.7	0.13	0.15	2.88	10.6
-1.6	0.14	0.14	3.54	13.1
-1.5	0.14	0.13	4.59	16.2
-1.4	0.19	0.12	5.38	18.1
-1.3	0.16	0.13	5.16	18.9
-1.2	0.16	0.13	5.16	18.4
-1.1	0.17	0.13	5.20	16.1
-1.0	0.15	0.13	3.26	11.8
-0.9	0.00	0.15	0.82	3.7
-0.8	-0.16	0.13	-4.53	-13.3
-0.7	-0.34	0.10	-10.53	-35.0
-0.6	-0.43	-0.02	-13.84	-52.7
-0.5	-0.36	-0.39	-13.11	-51.2
-0.4	-0.54	-0.34	-12.44	-48.3
-0.3	-0.44	-0.52	-16.87	-47.2
-0.2	-0.39	-0.49	-18.21	-37.4
-0.1	-0.39	-0.42	-17.08	-31.2
0.0	-0.36	-0.49	-14.90	-32.4

Calculation start point?

- Assume vehicle was going straight down the road at -3.0
- Begin passing maneuver left movement calculations at -2.9 seconds to impact, let data show right swerve effect on data starting at -0.8 seconds

Pre-Crash Data -5 to 0 sec [10 samples/sec] (First Recc

Time (sec)	Stability Control Lateral Acceleration (g)	Stability Control Longitudinal Acceleration (g)	Stability Control Yaw Rate (deg/sec)	Steering Wheel Angle (deg)
-3.0	-0.02	0.12	-1.94	-4.9
-2.9	0.03	0.12	-1.61	-3.2
-2.8	0.02	0.13	-0.36	0.6
-2.7	0.09	0.13	1.07	6.0
-2.6	0.12	0.12	2.74	11.1
-2.5	0.13	0.13	3.21	12.4
-2.4	0.13	0.13	2.71	10.4
-2.3	0.07	0.14	1.93	8.0
-2.2	0.07	0.14	1.57	6.4
-2.1	0.08	0.14	1.69	6.9
-2.0	0.08	0.15	1.91	7.6
-1.9	0.09	0.14	2.10	8.4
-1.8	0.10	0.15	2.38	9.1
-1.7	0.13	0.15	2.88	10.6
-1.6	0.14	0.14	3.54	13.1
-1.5	0.14	0.13	4.59	16.2
-1.4	0.19	0.12	5.38	18.1
-1.3	0.16	0.13	5.16	18.9
-1.2	0.16	0.13	5.16	18.4
-1.1	0.17	0.13	5.20	16.1
-1.0	0.15	0.13	3.26	11.8
-0.9	0.00	0.15	0.82	3.7
-0.8	-0.16	0.13	-4.53	-13.3
-0.7	-0.34	0.10	-10.53	-35.0
-0.6	-0.43	-0.02	-13.84	-52.7
-0.5	-0.36	-0.39	-13.11	-51.2
-0.4	-0.54	-0.34	-12.44	-48.3
-0.3	-0.44	-0.52	-16.87	-47.2
-0.2	-0.39	-0.49	-18.21	-37.4
-0.1	-0.39	-0.42	-17.08	-31.2
0.0	-0.38	-0.49	-14.90	-32.4

Lateral Distance from Lat Acceleration

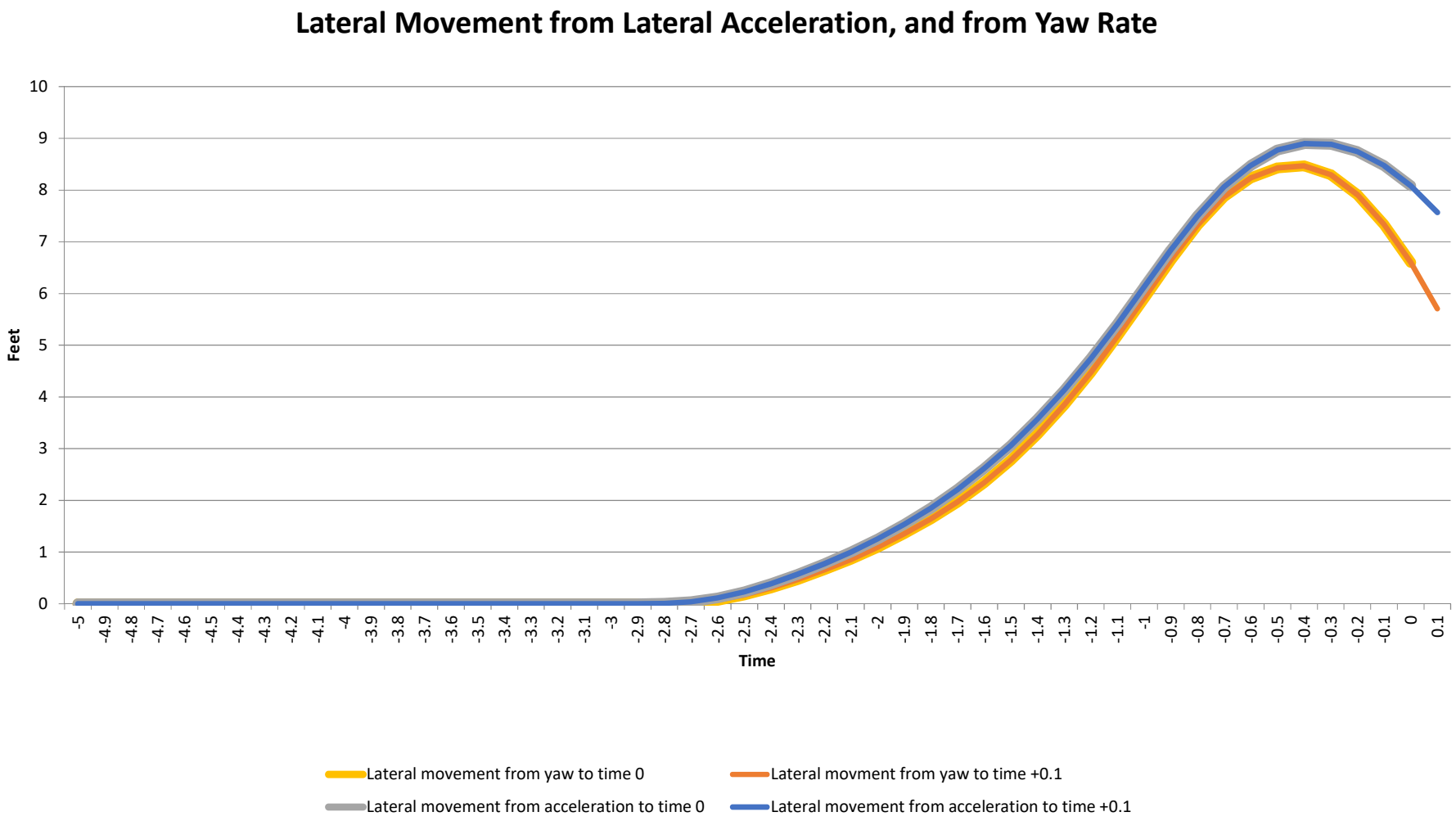
- Use $V_y=a_yt$ and calculate velocity change for each time interval
- Add velocity changes to get cumulative velocity at each interval
- Use $D=V_yt$ to get displacement change for each interval
- Add displacement changes to get cumulative displacement

- There is a free template on my website to do these calculations for you

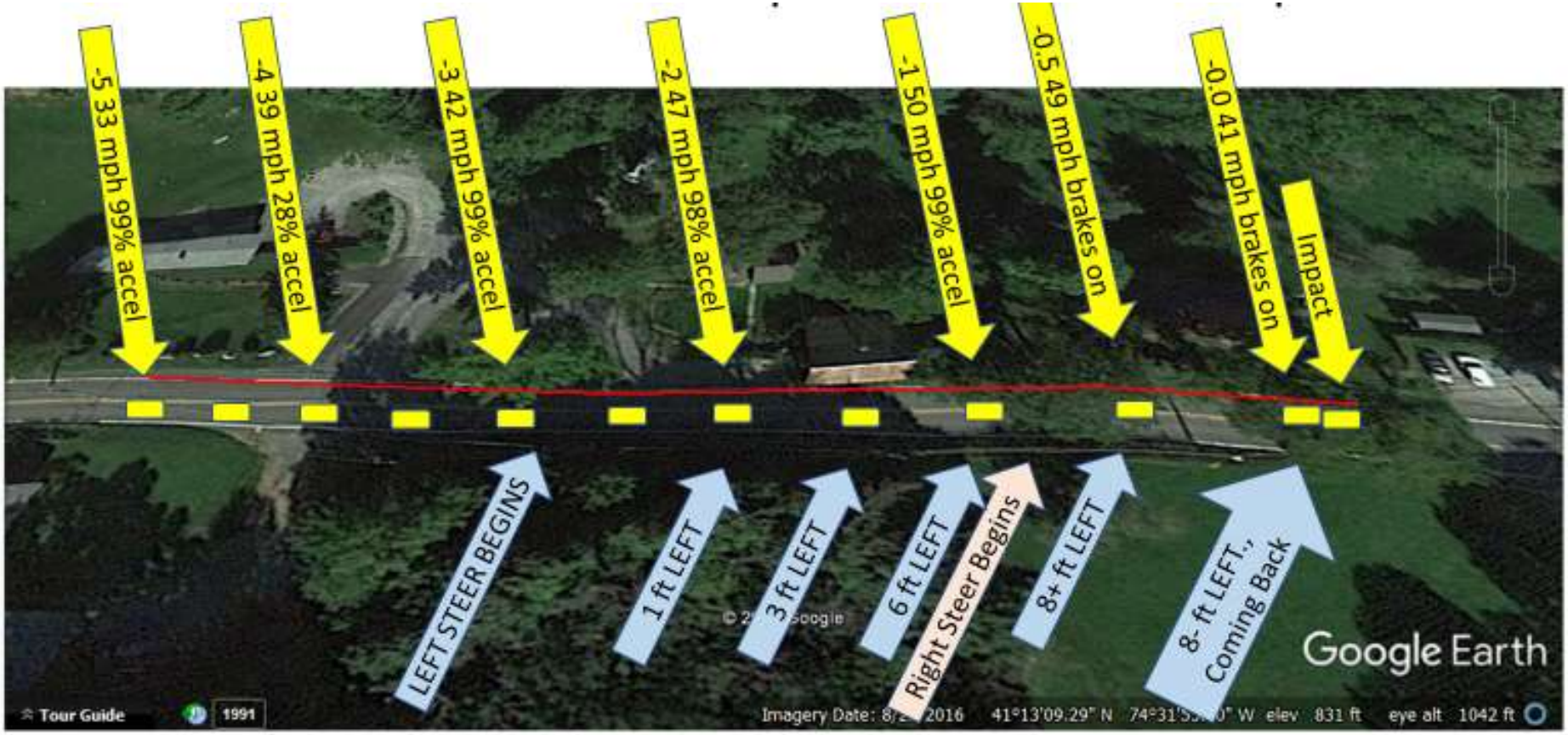
Lateral Distance from Yaw Rate

- Use yaw rate multiplied by time to get heading change for each interval
- Add up heading changes to get cumulative yaw angle
- Assume cumulative yaw angle tracks change in path of CG
- Sideways motion = Sin (cumulative yaw) * distance traveled forward this int
- Add up sideways motion from each interval to get cumulative change

- $V_y=a_yt$ and calculate velocity change for each time interval
- Add velocity changes to get cumulative velocity at each interval
- Use $D=V_yt$ to get displacement change for each interval
- Add displacement changes to get cumulative displacement


Lateral Movement from Lateral Acceleration, and from Yaw Rate
Feet
10
9
8
7
6
5
4
3
2
1
0
-5
-4.9
-4.8
-4.7
-4.6
-4.5
-4.4
-4.3
-4.2
-4.1
-4
-3.9
-3.8
-3.7
-3.6
-3.5
-3.4
-3.3
-3.2
-3.1
-3
-2.9
-2.8
-2.7
-2.6
-2.5
-2.4
-2.3
-2.2
-2.1
-2
-1.9
-1.8
-1.7
-1.6
-1.5
-1.4
-1.3
-1.2
-1.1
-1
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
Time
Lateral movement from yaw to time 0
Lateral movment from yaw to time +0.1
Lateral movement from acceleration to time 0
Lateral movement from acceleration to time +0.1

Annotate scene diagram with lateral movement



Conclusions

- Defendant's story that he had "just poked his nose out" is not consistent with 8+ feet of lateral movement. Assuming 6 ft wide cars normally in the middle of 12 ft wide lanes, moving 8 ft would put you overlapping with oncoming vehicle by 2 ft (approximately matches narrow overlap in vehicle photos).
- Defendant accelerated from -5 to -3 as part of his run up to pass, then began to pull out into other lane at -2.9 seconds. At -0.8 seconds he realized there was an oncoming vehicle and tried to abort. He was not able to get back into his lane.
- We presume he did not get past the vehicle he was intending to pass, as the vehicle being passed would have become involved in the wreck given the post crash rotation. It is assumed they did not stop to render assistance (kept going).

Discussion of Lateral Movement Limitations

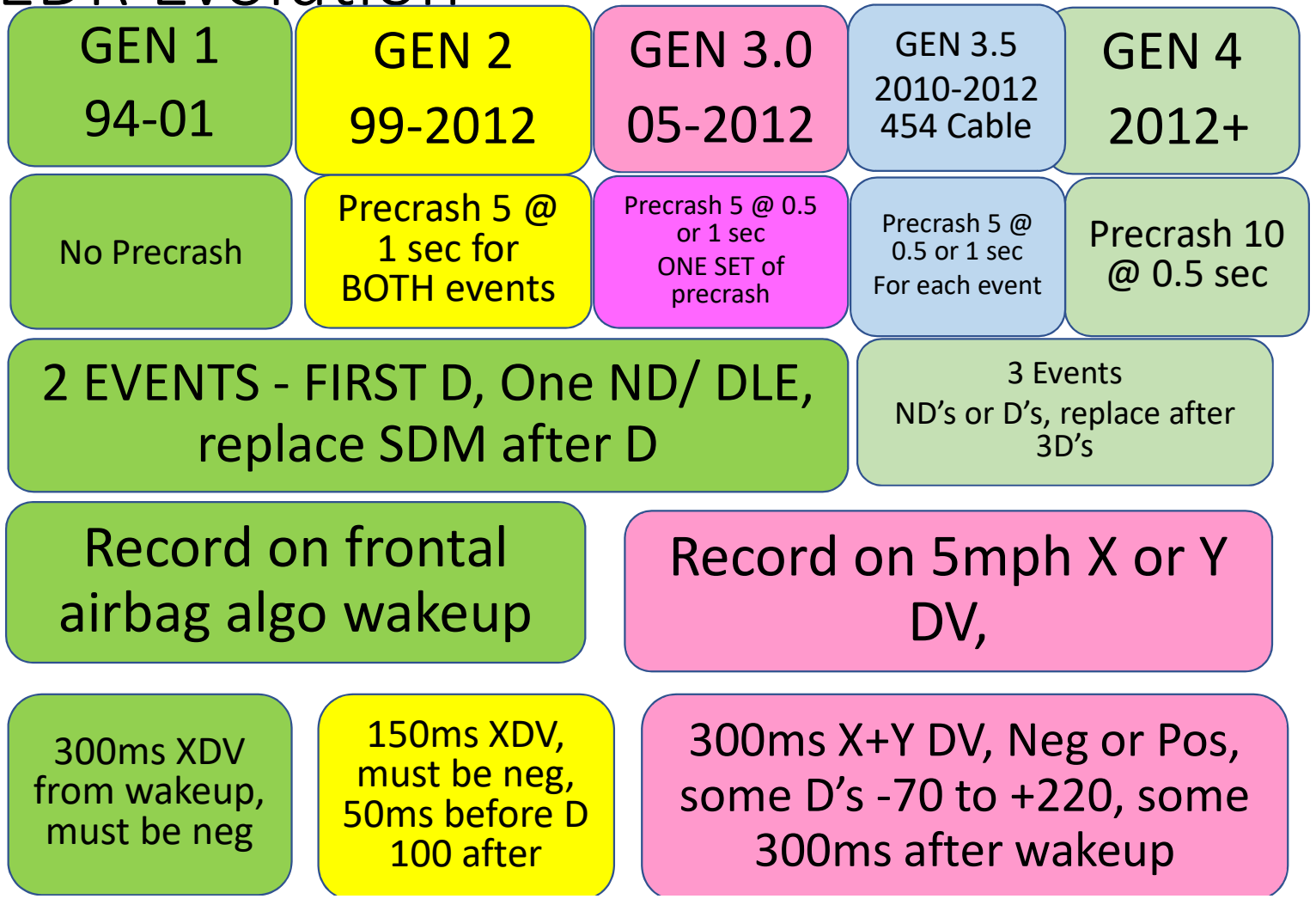
- Notice that BOTH lat accel and yaw rate were considered. Until we have more experience with stability control system data, take advantage of Ford having TWO data sources/methods available and show they both agree.
- In this case the data sources agreed closely, in other cases the two data sources have sometimes disagreed, and this reduces the confidence in any one of them. Turns from a stop or very low speed (low lat accel g's) seem to be situations where the agreement is poorer.
- Calculation accuracy depends on validity of assumption vehicle was going straight down the road, in the middle of its lane, at the start of the calculations. If road is not straight, road curvature must be considered.
- In this case, note gouge marks are slightly closer to centerline than calculations would predict.

END OF CASE STUDY 1

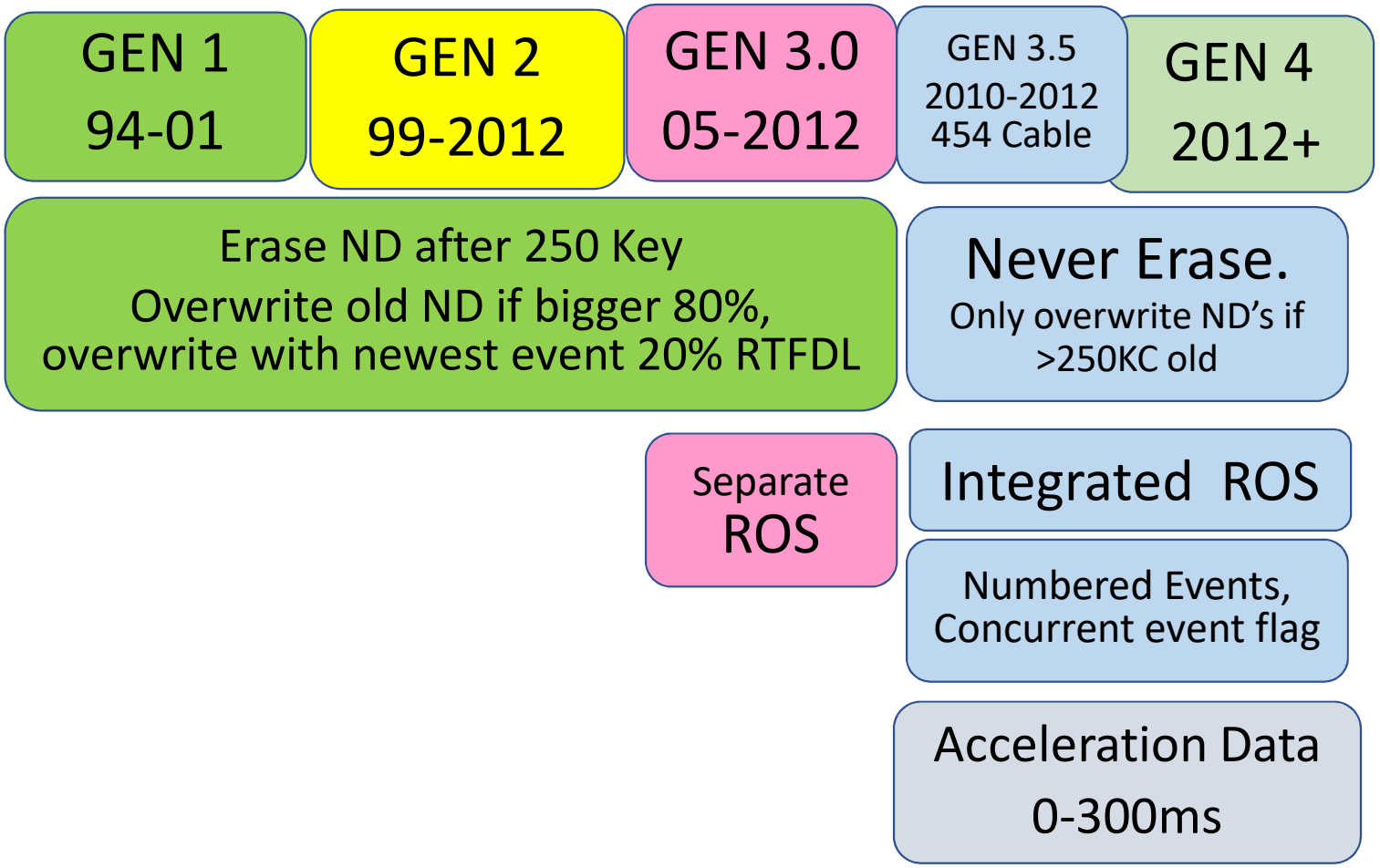
Case Study 2 – Car vs 2 Trains
Understanding 2010+ GM *Concurrent Event Flag*

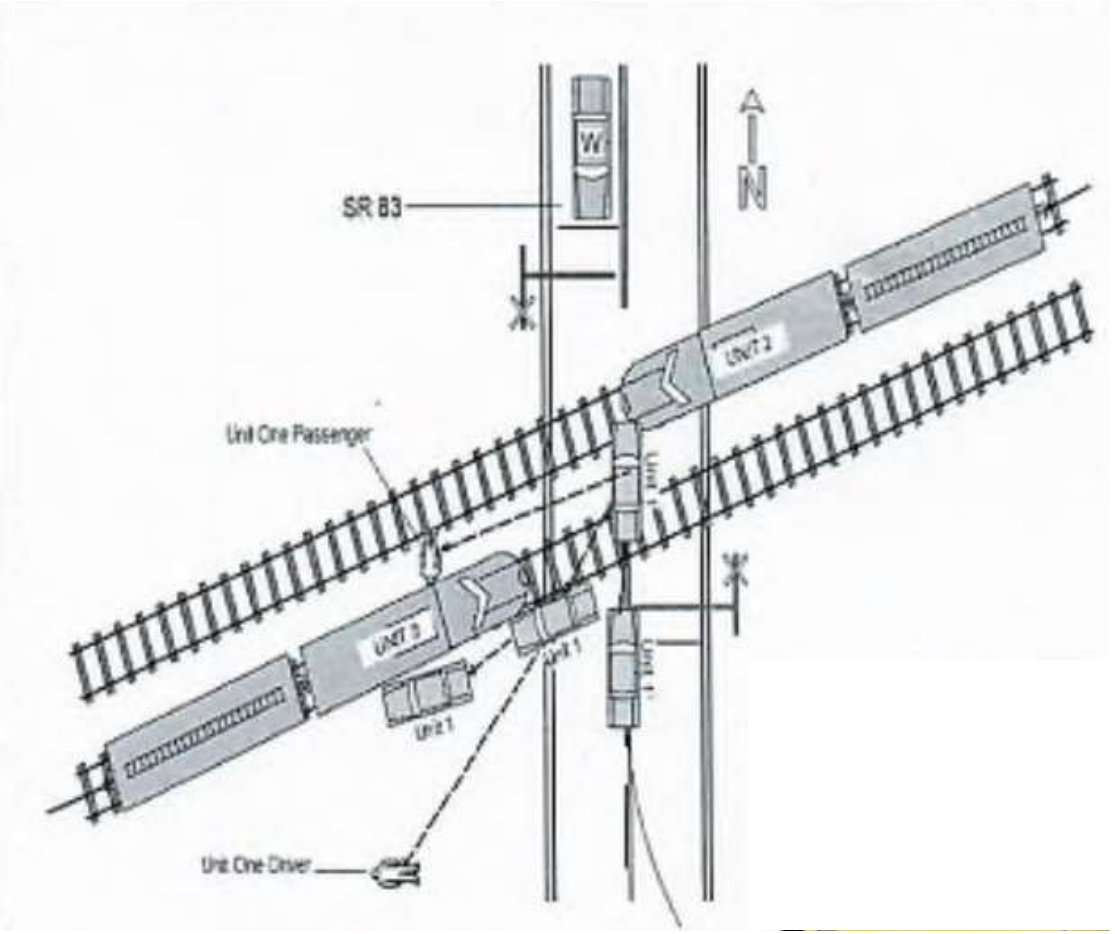
- Generation 3.5 began with the 2010 SDM-10 family.
- This family adds a ***third*** recording register, and a ***counter*** of how may events have reached the recording threshold.
- The ***rules*** for saving ND's ***change***, you CANNOT overwrite an ND until it is AT LEAST 250 key cycles old
- (Good – in a rollover this prevents overwriting start of event with end of event information).
- A new ***WARNING*** is added about what you may find when different algorithms are running concurrently

GM EDR Evolution



GM EDR Evolution #2





Unit 1 (car) was northbound on road when Unit 2 (train 1) was eastbound on thesouthern set of CSX tracks. Unit 1 struck the railroad gate and entered the railroad crossing. Unit 2 (train 1) struck/was struck by Unit 1 (car). Unit 3 (train 2) then struck Unit 1 (car). Both car occupants were ejected.

3 EVENTS IN MEMORY

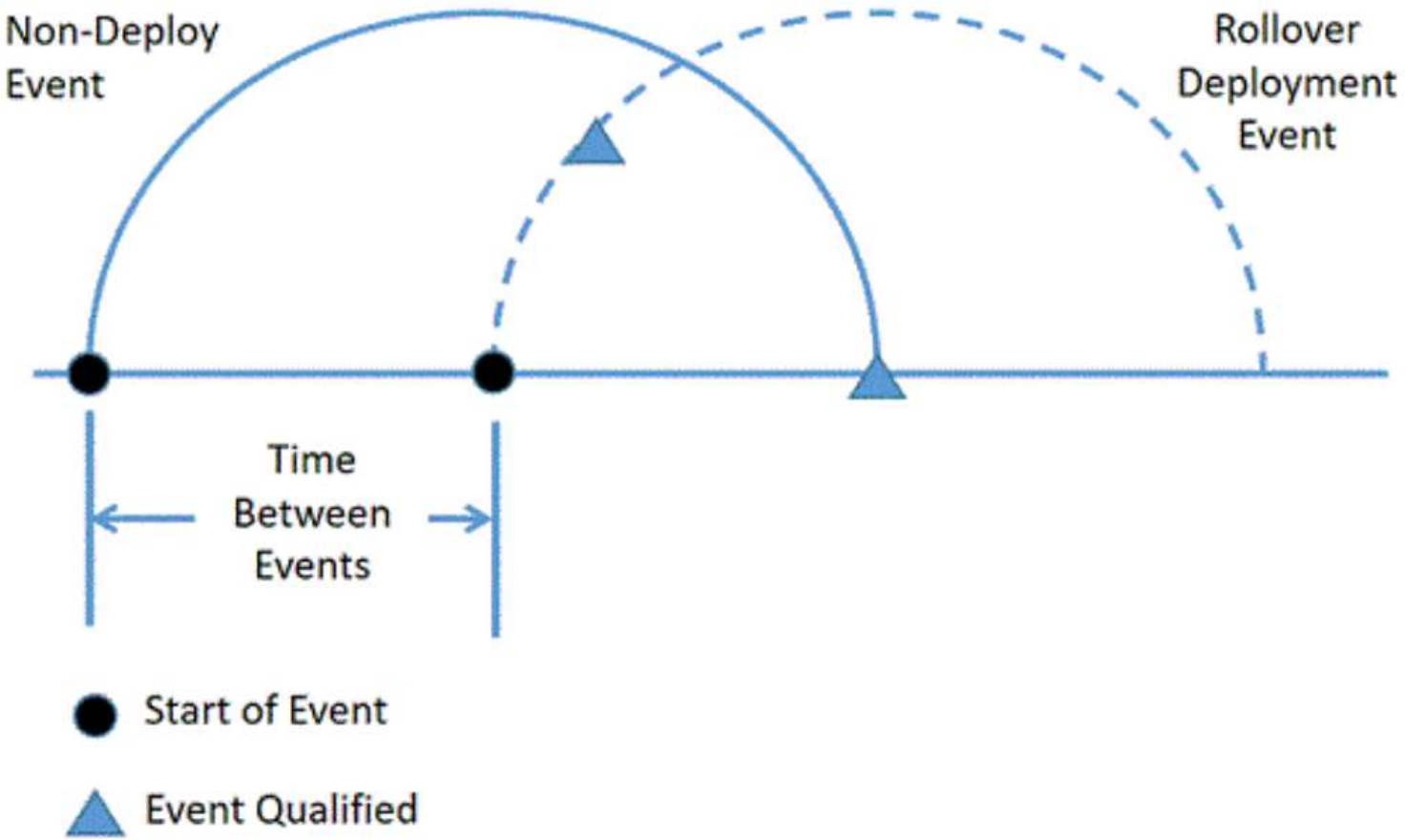
CDR File Information

User Entered VIN	1G11C5SL2FF102592
User	Tpr. Ryan Thomas
Case Number	47-0219-47
EDR Data Imaging Date	02/09/2015
Crash Date	02/05/2015
Filename	1G11C5SL2FF102592_ACM 47-0219-47.CDRX
Saved on	Monday, February 9 2015 at 09:52:02
Imaged with CDR version	Crash Data Retrieval Tool 14.2.1
Reported with CDR version	Crash Data Retrieval Tool 18.0.2
Reported with Software Licensed to (Company Name)	Ruth Consulting LLC
EDR Device Type	Airbag Control Module
Event(s) recovered	Deployment, Deployment, Deployment

Data Limitations about Concurrent event flag

Example of a Concurrent Event:

A Non-Deployment event begins. Before the Non-Deployment event is qualified, a Rollover Deployment event begins and is qualified. Sometime after the Rollover event is qualified, the Non-Deployment event is qualified. The Rollover event will be recorded in the first open record even though the Non-Deployment event enabled before the Rollover event. The Non-Deployment event will be recorded in the next open record. The "Concurrent Event Flag Set" parameter will indicate "Yes" for the Non-Deployment event. The "Time Between Events" parameter will indicate the time from the start of the Non-Deployment event to the start of the Rollover event.

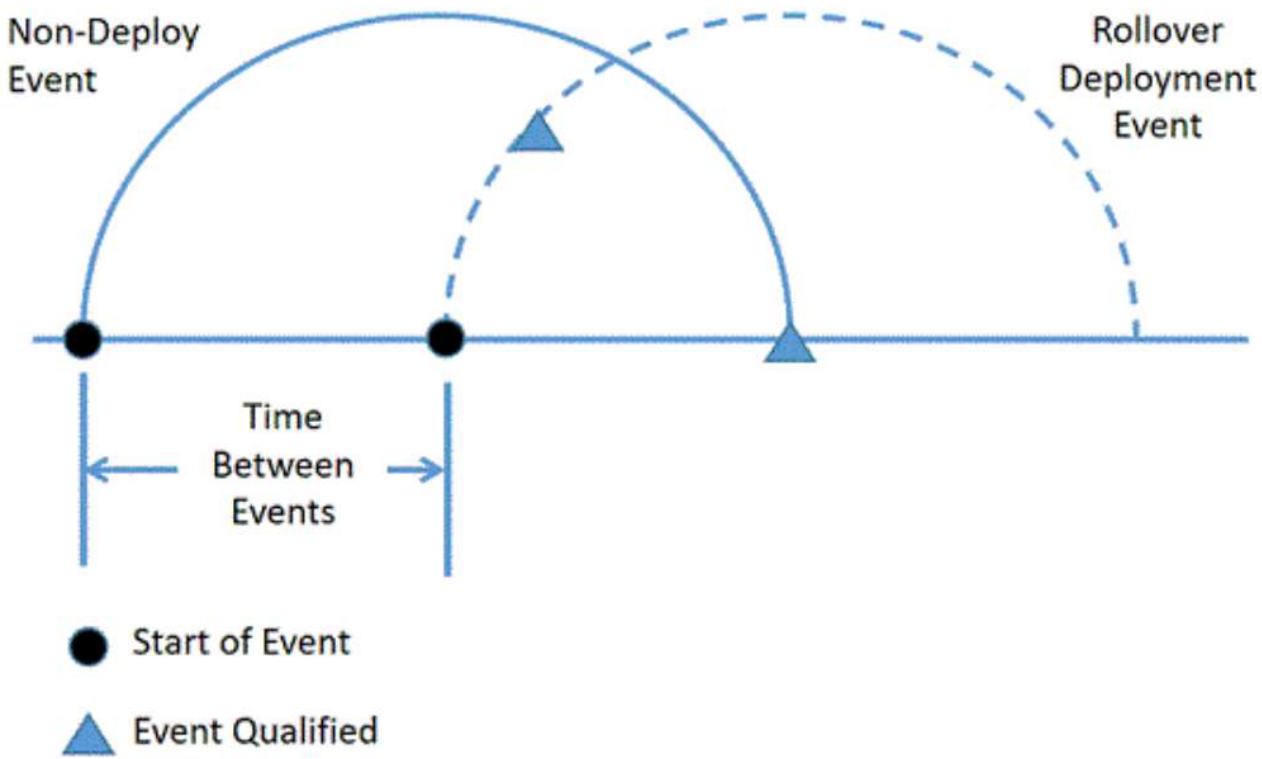


Event Record #1	**Event Record #2**
Event record Type = Rollover	Non-deployment
Concurrent Event Flag = No	Concurrent Event Flag = Yes
Time Between Events = N/A	Time Between Events = XX seconds

FIRST TRAIN HIT TO PASSENGER FRONT, SO IS SECOND HIT!

Data Limitations about Concurrent Evens

Example of a Concurrent Event:
A Non-Deployment event begins. Before the Non-Deployment event is qualified, a Rollover Deployment event begins and is qualified. Sometime after the Rollover event is qualified, the Non-Deployment event is qualified. The Rollover event will be recorded in the first open record even though the Non-Deployment event enabled before the Rollover event. The Non-Deployment event will be recorded in the next open record. The "Concurrent Event Flag Set" parameter will indicate "Yes" for the Non-Deployment event. The "Time Between Events" parameter will indicate the time from the start of the Non-Deployment event to the start of the Rollover event.



Event Record #1	**Event Record #2**
Event record Type = Rollover	Non-deployment
Concurrent Event Flag = No	Concurrent Event Flag = Yes
Time Between Events = N/A	Time Between Events = XX seconds

GM Tells us there were 5 events that met the 5mph recording threshold, but they only have 3 spaces in memory, all were deployments

System Status at Time of Retrieval

Dynamic Deployment Event Counter	3
Multi-Event, Number of Events (Dynamic Event Counter)	5
Dynamic OnStar Notification Event Counter	3

We have the first recorded event

System Status at Event (Event Record 1)

Event Record Type	Deployment
OnStar Deployment Status Data Sent	Yes
Complete file recorded (Event Recording Complete)	Yes
Crash Record Locked	Yes
OnStar SDM Recorded Vehicle Velocity Change Data Sent	Yes
Deployment Event Counter	1
Multi-Event, Number of Events (Event Counter)	1
OnStar Notification Event Counter	1
Time From Event 1 to 2 (Time Between Events) (seconds)	Data Not Available

It was a big one

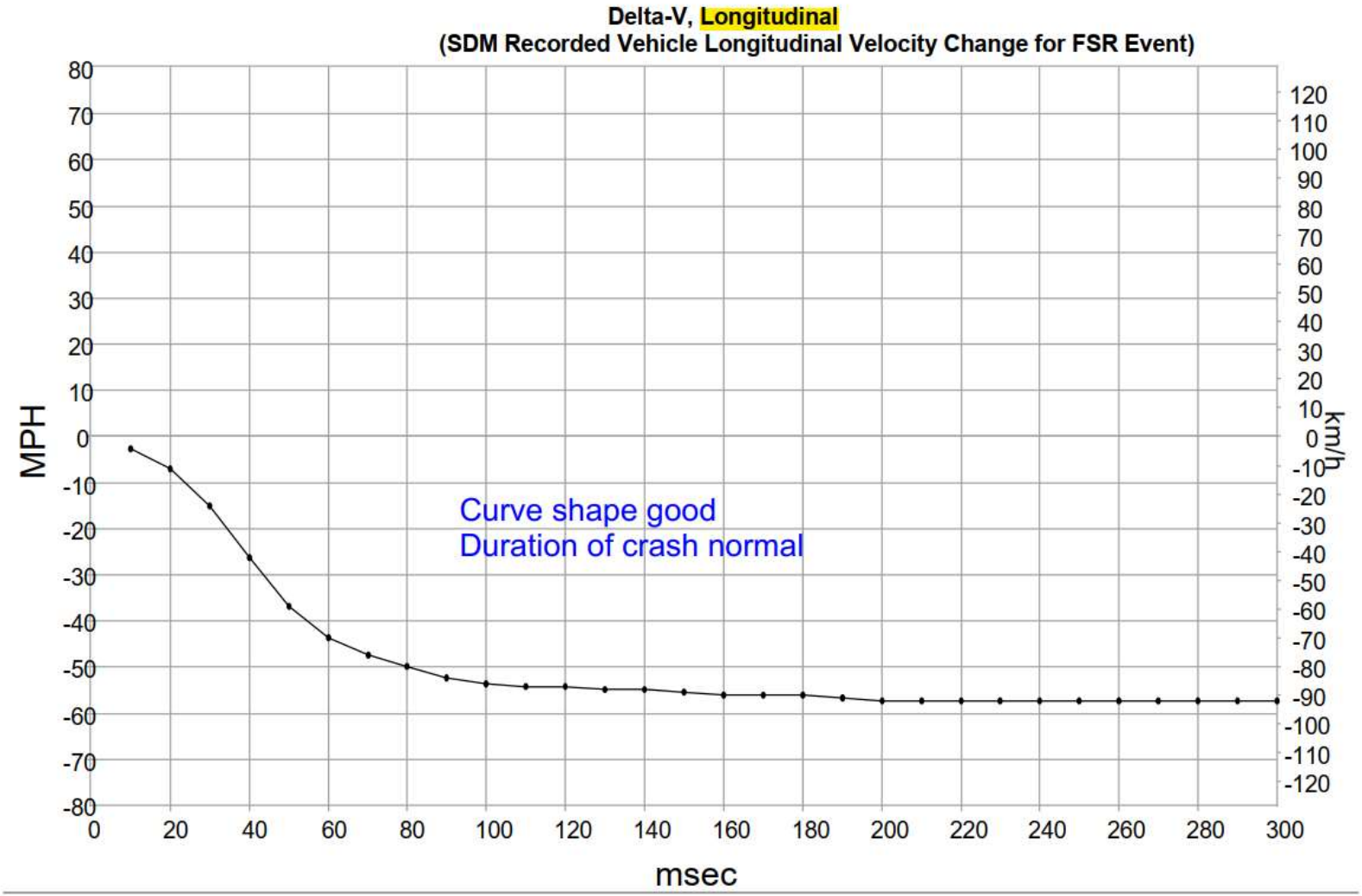
Maximum Delta-V, Longitudinal (Maximum Longitudinal SDM Recorded Vehicle Velocity Change for FSR Event) MPH [km/h]	-57 [-92]
Time, Maximum Delta-V (Time From FSR Time Zero to Maximum Longitudinal SDM Recorded Vehicle Velocity Change)(msec)	222
Maximum Delta-V, Lateral (Maximum Lateral SDM Recorded Vehicle Velocity Change for FSR Event) MPH [km/h]	-39 [-62]
Time Maximum Delta-V, Lateral (Time From FSR Time Zero to Maximum Lateral SDM Recorded Vehicle Velocity Change)(msec)	88
High Voltage Disable Notification Sent	Yes
Deployment Commanded in Energy Reserve Mode Power Lost at Impact	Yes

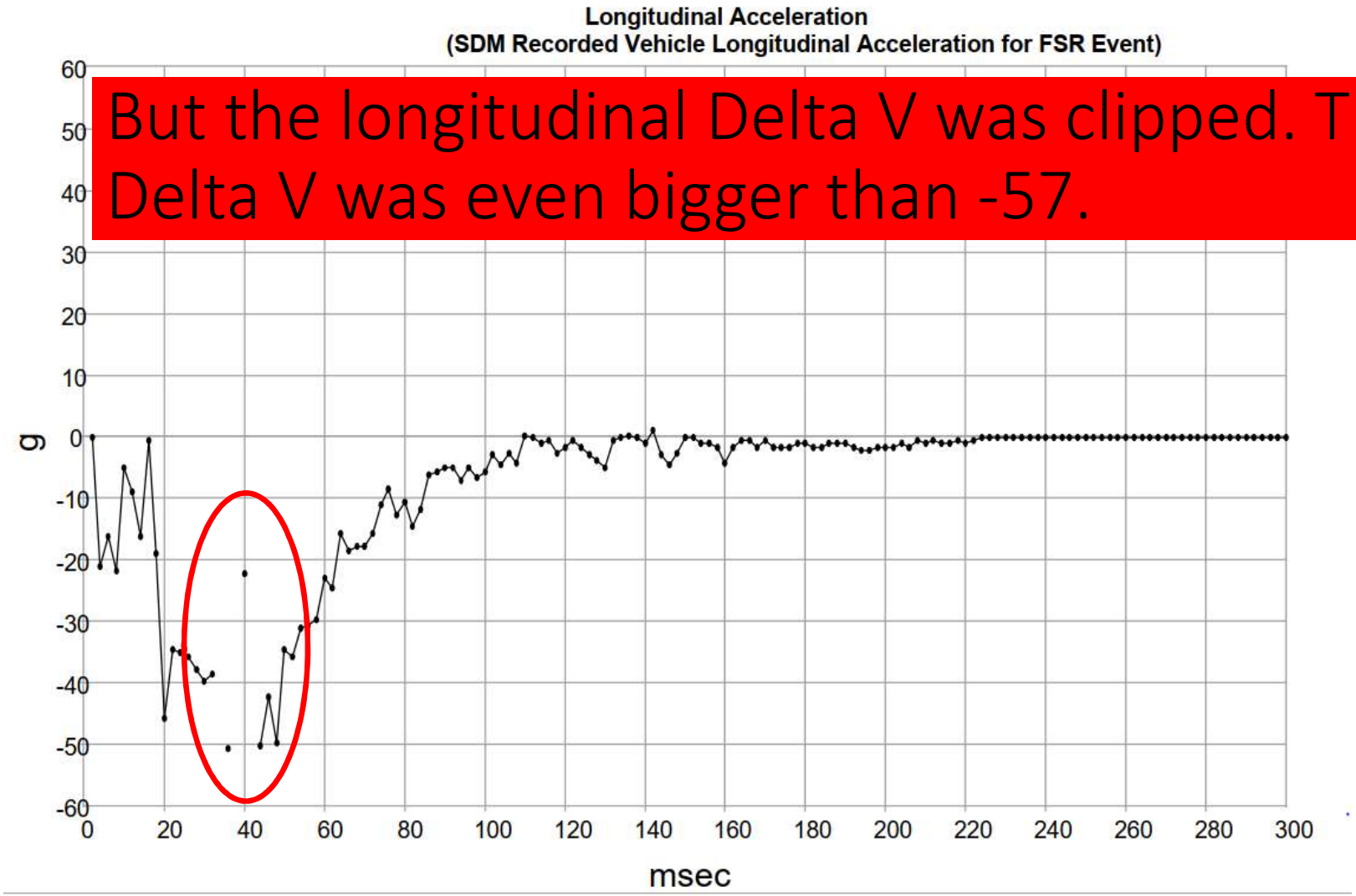
It blew almost every airbag

Event Data (Event Record 1)

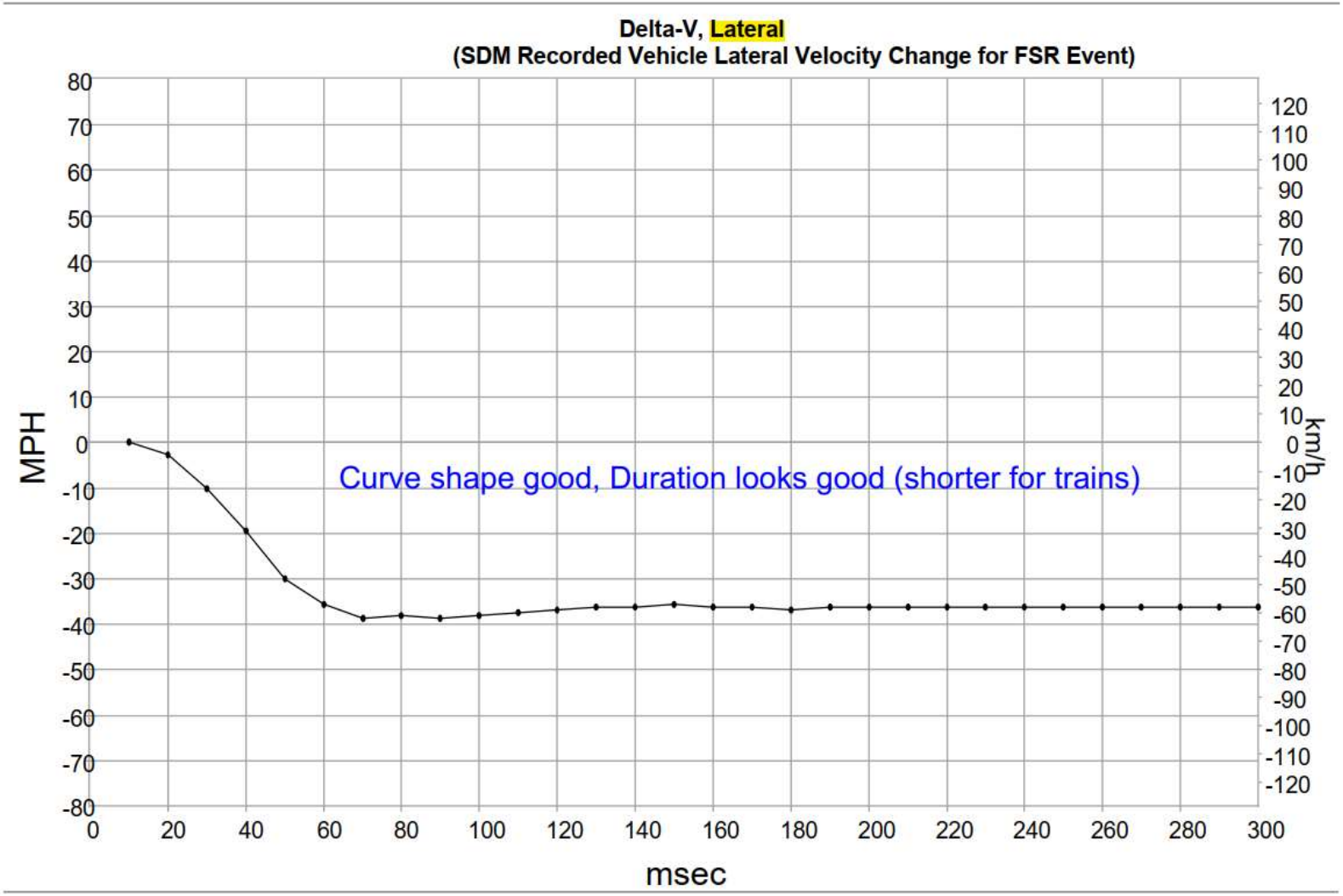
Driver 1st Stage Deployment Loop Commanded		Yes
Passenger 1st Stage Deployment Loop Commanded		Yes
Driver 2nd Stage Deployment Loop Commanded		Yes
Passenger 2nd Stage Deployment Loop Commanded		Yes
Driver Pretensioner Deployment Loop #1 Commanded		Yes
Passenger Pretensioner Deployment Loop #1 Commanded		Yes
Driver Pretensioner Deployment Loop #2 Commanded		Yes
Passenger Pretensioner Deployment Loop #2 Commanded		Yes
Driver Thorax Loop Commanded	Not the struck side	No
Passenger Thorax Loop Commanded		Yes
Left Row 2 Thorax Loop Commanded	Not the struck side	No
Right Row 2 Thorax Loop Commanded		Yes
Left Row 1 Roof Rail/Head Curtain Loop Commanded		Yes
Right Row 1 Roof Rail/Head Curtain Loop Commanded		Yes
Driver Knee Deployment Loop Commanded		Yes
Passenger Knee Deployment Loop Commanded		Yes
Frontal Air Bag Deployment, Time to 1st Stage Deployment, Driver (Driver 1st		

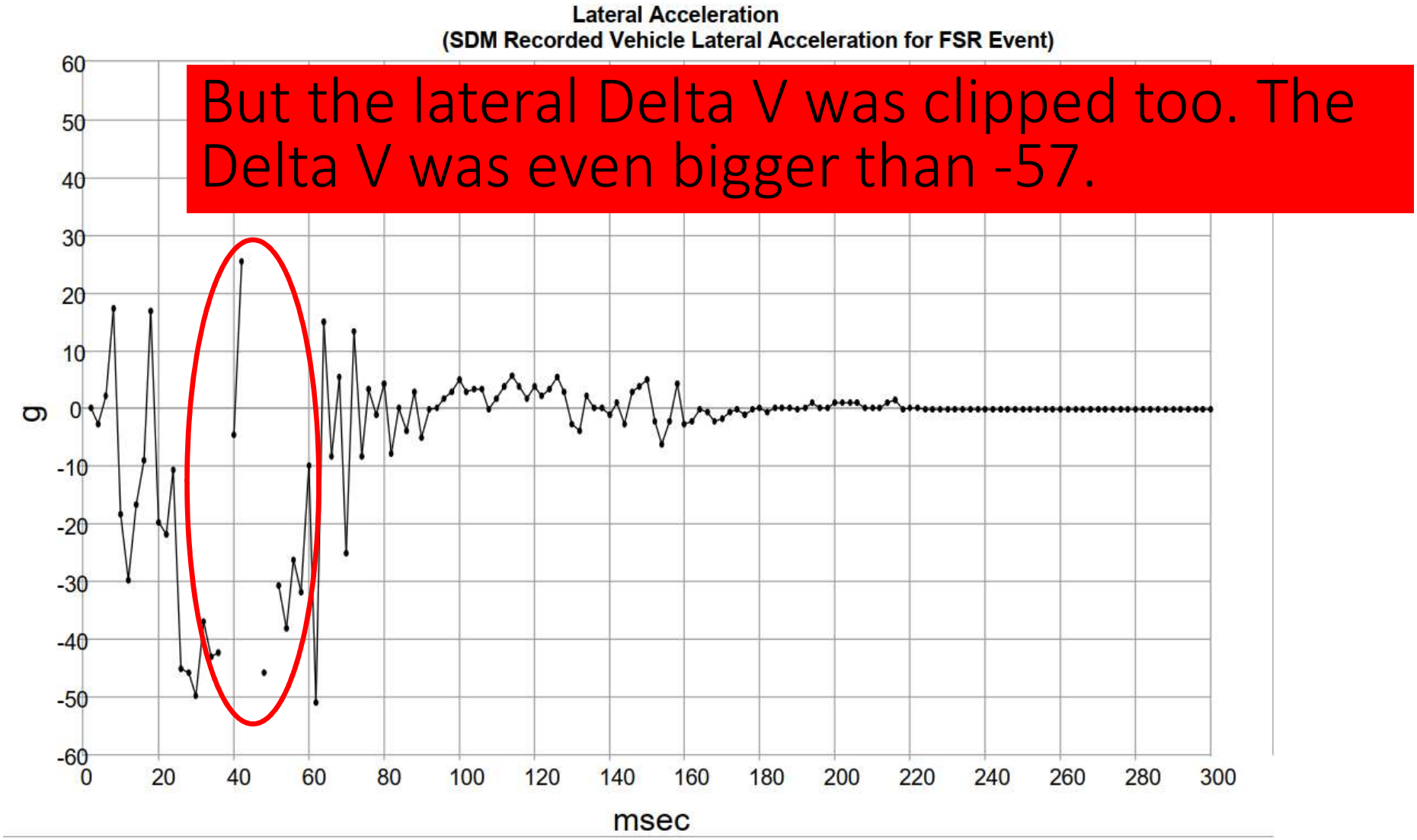
Longitudinal Crash Pulse (Event Record 1)




Longitudinal Acceleration
(SDM Recorded Vehicle Longitudinal Acceleration for FSR Event)
But the longitudinal Delta V was clipped. The Delta V was even bigger than -57.
g
msec
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

Lateral Crash Pulse (Event Record 1)




Lateral Acceleration
(SDM Recorded Vehicle Lateral Acceleration for FSR Event)
But the lateral Delta V was clipped too. The Delta V was even bigger than -57.
g
msec
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

Coming in to train tracks way too hot???

Pre-Crash Data -5.0 to -0.5 sec (Event Record 1)

Times (sec)	Accelerator Pedal, % Full (Accelerator Pedal Position)	Service Brake (Brake Switch Circuit State)	Engine RPM (Engine Speed)	Engine Throttle, % Full (Throttle Position)	Speed, Vehicle Indicated (Vehicle Speed) (MPH [km/h])
-5.0	0	On	1216	3	45 [73]
-4.5	0	On	1216	3	44 [71]
-4.0	0	On	1152	3	43 [69]
-3.5	0	On	1088	3	41 [66]
-3.0	0	On	1088	3	38 [61]
-2.5	0	On	1088	4	31 [50]
-2.0	33	Off	1408	42	30 [49]
-1.5	0	Off	2432	32	30 [49]
-1.0	0	On	1536	24	23 [37]
-0.5	0	On	1152	2	11 [17]

0.75 seconds between events – or is it????

System Status at Event (Event Record 2)

Event Record Type	Deployment
OnStar Deployment Status Data Sent	Yes
Complete file recorded (Event Recording Complete)	Yes
Crash Record Locked	Yes
OnStar SDM Recorded Vehicle Velocity Change Data Sent	Yes
Deployment Event Counter	2
Multi-Event, Number of Events (Event Counter)	2
OnStar Notification Event Counter	2
Time From Event 1 to 2 (Time Between Events) (seconds)	0.75
Concurrent Event Flag Set This means you are going to be confused	Yes

No Delta V for Event Record 2 – a CLUE it is a rollover – GM does not record DV in rollovers

Maximum Delta-V, Longitudinal (Maximum Longitudinal SDM Recorded Vehicle Velocity Change for FSR Event) MPH [km/h]	Data Not Available
Time, Maximum Delta-V (Time From FSR Time Zero to Maximum Longitudinal SDM Recorded Vehicle Velocity Change)(msec)	Data Not Available
Maximum Delta-V, Lateral (Maximum Lateral SDM Recorded Vehicle Velocity Change for FSR Event) MPH [km/h]	Data Not Available
Time Maximum Delta-V, Lateral (Time From FSR Time Zero to Maximum Lateral SDM Recorded Vehicle Velocity Change)(msec)	Data Not Available
High Voltage Disable Notification Sent	Yes
Deployment Commanded in Energy Reserve Mode	Yes

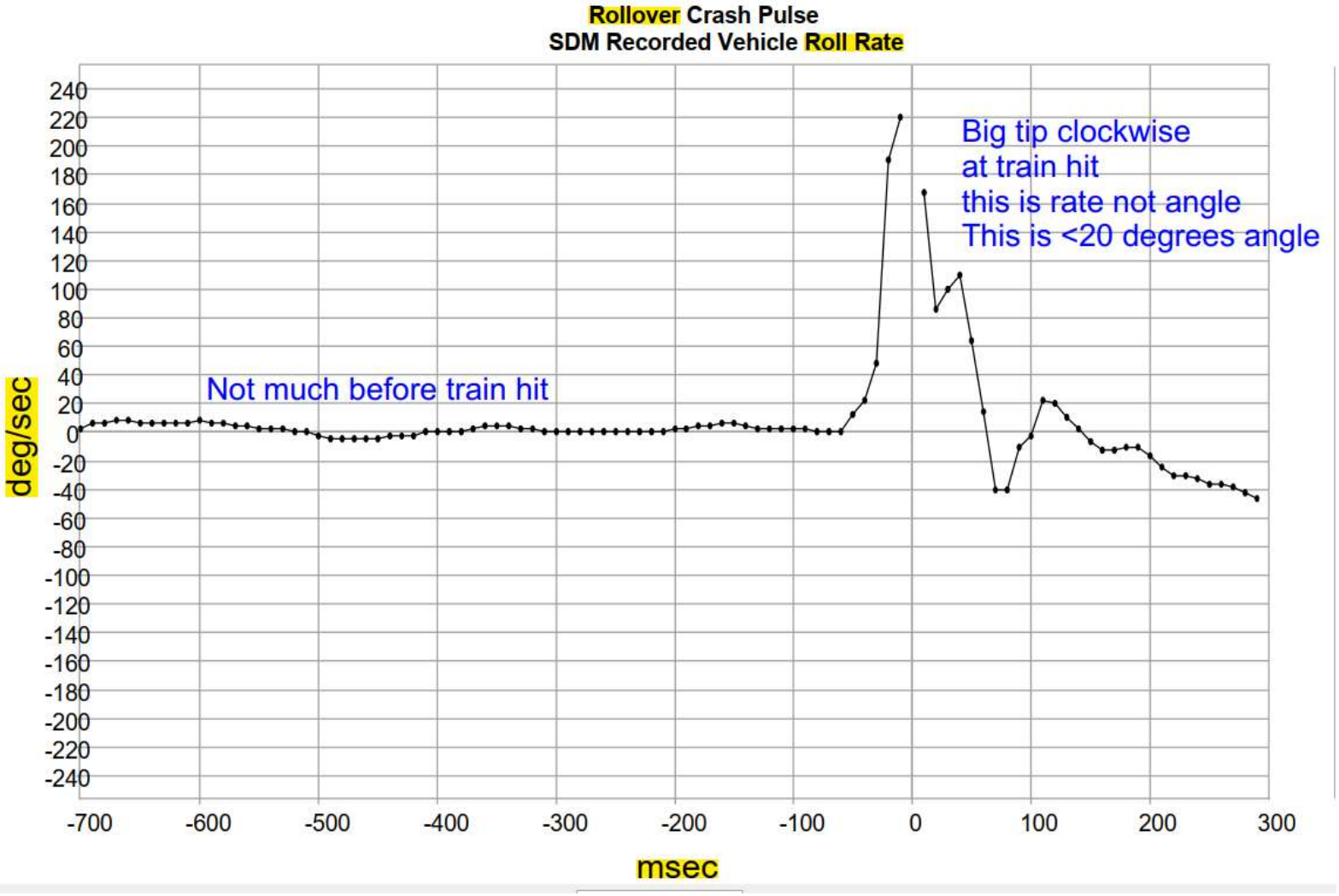
Event Data (Event Record 2)

Driver 1st Stage Deployment Loop Commanded	No
Passenger 1st Stage Deployment Loop Commanded	No
Driver 2nd Stage Deployment Loop Commanded	No
Passenger 2nd Stage Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop #1 Commanded	No
Passenger Pretensioner Deployment Loop #1 Commanded	No
Driver Pretensioner Deployment Loop #2 Commanded	No
Passenger Pretensioner Deployment Loop #2 Commanded	No
Driver Thorax Loop Commanded	No
Passenger Thorax Loop Commanded	No
Left Row 2 Thorax Loop Commanded	No
Right Row 2 Thorax Loop Commanded	No
Left Row 1 Roof Rail/Head Curtain Loop Commanded	No
Right Row 1 Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No

Why didn't anything deploy? See Data Limitations!

-Once a firing loop has been commanded to be deployed, it will not be commanded to be deployed again during the same ignition cycle. Firing loop times for subsequent deployment type events, during the same ignition cycle, will record the deployment times as N/A.

Rollover Crash Pulse (Event Record 2)



Event 2 Precrash – looks like Before #1??

Pre-Crash Data -5.0 to -0.5 sec (Event Record 2)

Times (sec)	Accelerator Pedal, % Full (Accelerator Pedal Position)	Service Brake (Brake Switch Circuit State)	Engine RPM (Engine Speed)	Engine Throttle, % Full (Throttle Position)	Speed, Vehicle Indicated (Vehicle Speed) (MPH [km/h])	Rec 1
-5.0	0	On	1216	3	47 [75]	
-4.5	0	On	1216	3	45 [73]	45
-4.0	0	On	1216	3	44 [71]	44
-3.5	0	On	1152	3	43 [69]	43
-3.0	0	On	1088	3	41 [66]	41
-2.5	0	On	1088	3	38 [61]	38
-2.0	0	On	1088	4	31 [50]	31
-1.5	33	Off	1408	42	30 [49]	30
-1.0	0	Off	2432	32	30 [49]	30
-0.5	0	On	1536	24	23 [37]	23
						11

Record 3 (4th to qualify) 1.01 seconds after what?

System Status at Event (Event Record 3)

Event Record Type	Deployment
OnStar Deployment Status Data Sent	Yes
Complete file recorded (Event Recording Complete)	Yes
Crash Record Locked	Yes
OnStar SDM Recorded Vehicle Velocity Change Data Sent	Yes
Deployment Event Counter	3
Multi-Event, Number of Events (Event Counter)	4
OnStar Notification Event Counter	3
Time From Event 1 to 2 (Time Between Events) (seconds)	1.01
Concurrent Event Flag Set	No

Record 3 Delta V summary

Maximum Delta-V, Longitudinal (Maximum Longitudinal SDM Recorded Vehicle Velocity Change for FSR Event) MPH [km/h]	Backwards?	1 [2]
Time, Maximum Delta-V (Time From FSR Time Zero to Maximum Longitudinal SDM Recorded Vehicle Velocity Change)(msec)		120
Maximum Delta-V, Lateral (Maximum Lateral SDM Recorded Vehicle Velocity Change for FSR Event) MPH [km/h]	Pass Side	-5 [-8]
Time Maximum Delta-V, Lateral (Time From FSR Time Zero to Maximum Lateral SDM Recorded Vehicle Velocity Change)(msec)		102

It said it's a deployment, but what deployed?

Event Data (Event Record 3)

Driver 1st Stage Deployment Loop Commanded	No
Passenger 1st Stage Deployment Loop Commanded	No
Driver 2nd Stage Deployment Loop Commanded	No
Passenger 2nd Stage Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop #1 Commanded	No
Passenger Pretensioner Deployment Loop #1 Commanded	No
Driver Pretensioner Deployment Loop #2 Commanded	No
Passenger Pretensioner Deployment Loop #2 Commanded	No
Driver Thorax Loop Commanded	No
Passenger Thorax Loop Commanded	No
Left Row 2 Thorax Loop Commanded	No
Right Row 2 Thorax Loop Commanded	No
Left Row 1 Roof Rail/Head Curtain Loop Commanded	No
Right Row 1 Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No

-Once a firing loop has been commanded to be deployed, it will not be commanded to be deployed again during the same ignition cycle. Firing loop times for subsequent deployment type events, during the same ignition cycle, will record the deployment times as N/A.

Precrash Data

Pre-Crash Data -5.0 to -0.5 sec (Event Record 3)

Times (sec)	Accelerator Pedal, % Full (Accelerator Pedal Position)	Service Brake (Brake Switch Circuit State)	Engine RPM (Engine Speed)	Engine Throttle, % Full (Throttle Position)	Speed, Vehicle Indicated (Vehicle Speed) (MPH [km/h])
-5.0	0	On	1088	3	41
-4.5	0	On	1088	3	38
-4.0	0	On	1088	4	31
-3.5	33	Off	1408	42	30
-3.0	0	Off	2432	32	30
-2.5	0	On	1536	24	23
-2.0	0	On	1152	2	11
-1.5	65	Off	1280	42	17
-1.0	Data Not Available	Off	Data Not Available	Data Not Available	Data Not Available
-0.5	Data Not Available	Off	Data Not Available	Data Not Available	Data Not Available

Power Loss

R1 R2 R3

R1	R2
	47
45	45
44	44
43	43
41	41
38	38
31	31
30	30
30	30
23	23
11	

Comparing precrash speed from 3 events

Times (sec)	Speed, Vehicle Indicated (Vehicle Speed) (MPH [km/h]) R3	R1	R2
		47	
		45	45
		44	44
		43	43
-5.0	41	41	41
-4.5	38	38	38
-4.0	31	31	31
-3.5	30	30	30
-3.0	30	30	30
-2.5	23	23	23
-2.0	11	11	
-1.5	17		
-1.0	Data Not Available	Power Loss	
-0.5	Data Not Available		

- Record 1 says it QUALIFIED first, no time between events because it was first. Big Delta V's!
- Record 2 says it QUALIFIED second (rollover), 0.75 sec time between events to previous wakeup (likely R1). Rolled <20 deg.
- Record 3 says it QUALIFIED fourth, 1.01 sec between it and previous wake-up (likely third event to qualify, overwritten because it was an ND).

Conclusions from Analysis

- Driver came in to train tracks WAY TOO HOT
- Likely distracted driving, took out train gate, did not try to drive around it – not your typical “beat the train” case
- Initial hit generated TWO events – a very severe frontal event and then a rollover event.
- Vehicle gets spun around, has minor altercation with second train. Created additional event. Two other events qualified for recording but there were only 3 spaces in memory, so the deployments got priority. The one second between events in Record 3 is the time to the previous wake-up.
- After the initial event we only care because This is collateral damage but must be explained since it is in the file.

Moral of the Story

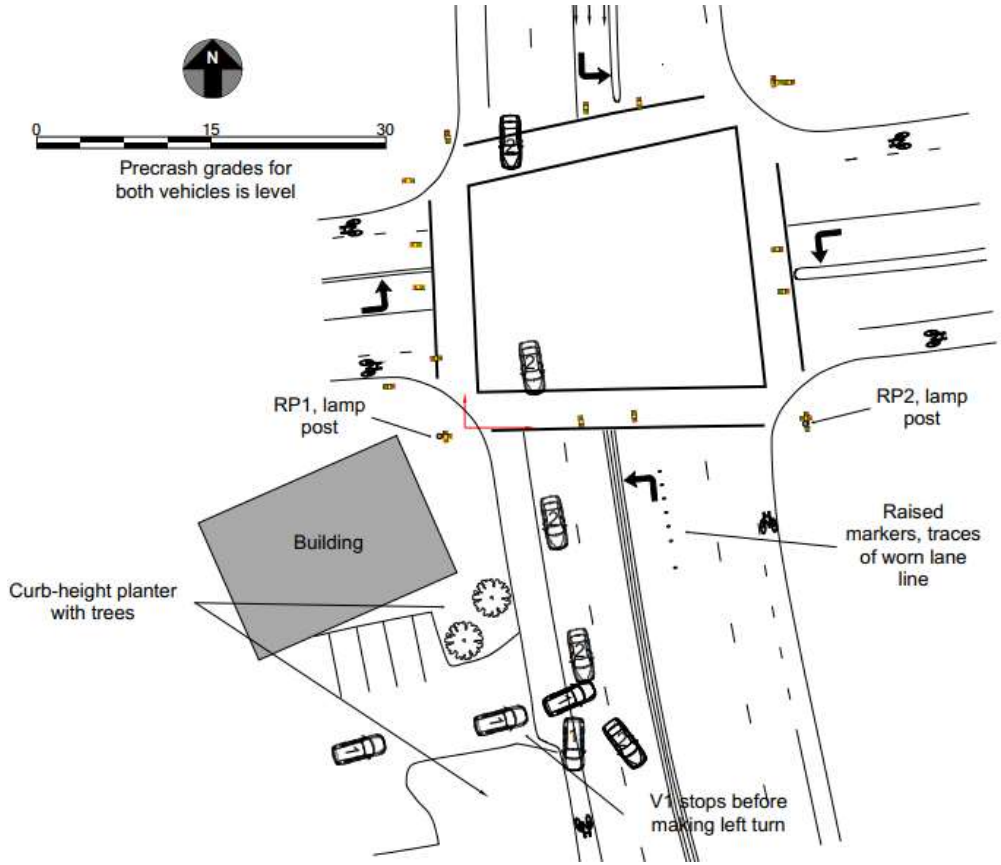
- IF you have a 2010+ GM (SDM-10 or later) with multiple events, IMMEDIATELY OVERLAY THE PRECRASH DATA from the multiple events. Use the one with the oldest data as the first event.
- DO NOT rely upon the time between events. It is the time between an event and the prior WAKEUP, that wakeup may not have even qualified for recording and may not be anywhere in the memory.
- Wakeups that do not QUALIFY for recording may not even be acknowledged in the event numbering system

- END OF CASE STUDY 2

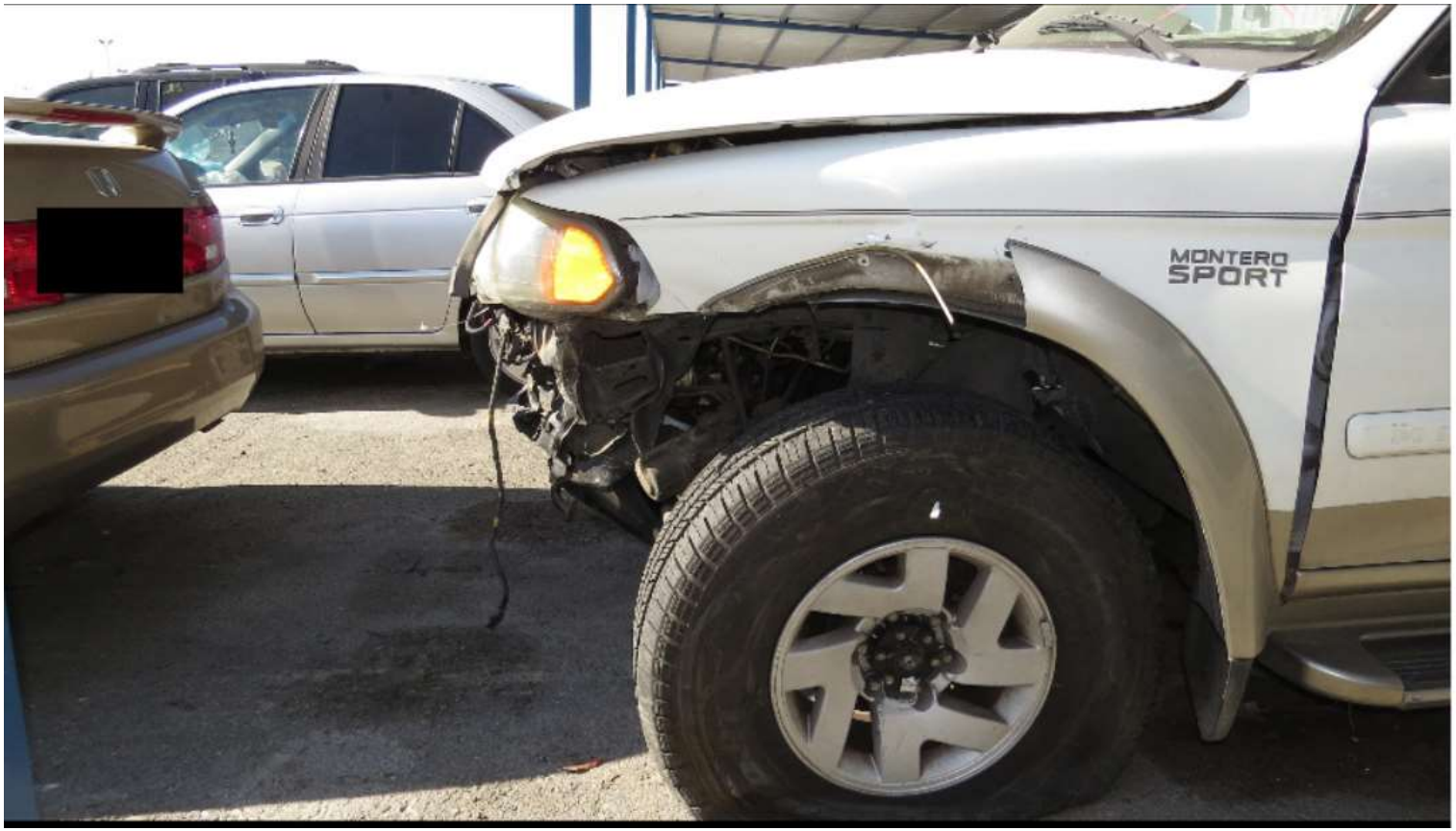
NEW NHTSA CISS DATABASE

- https://crashviewer.nhtsa.dot.gov/CISS/SearchIndex
- NHTSA recently loaded a sample of the 2016 Crash Investigation Sampling System cases
- Searchable by manufacturer, model year, model, EDR data available, driver assist technology available, etc
- Great source of info on what to expect in your vehicle's EDR, confirmation of EDR polarity, etc.

Case Study 3 CISS 1-33-2016-048-03
Mitsubishi Pulls out in front of Toyota

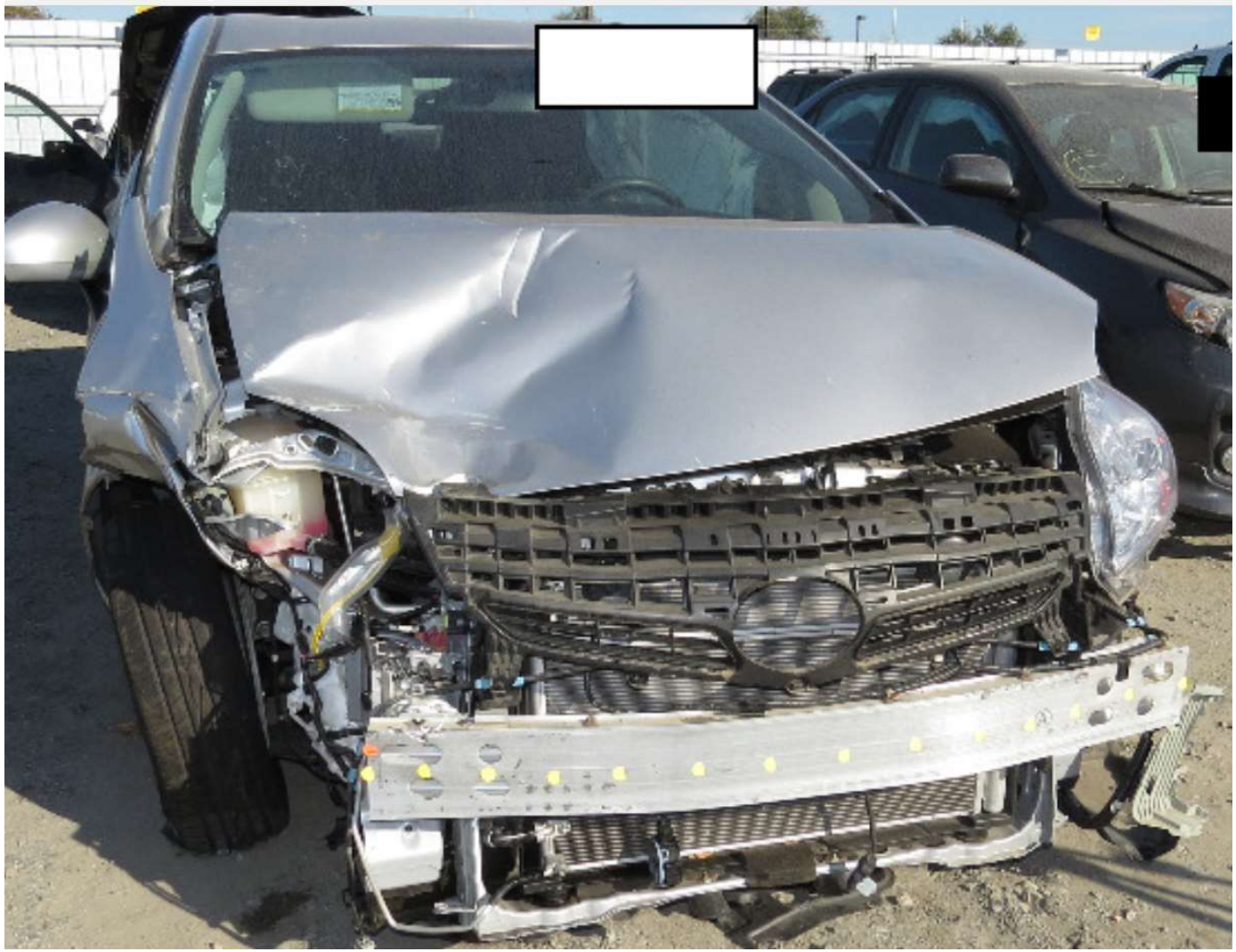


00 Mitsubishi Montero Driver Front Side



001 Mitsubishi Montero Front Corner

14 Toyota Prius Front Pass Corner



3 events recovered in 14 Toyota Prius

CDR File Information

User Entered VIN/Frame Number	JTDKN3DU5E0******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	20161033048_V2_ACM PRIUS.CDRX
Saved on	Monday, November 14 2016 at 11:28:41
Imaged with CDR version	Crash Data Retrieval Tool 16.6
Reported with CDR version	Crash Data Retrieval Tool 18.0.2
Reported with Software Licensed to (Company Name)	Ruth Consulting LLC
EDR Device Type	Airbag Control Module
Event(s) recovered	Front/Rear (2), Side (1)

System Status at Time of Retrieval

ECU Part Number	89170-47540
EDR Generation	13EDR
Complete File Recorded	Yes
Freeze Signal	ON
Freeze Signal Factor	Front Airbag Deployment
Diagnostic Trouble Codes Exist	No
Ignition Cycle ,Download (times)	6999
Multi-event, number of events (times)	2 or greater
Time from event 1 to 2 (s)	-0.008
Time from Previous Pre Crash TRG (msec)	16381 or greater
Latest Pre-Crash Page	1
Contains Unlinked Pre-Crash Data	No

Event Record Summary at Retrieval

Events Recorded	TRG Count	Crash Type	Time (msec)	Pre-Crash & DTC Data Recording Status	Event & Crash Pulse Data Recording Status
Most Recent Event	3	Front/Rear Crash	0	Complete (Page 1)	Complete (Front/Rear Page 1)
1st Prior Event	2	Side Crash	8	Complete (Page 1)	Complete (Side Page 0)
2nd Prior Event	1	Front/Rear Crash	-16381 or greater	Complete (Page 0)	Complete (Front/Rear Page 0)

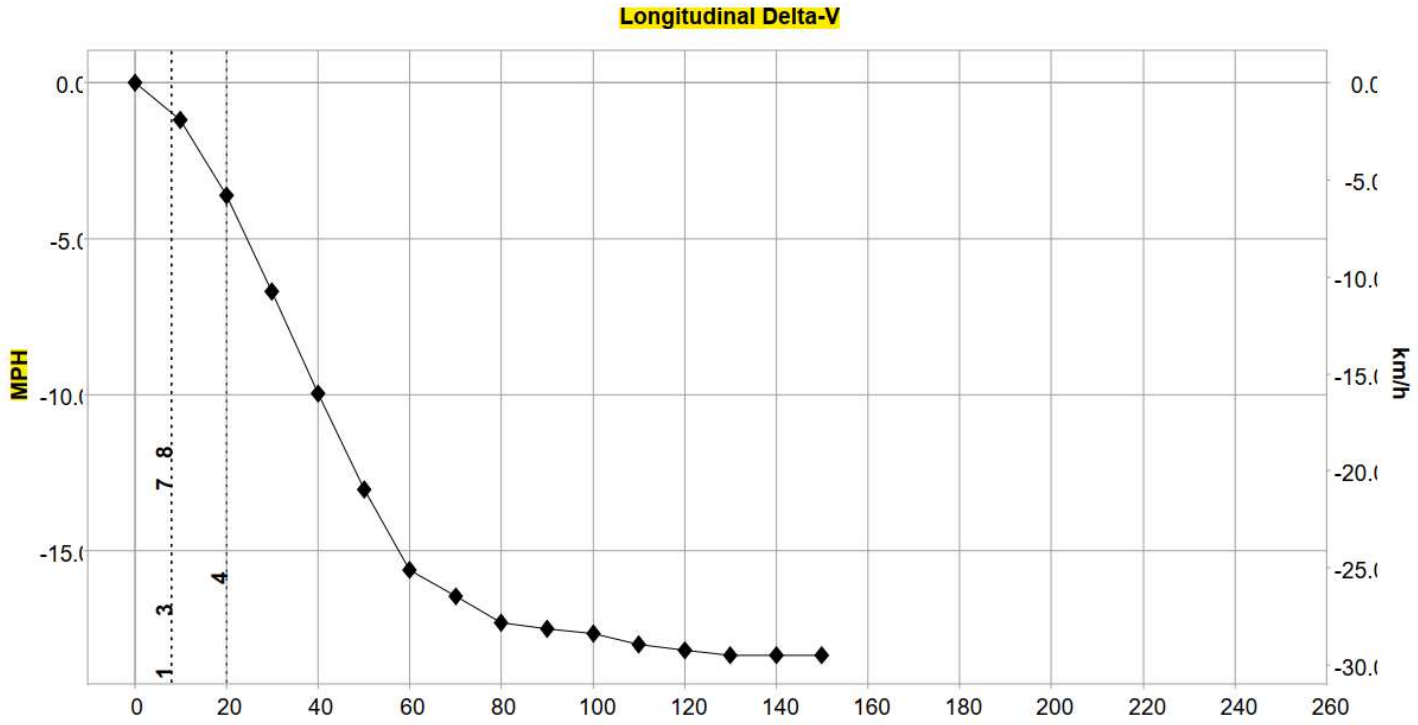
Events 2 and 3 are a pair that go together. Because it is a 13 EDR all the data we need is in the Frontal Event. Event 1 is unrelated

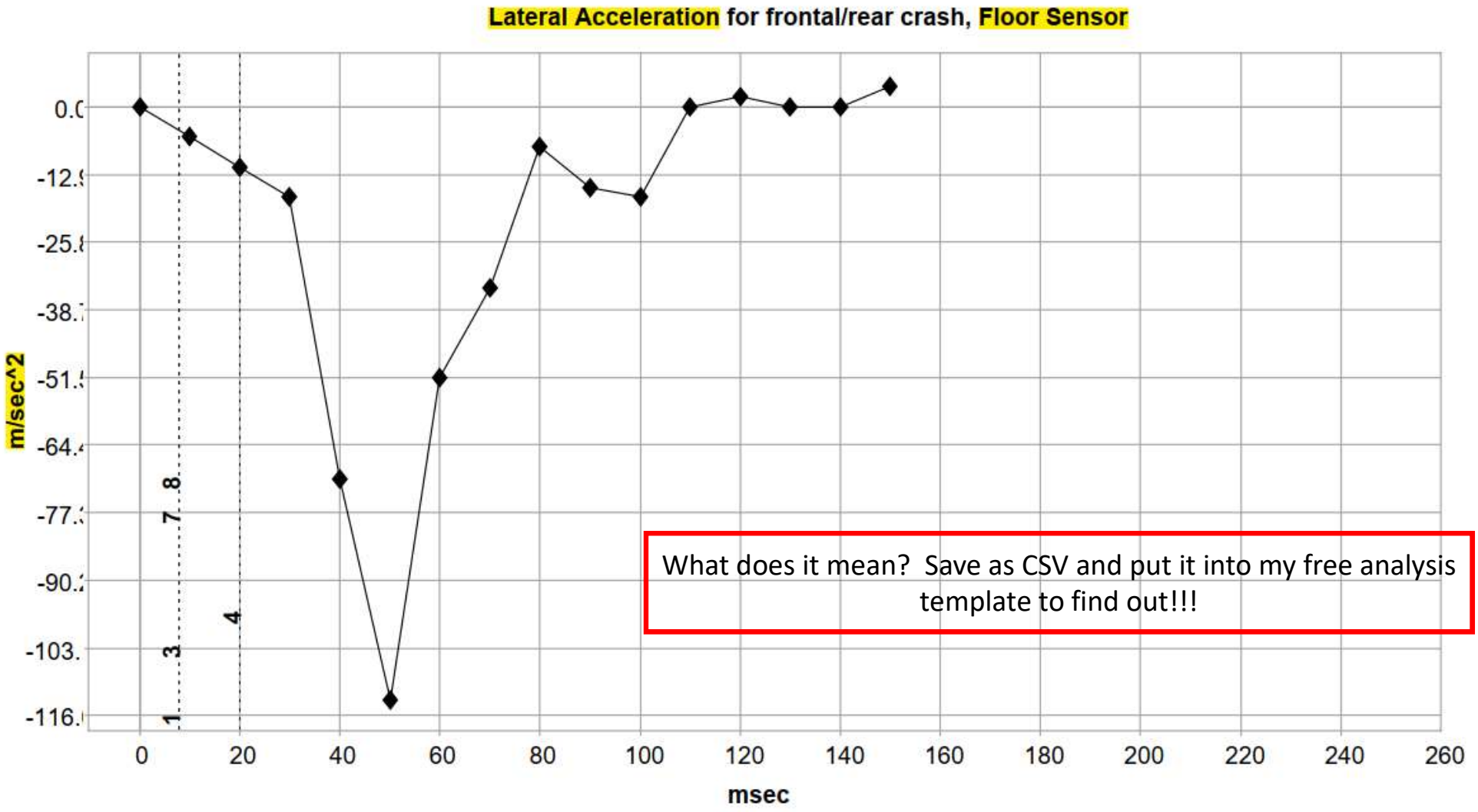
System Status at Event (Most Recent Event, TRG 3)

Recording Status, Front/Rear Crash Info.	Complete
Crash Type	Front/Rear Crash
TRG Count (times)	3
Previous Crash Type	Side Crash
Time from Pre-Crash TRG (msec)	0
Linked Pre-Crash Page	1
Frontal Airbag Deployment, Time to 1st Stage Deployment, Driver (msec)	8
Frontal Airbag Deployment, Time to 1st Stage Deployment, Front Passenger (msec)	No
Pretensioner Deployment, Time to Fire, Driver (msec)	8
Pretensioner Deployment, Time to Fire, Front Passenger (msec)	No
Frontal Airbag Deployment, Time to 2nd Stage, Driver (msec)	20
Frontal Airbag Deployment, Time to 2nd Stage, Front Passenger (msec)	N/A
Active Head Restraint, Time to Deploy, Driver (msec)	SNA
Active Head Restraint, Time to Deploy, Front Passenger (msec)	SNA
Side Curtain Airbag Deployment, Time to Deploy, Driver (msec)	8
Side Curtain Airbag Deployment, Time to Deploy, Passenger (msec)	8
Side Airbag Deployment, Time to Deploy, Driver (msec)	SNA
Side Airbag Deployment, Time to Deploy, Passenger (msec)	SNA
Rear Window Airbag Deployment, Time to Deploy (msec)	SNA

Longitudinal/Lateral Crash Pulse (Most Recent Event, TRG 3 - table 1 of 2)

Recording Status, Time Series Data	Complete
Time from Time Zero to TRG (msec)	8.0
Length of Delta-V (msec)	150
Max. Longitudinal Delta-V (MPH [km/h])	-18.3 [-29.5]
Time, Maximum Delta-V, Longitudinal (msec)	125.5
Power Supply Status at Max. Delta-V	ON
Clipping Time of Longitudinal Delta-V (msec)	No
Clipping Time of Lateral Acceleration, Floor Sensor (msec)	16.5




Lateral Acceleration for frontal/rear crash, Floor Sensor
m/sec^2
0.0
-12.9
-25.8
-38.7
-51.5
-64.4
-77.3
-90.2
-103.
-116.
1
3
4
7
8
0
20
40
60
80
100
120
140
160
180
200
220
240
260
msec
What does it mean? Save as CSV and put it into my free analysis template to find out!!!

Longitudinal/Lateral Crash Pulse (Most Recent Event, TRG 3 -

What does it mean? Save as CSV and put it into my free analysis template to find out!!!

Time (msec)	Longitudinal Delta-V (MPH [km/h])	Lateral Acceleration for Frontal/Rear Crash, Floor Sensor (m/sec^2)	Power Supply
0	0.0 [0.0]	0.0	ON
10	-1.2 [-1.9]	-5.7	ON
20	-3.6 [-5.8]	-11.5	ON
30	-6.7 [-10.8]	-17.2	ON
40	-9.9 [-16.0]	-70.9	ON
50	-13.0 [-21.0]	-113.0	ON
60	-15.6 [-25.1]	-51.7	ON
70	-16.5 [-26.5]	-34.5	ON
80	-17.3 [-27.9]	-7.7	ON
90	-17.5 [-28.1]	-15.3	ON
100	-17.7 [-28.4]	-17.2	ON
110	-18.0 [-29.0]	0.0	ON
120	-18.2 [-29.2]	1.9	ON
130	-18.3 [-29.5]	0.0	ON
140	-18.3 [-29.5]	0.0	ON
150	-18.3 [-29.5]	3.8	ON
160	0.0 [0.0]	0.0	ON
170	0.0 [0.0]	0.0	ON

Template Results for Lateral DV and PDOF

Time (msec	Longitudinal Delta-V (MPH)	Lateral Acceleration for Frontal/Rear Crash, Floor Sensor (m/sec^2)	Power Supply Status	Lat DV from Floor Sensor, (MPH)	PDOF in degrees
0	0	0	ON	0	
10	-1.2	-5.7	ON	-0.1	6.1
20	-3.6	-11.5	ON	-0.4	6.1
30	-6.7	-17.2	ON	-0.8	6.6
40	-9.9	-70.9	ON	-2.4	13.4
50	-13	-113	ON	-4.9	20.6
60	-15.6	-51.7	ON	-6.1	21.2
70	-16.5	-34.5	ON	-6.8	22.5
80	-17.3	-7.7	ON	-7.0	22.0
90	-17.5	-15.3	ON	-7.3	22.8
100	-17.7	-17.2	ON	-7.7	23.6
110	-18	0	ON	-7.7	23.2
120	-18.2	1.9	ON	-7.7	22.9
130	-18.3	0	ON	-7.7	22.8
140	-18.3	0	ON	-7.7	22.8
150	-18.3	3.8	ON	-7.6	22.5

Pre-Crash Data, 1 Sample (Most Recent Event, TRG 3)

Recording Status, Pre-Crash/Occupant	Complete
Time from Pre-Crash to TRG (msec)	500
TRG Count when Pre-crash TRG was Established (times)	2
Safety Belt Status, Driver	ON
Safety Belt Status, Front Passenger	OFF
Occupant Size Classification, Front Passenger	Not Occupied
Frontal Airbag Suppression Switch Status, Front Passenger	SNA
RSCA Disable Switch	SNA
Seat Track Position Switch, Foremost, Status, Driver	No
Airbag Warning Lamp, On/Off	OFF
Ignition Cycle ,Crash (times)	6997

Vs. 6999 at readout

Pre-Crash Data, -5 to 0 seconds (Most Recent Event, TRG 3)

Time (sec)	-5	-4.5	-4	-3.5	-3	-2.5	-2	-1.5	-1	-0.5	0 (TRG)
Vehicle Speed (MPH [km/h])	46.6 [75]	46.6 [75]	46.6 [75]	46.6 [75]	46.6 [75]	46.6 [75]	46.6 [75]	46 [74]	46 [74]	44.1 [71]	40.4 [65]
Accelerator Pedal, % Full (%)	21.5	15.0	2.5	9.5	0.0	0.0	0.0	20.5	0.0	0.0	Within 24 ms of impact
Percentage of Engine Throttle (%)	Invalid	Invalid	Invalid	Invalid	Invalid	Invalid	Invalid	Invalid	Invalid	Invalid	Invalid
Engine RPM (RPM)	1,000	1,000	1,000	1,000	900	900	900	900	900	1,000	900
Motor RPM (RPM)	5,500	5,600	5,500	5,600	5,600	5,500	5,500	5,500	5,500	5,300	4,900
Service Brake, ON/OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
Brake Oil Pressure (Mpa)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10% 1.25	33% 4.03
Longitudinal Acceleration , VSC Sensor (m/sec^2)	-0.144	0.000	-0.646	-0.287	-0.431	-0.431	-0.072	-0.431	-0.359	.23g -2.297	0.90g -8.973
Yaw Rate (deg/sec)	2.93	2.44	2.44	2.93	3.42	3.42	3.42	3.42	7.32	14.15	16.59
Steering Input (degrees)	15.0	13.5	13.5	15.0	16.5	16.5	16.5	16.5	37.5	9° swerve 67.5	64.5

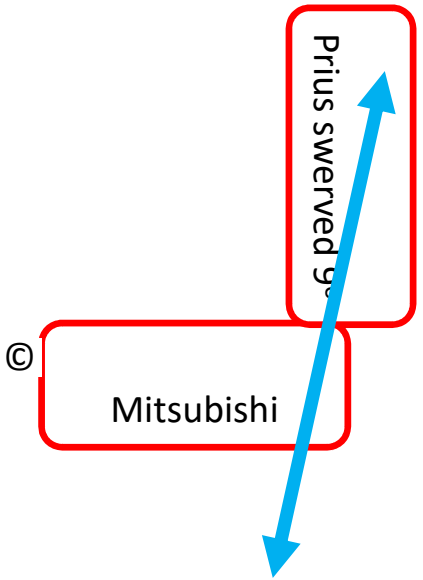
Recap of Toyota Behavior

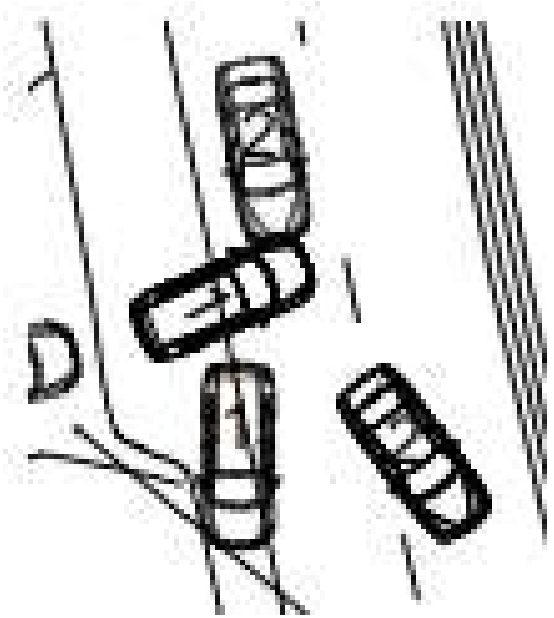
- Last reported speed 40.4 mph within 24ms of impact
- Swerves 9 degrees left to in effort to avoid
- -18.3X, -7.7Y Delta V, 19.7 Total @ 22^{o} PDOF

- Mitsubishi Montero 1800KG/3966 lbs
- Toyota 1485Kg/2755 lbs
- Weight ratio 1.44
- Mitsubishi Total Delta V = 19.7*(2755/3966)=13.68 mph

Draw Vehicles at Max Engagement Determine offset if doing closing speed

- NHTSA estimates relative approach angle as 100 degrees, showing Mitsubishi 10 degrees into turn and Prius going straight. Given 9 degree swerve, Prius heading must be adjusted – use 91 degrees.
- Mitsu rotates over 90 deg
- Offset approx. 3 ft
- Toyota little/no rotation





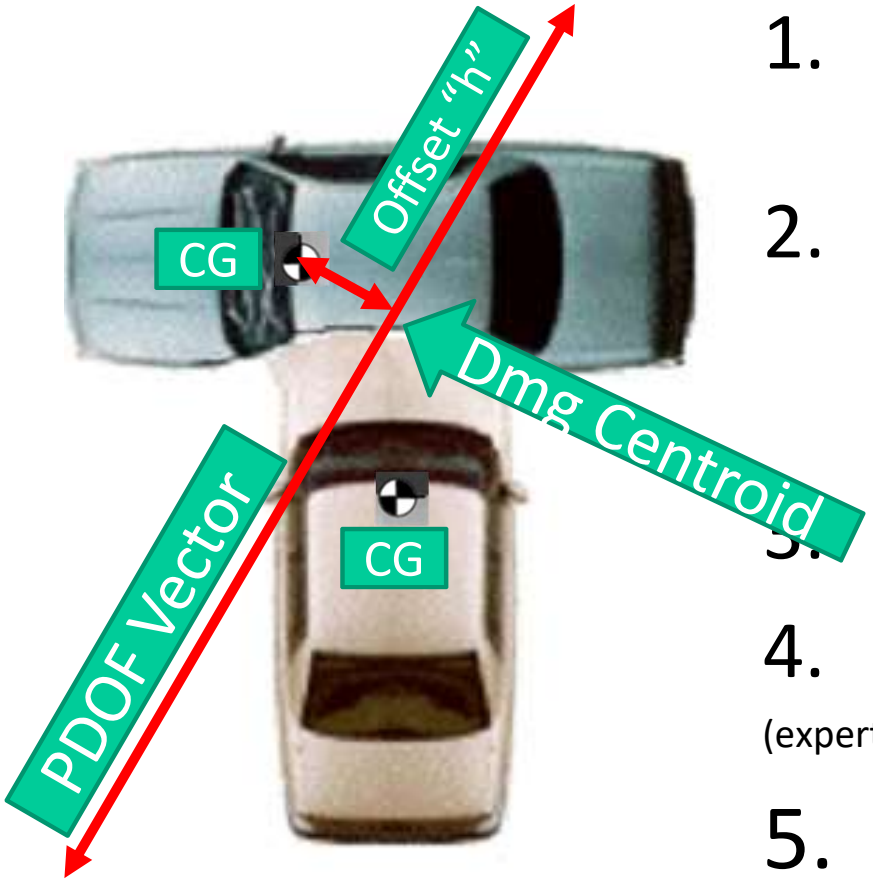
Calculate Mitsubishi PDOF

- PDOF2 = 180-RA-PDOF1 = 180-91-22=67 degrees

Estimate Closing Speed

$$\text{ClosingSpeed} = \left[\frac{1}{1+e}\right]\left[\frac{|\Delta V_1|}{\gamma_1} + \frac{|\Delta V_2|}{\gamma_2}\right]$$

Step by Step EMR Process 1



1. Draw vehicles @MAX ENGAGEMENT
   (NOT first bumper touch)
2. Find the DAMAGE CENTROID, the center of the damage AREA
   (NOT the center of the damage FACE)
3. Draw PDOF line thru CENTROID
4. Look up CG and place on diagram

(expert autostats or Canadian specs, often 4 to 8" behind top of windshield)

5. Measure **perpendicular**

   distance CG to PDOF, lever arm "h"

Step by Step EMR Process 2

6. Calculate **Yaw Moment of Inertia**

$I_{y\text{-Car}}$ = 1.03(weight in lbs) – 1206 * •

$I_{y\text{-Pickup}}$ = 1.03(weight in lbs) – 1343 *

Heydinger & Garrott 1999-01-1336 inertial properties, 2010-01-0086 added CG to database

7. Calculate **K²** (K is *Radius of Gyration*)

$$k^2 = \frac{\text{Yaw Moment of Inertia}(g)}{\text{Vehicle Weight}} = \frac{I_y g}{W}$$

8. Calculate **Effective Mass Ratio** (Gamma) γ

$$\gamma = \frac{k^2}{k^2 + h^2}$$

Don't square k^2 again

EMR adjustment to Closing Speed

Given Mitsu ΔV1 of 16.3mph @ COM

, V1 = 3966lbs

I_{y1}=1.03*3966-1206 = 2879

$$k_{v12} = \frac{I_y g}{W} = \frac{2879*32.2}{3966} = 23.37$$

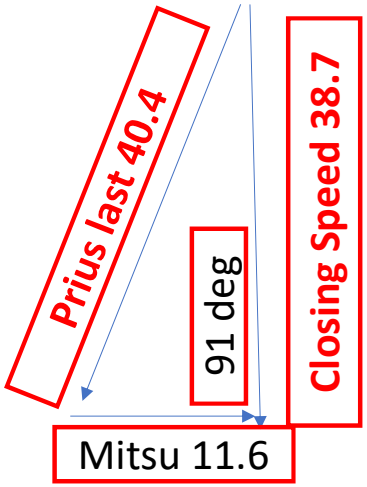
$$\gamma_{v1} = \frac{k^2}{k^2+h^2} = \frac{23.37}{23.37+3^2} = 0.722 \text{ unitless}$$

$$CS = \frac{1}{1+e}\left(\frac{|\Delta V1|}{\gamma 1} + \frac{|\Delta V2|}{\gamma 2}\right)$$

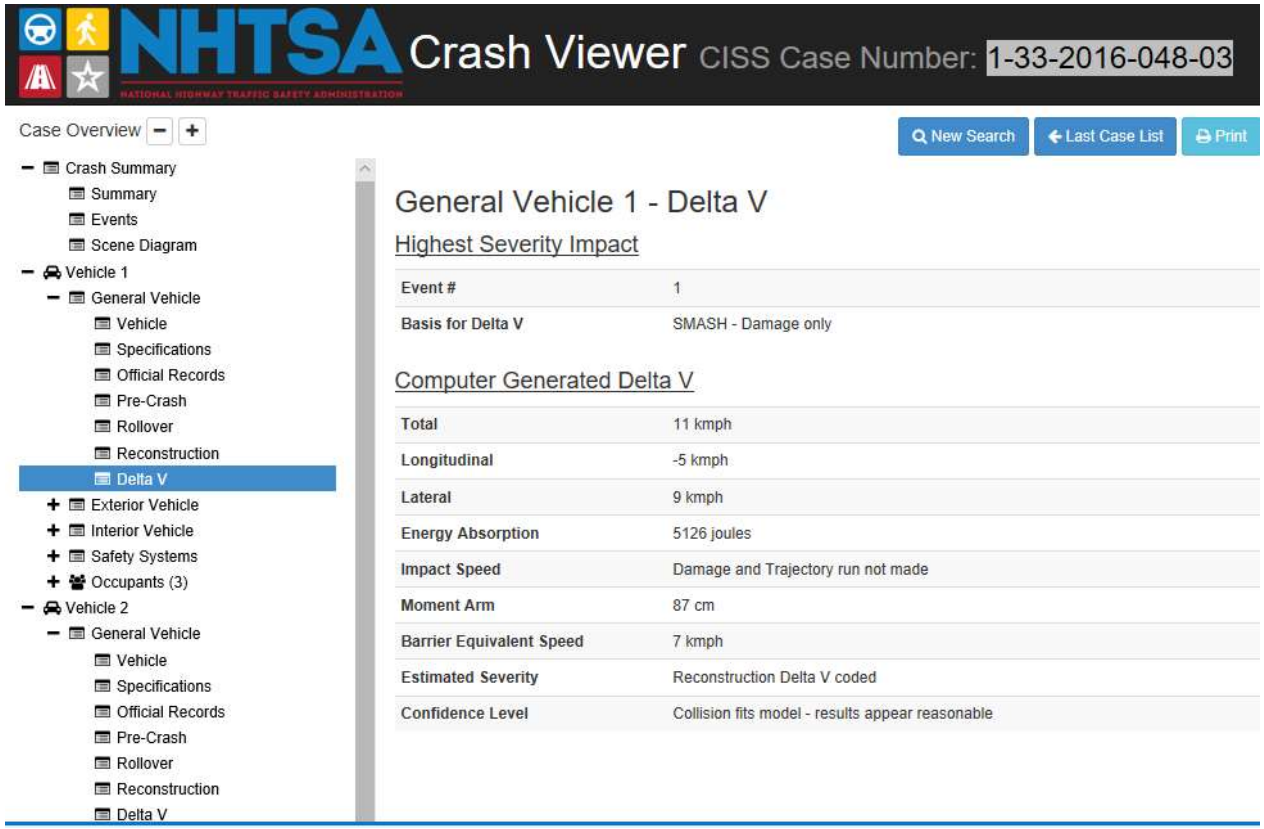
$$CS = \frac{1}{1+.1}\left(\frac{|13.7|}{0.722} + \frac{|19.7|}{1}\right) = 38.7\text{mph}$$

Closing Speed Triangle

- 91 degree relative angle is so close to 90 let's call it a right triangle
- Mitsu speed is $\sqrt{40.4 * 40.4 - 38.7 - 38.7} = 11.6$
- Checks with Delta V y of Toyota of 7.7 using intersection approximation



Check EDR results with physical evidence



Case Overview − +

New Search | Last Case List | Prin

- − Crash Summary
  - Summary
  - Events
  - Scene Diagram
- − Vehicle 1
  - − General Vehicle
    - Vehicle
    - Specifications
    - Official Records
    - Pre-Crash
    - Rollover
    - Reconstruction
    - Delta V
  - + Exterior Vehicle
  - + Interior Vehicle
  - + Safety Systems
  - + Occupants (3)
- − Vehicle 2
  - − General Vehicle
    - Vehicle
    - Specifications
    - Official Records
    - Pre-Crash
    - Rollover
    - Reconstruction
    - Delta V

General Vehicle 2 - Delta V

Highest Severity Impact

Event #	1
Basis for Delta V	SMASH - Damage only

Computer Generated Delta V

Total	15 kmph
Longitudinal	-14 kmph
Lateral	-5 kmph
Energy Absorption	23568 joules
Impact Speed	Damage and Trajectory run not made
Moment Arm	-65 cm
Barrier Equivalent Speed	18 kmph
Estimated Severity	Reconstruction Delta V coded
Confidence Level	Collision fits model - results appear reasonable

Conclusions

- Prius traveling last known speed of 40.4 mph is within 24ms of impact, a good indicator of speed
- Mitsubishi is traveling about 12.6mph
- Swerve of Toyota influenced the analysis

- End of Case Study 3 and presentation