EDR Case Studies Intersection Crash

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UNF
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Case Description 1

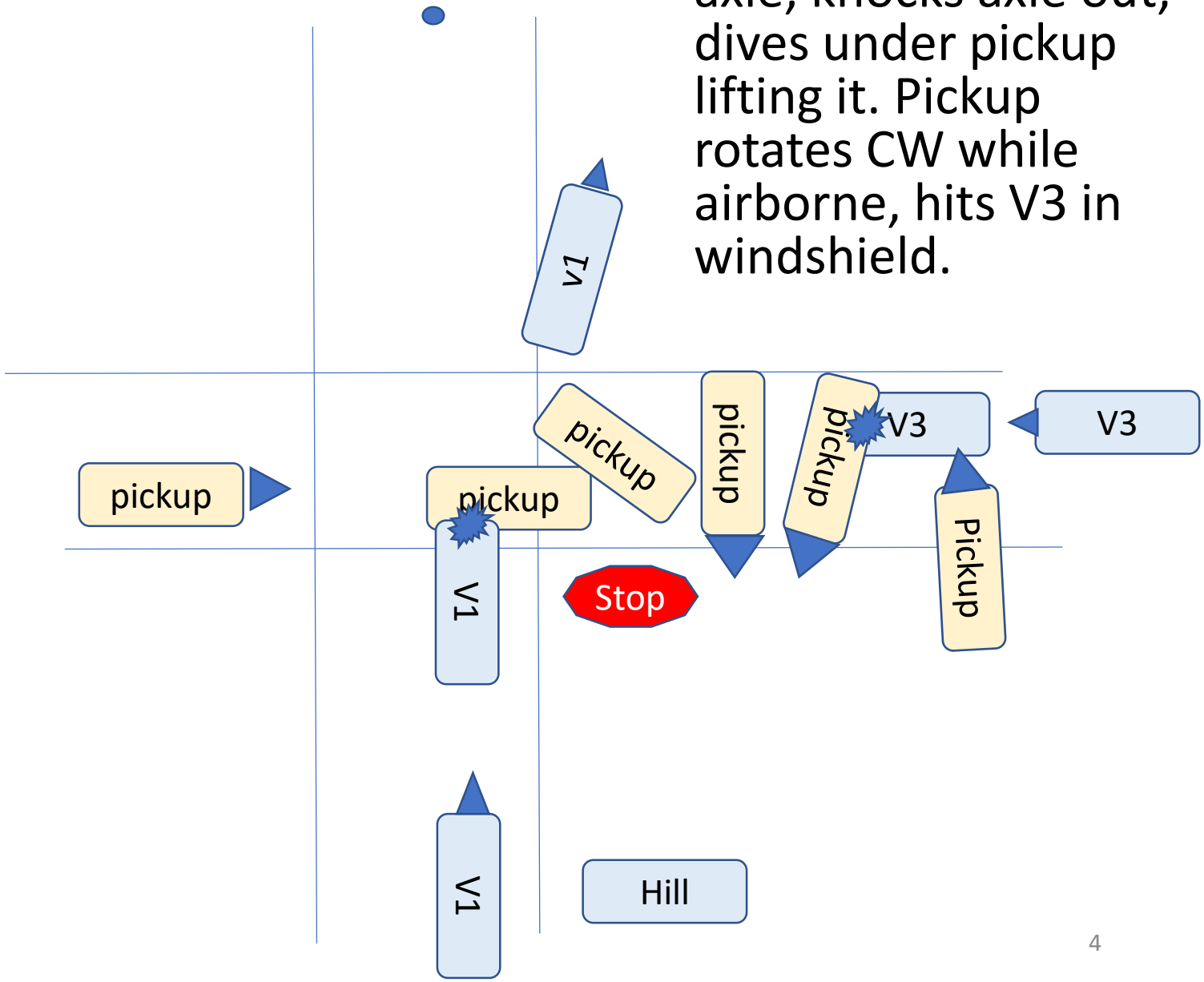
- Criminal Prosecution Case – Reckless Driving resulting in Death
- Charged V1 driver is in 25 mph residential area, comes over top of small hill at 48 mph (per EDR), sees stop sign at intersection at bottom of hill.
- Driver may slow but enters intersection, pickup crossing from right gets hit in rear axle (Pickup had no traffic control device)
- V1 knocks axle out front under V2 pickup, goes under pickup and lifts pickup rear off the ground and rotates it clockwise

Case Description Cont'd

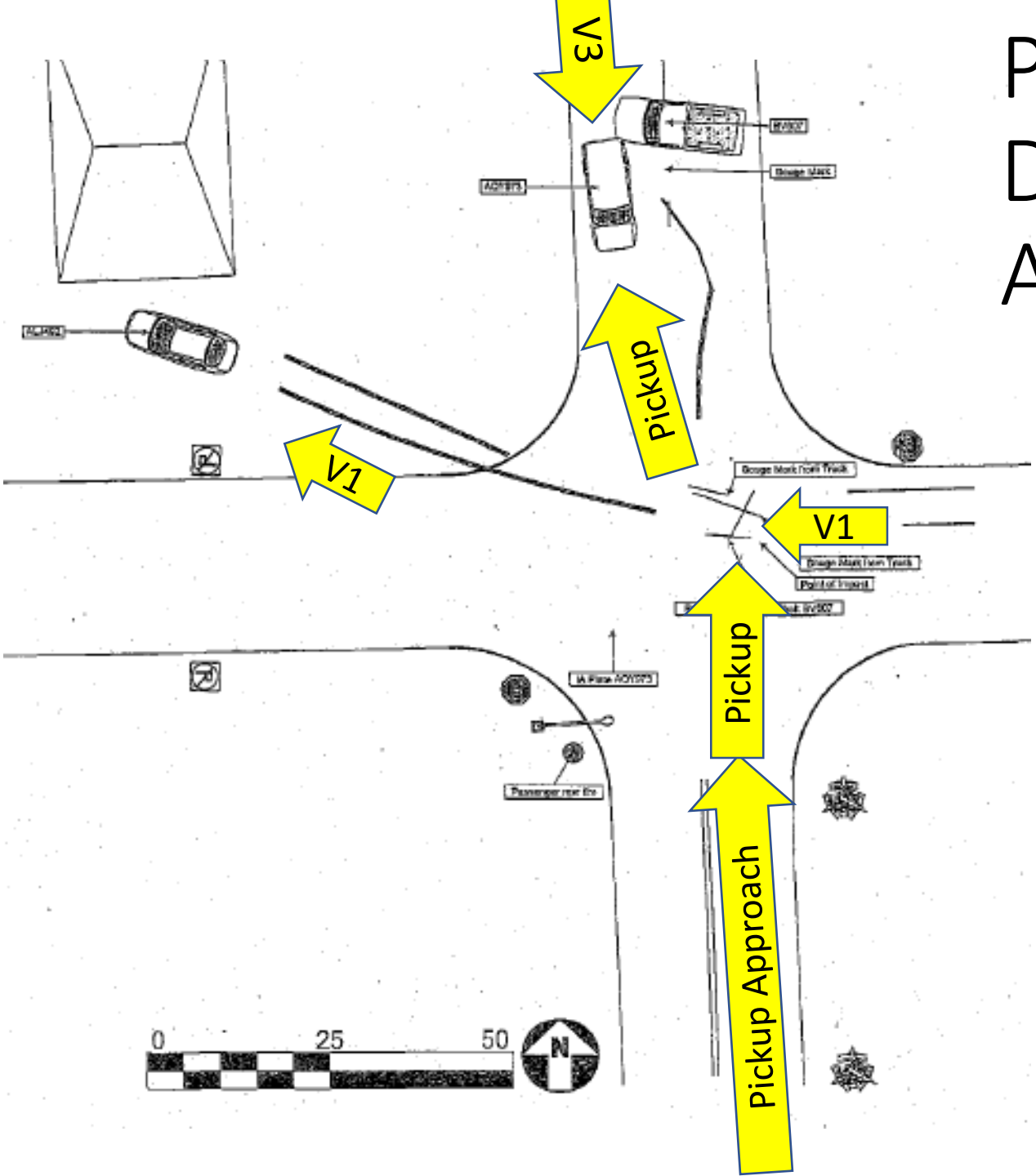
- V3 approaches from right
- Airborne pickup rear end crashes through windshield of V3, killing front seat passenger (a child)
- V2 rotates back counterclockwise and comes to rest behind V3
- After V1 goes under pickup it continues forward and right into yard

Crash Scenario

- V1 hits pickup in rear axle, knocks axle out, dives under pickup lifting it. Pickup rotates CW while airborne, hits V3 in windshield.



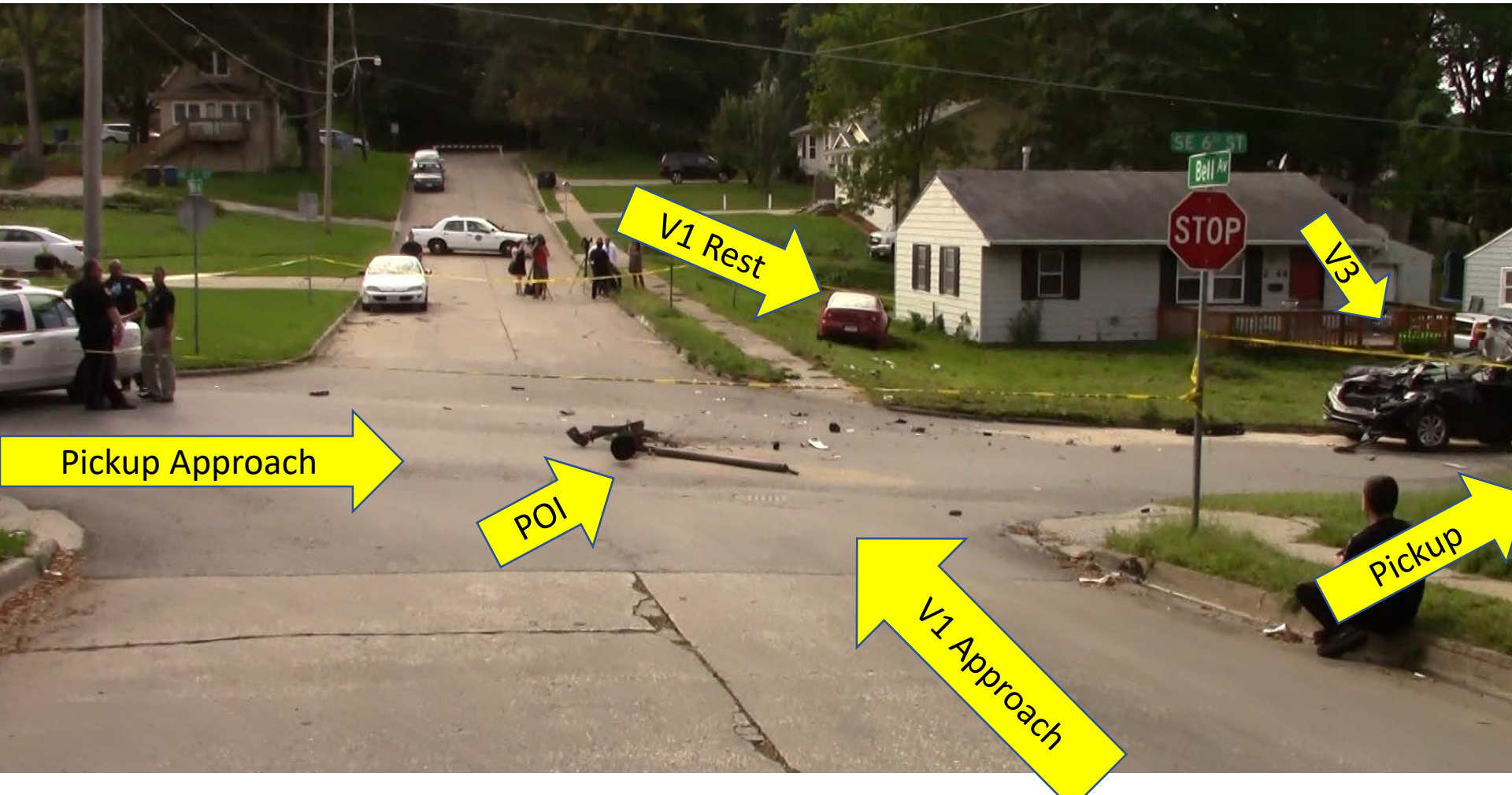
Police Diagram Annotated



Hill

V1 Approach

Crash Scene – note tire marks on police diagram are not very visible

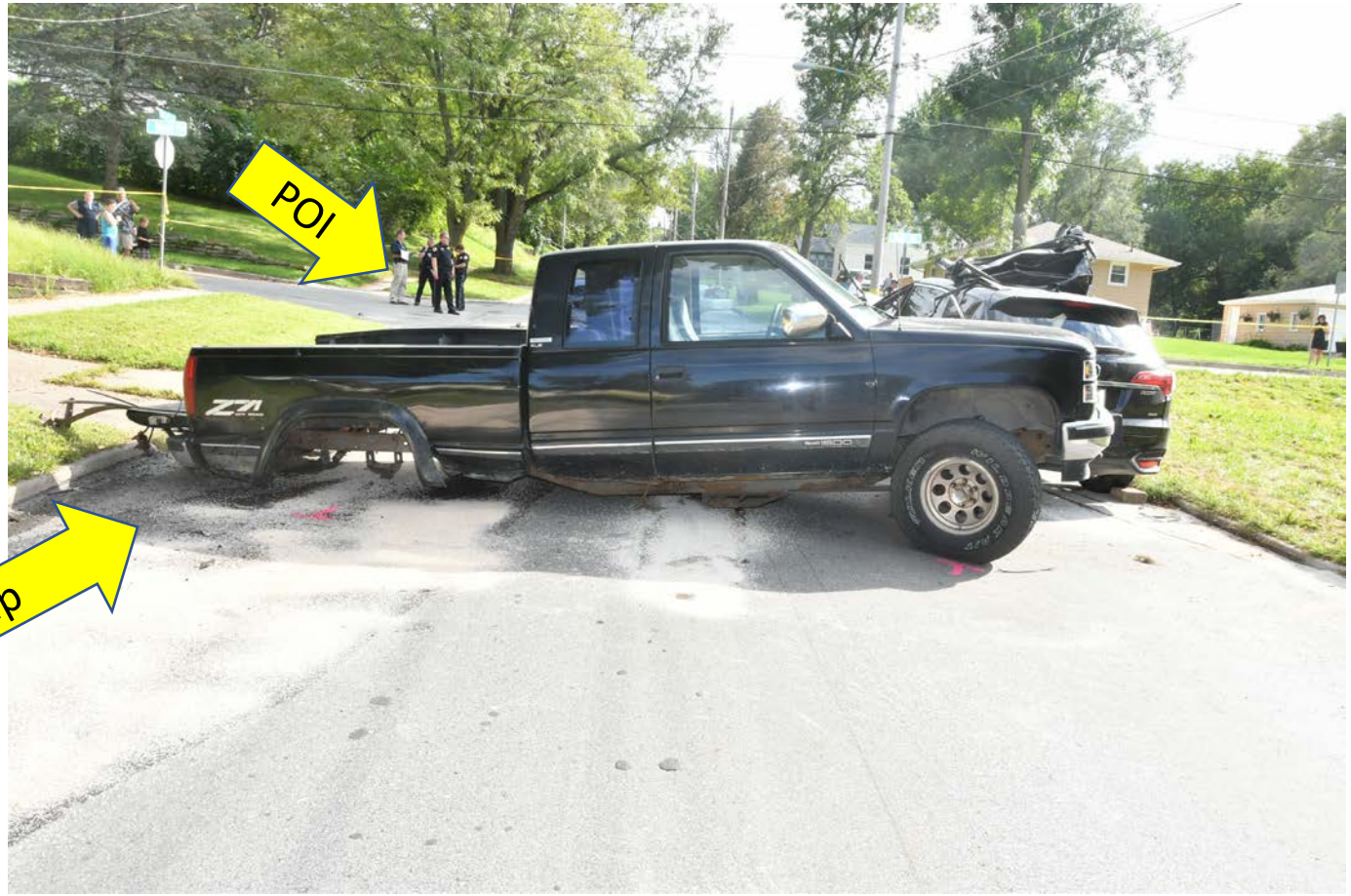



V1 Rest
V3
Pickup
POI

Scene

Defendant's car at rest
Went underneath pickup rear end

Pickup at Rest (V3 to right)



Other Facts of Interest

- 18 year old with no Driver's License
- Buying car from his dad with payments, has been driving 11 months with no license and no driver training
- Girl friend in front pass seat, two kids in the back seat
- Pickup Driver sees V1 is going to blow stop sign, tries to speed up to get through ahead of him
- Victim V3 is just in the wrong place at the wrong time – what are the odds a pickup truck rear end will come airborne thru your windshield on a residential street??????
- No Alcohol involved

BOSCH

16-27805

CDR CRASH DATA RETRIEVAL

EXAMINE CDR REPORT

IMPORTANT NOTICE: Robert Bosch LLC and the manufacturers whose vehicles are accessible using the CDR System urge end users to use the latest production release of the Crash Data Retrieval system software when viewing, printing or exporting any retrieved data from within the CDR program. Using the latest version of the CDR software is the best way to ensure that retrieved data has been translated using the most current information provided by the manufacturers of the vehicles supported by this product.

CDR File Information

User Entered VIN	1G2ZH578764183735
User	Hedlund, J. 5070
Case Number	20160027805
EDR Data Imaging Date	09/09/2016
Crash Date	09/08/2016
Filename	16-27805 PONTIAC G6.CDRX
Saved on	Friday, September 9 2016 at 18:36:51
Collected with CDR version	Crash Data Retrieval Tool 16.6
Reported with CDR version	Crash Data Retrieval Tool 16.6
EDR Device Type	Airbag Control Module
Event(s) recovered	Deployment

Comments

No comments entered.

Data Limitations

Recorded Crash Events:

There are two types of recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event records data but does not deploy the air bag(s). The minimum SDM Recorded Vehicle Velocity Change, that is needed to record a Non-Deployment Event, is five MPH. A Non-Deployment Event may contain Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded vehicle velocity change. This event will be cleared by the SDM, after approximately 250 ignition cycles. This event can be overwritten by a second Deployment Event, referred to as Deployment Event #2, if the Non-Deployment Event is not locked. The data in the Non-Deployment Event file will be locked, if the Non-Deployment Event occurred within five seconds of a Deployment Event. A locked Non Deployment Event cannot be overwritten or cleared by the SDM.

The second type of SDM recorded crash event is the Deployment Event. It also may contain Pre-Crash and Crash data. The SDM can store up to two different Deployment Events. If a second Deployment Event occurs any time after the Deployment Event, the

System Status At Deployment

Ignition Cycles At Investigation	20585
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time (seconds)	655200
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	1362
Ignition Cycles At Event	20585
Ignition Cycles Since DTCs Were Last Cleared	254
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Belt Switch Circuit Status (If Equipped)	BUCKLED
Diagnostic Trouble Code at Event Enable, fault number: 1	N/A
Diagnostic Trouble Code at Event Enable, fault number: 2	N/A
Diagnostic Trouble Code at Event Enable, fault number: 3	N/A
Diagnostic Trouble Code at Event Enable, fault number: 4	N/A
Diagnostic Trouble Code at Event Enable, fault number: 5	N/A
Diagnostic Trouble Code at Event Enable, fault number: 6	N/A
Automatic Passenger SIR Suppression System Validity Status at AE	Valid
Automatic Passenger SIR Suppression System Status at AE	Air Bag Not Suppressed
Automatic Passenger SIR Suppression System Validity Status at First Deployment Command	Valid
Automatic Passenger SIR Suppression System Status at First Deployment Command	Air Bag Not Suppressed
Driver 1st Stage Time From Algorithm Enable to Dep	36
Driver 2nd Stage Time From Algorithm Enable to De	38
Passenger 1st Stage Time From Algorithm Enable to c)	36
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	38
Driver Side or Roof Rail/Head Curtain Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger Side or Roof Rail/Head Curtain Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Time Between Events (sec)	0
Driver First Stage Deployment Loop Commanded	Yes
Passenger 2nd Stage Deployment Loop Commanded for Disposal	No
Crash Record Locked	Yes
Vehicle Event Data (Pre-Crash) Associated With This Event	Yes
Event Recording Complete	Yes

KEY CYCLES MATCH

BAGS DEPLOYED

COMPLETE RECORDING

Multiple Event Data

Associated Events Not Recorded	0
An Event(s) Preceded the Recorded Event(s)	No
An Event(s) was in Between the Recorded Event(s)	No
An Event(s) Followed the Recorded Event(s)	No
The Event(s) Not Recorded was a Deployment Event(s)	No
The Event(s) Not Recorded was a Non-Deployment Event(s)	No

SINGLE EVENT

System Status At AE

Vehicle Identification Number	**2ZH578*6*183735
Low Tire Pressure Warning Lamp (If Equipped)	OFF
Vehicle Power Mode Status	Run
Remote Start Status (If Equipped)	Inactive
Run/Crank Ignition Switch Logic Level	Active
Brake System Warning Lamp (If Equipped)	OFF

KEY ON

KEY ON

System Status At 1 second

RPM CROSSCHECK

Transmission Range (If Equipped)	Fourth Gear
Transmission Selector Position (If Equipped)	Drive
Traction Control System Active (If Equipped)	No
Service Engine Soon (Non-Emission Related) Lamp	OFF
Service Vehicle Soon Lamp	OFF
Outside Air Temperature (degrees F) (If Equipped)	86
Left Front Door Status (If Equipped)	Closed
Right Front Door Status (If Equipped)	Closed
Left Rear Door Status (If Equipped)	Unused
Right Rear Door Status (If Equipped)	Unused
Rear Door(s) Status (If Equipped)	Closed

Pre-crash data

Parameter	-2 sec	-1 sec
Reduced Engine Power Mode	OFF	OFF
Cruise Control Active (If Equipped)	No	No
Cruise Control Resume Switch Active (If Equipped)	No	No
Cruise Control Set Switch Active (If Equipped)	No	No

Defendant was at 100% throttle climbing blind hill

Pre-Crash Data

Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Vehicle Speed (MPH)	47	48	47	46	42
Engine Speed (RPM)	3712	3584	1536	1408	1216
Percent Throttle	100	27	0	0	0
Brake Switch Circuit State	OFF	OFF	OFF	ON	ON
Accelerator Pedal Position (percent)	100	41	0	0	0
Antilock Brake System Active (If Equipped)	No	No	No	No	No
Lateral Acceleration (feet/s²)(If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid
Yaw Rate (degrees per second) (If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid

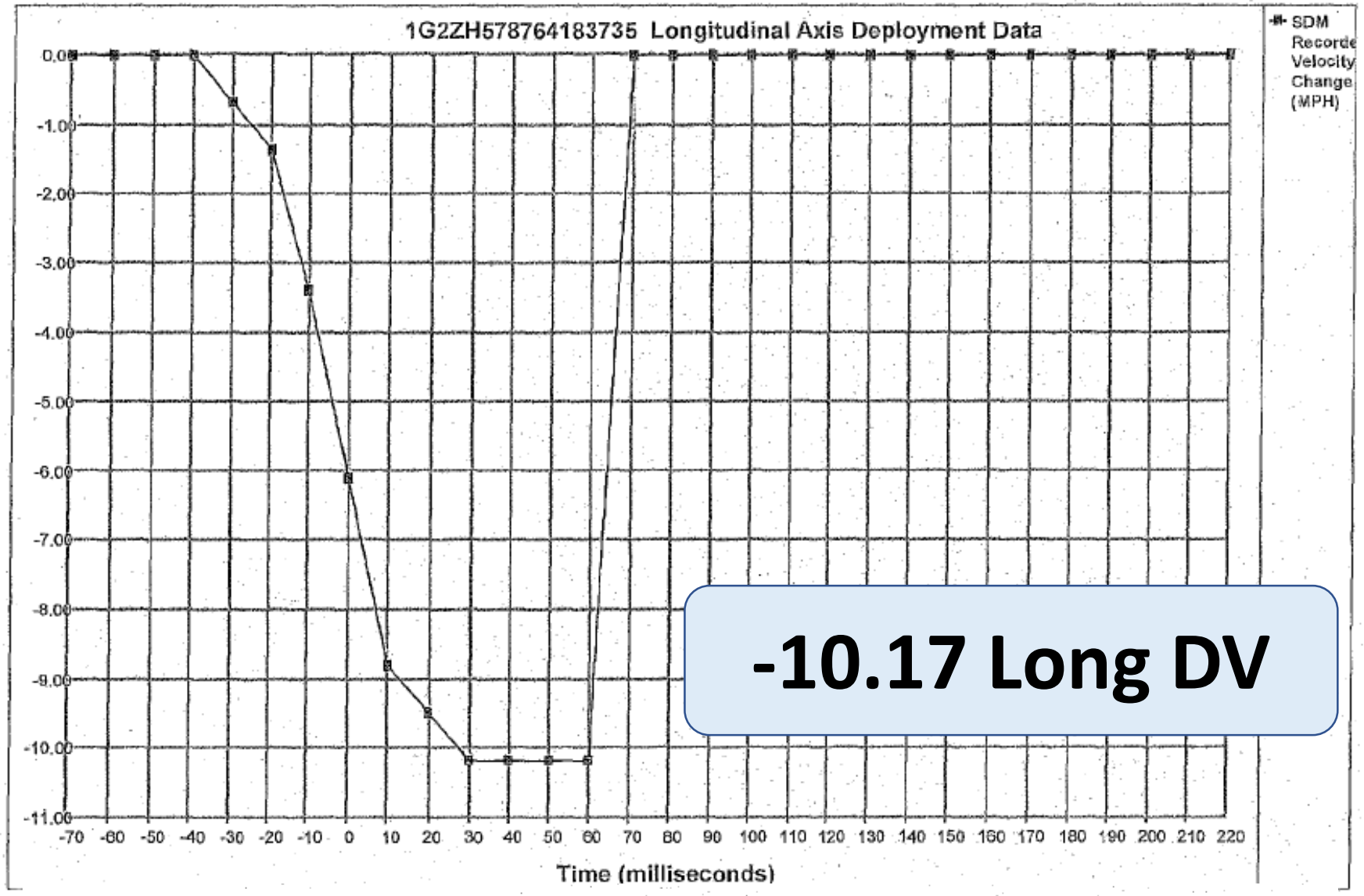
FASTEST 48

LAST REPORTED 42

100

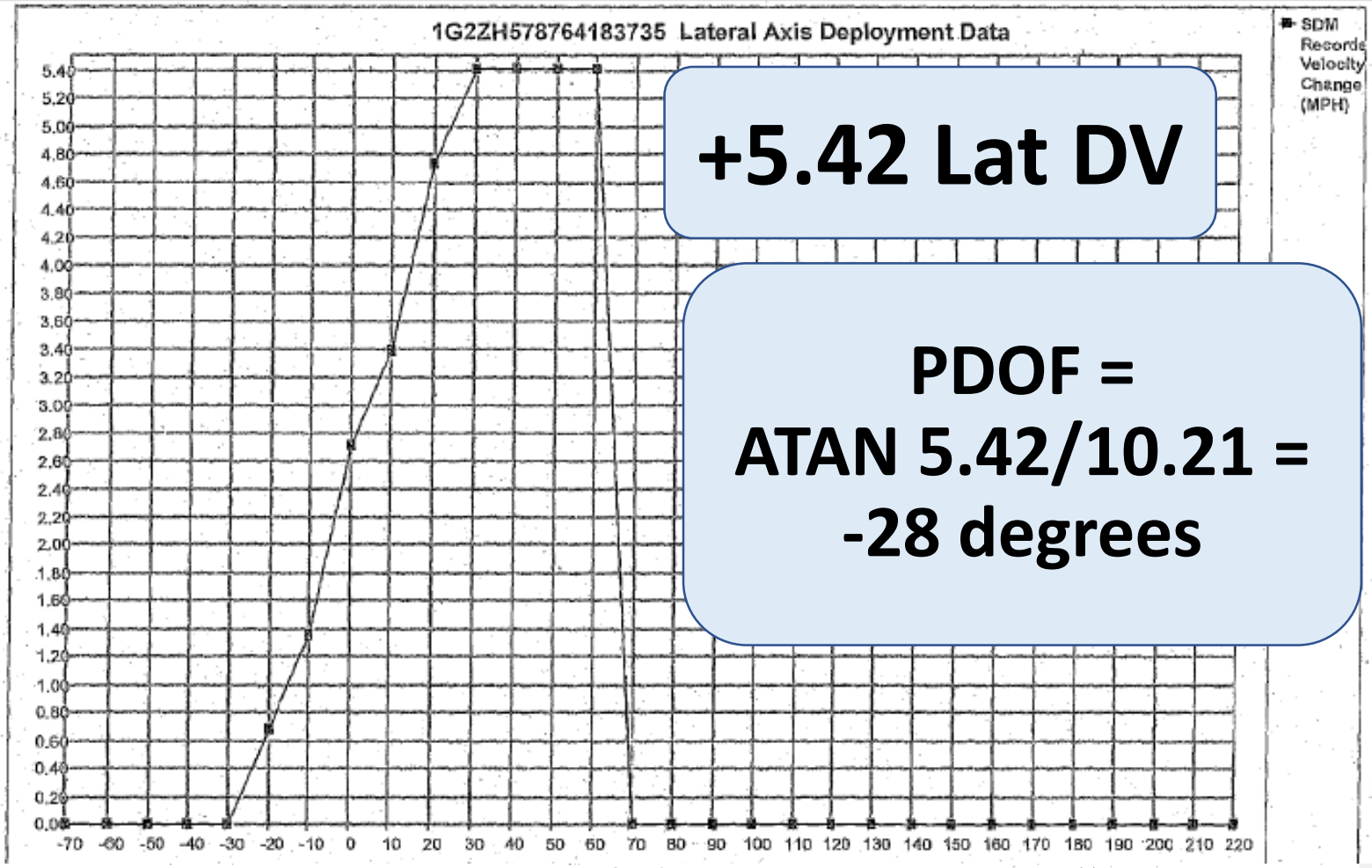
ON

No ABS



-10.17 Long DV

Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	-0.68	-1.36	-3.39	-6.10	-8.81	-9.49	-10.17	-10.17	-10.17



+5.42 Lat DV

PDOF =
ATAN 5.42/10.21 =
-28 degrees

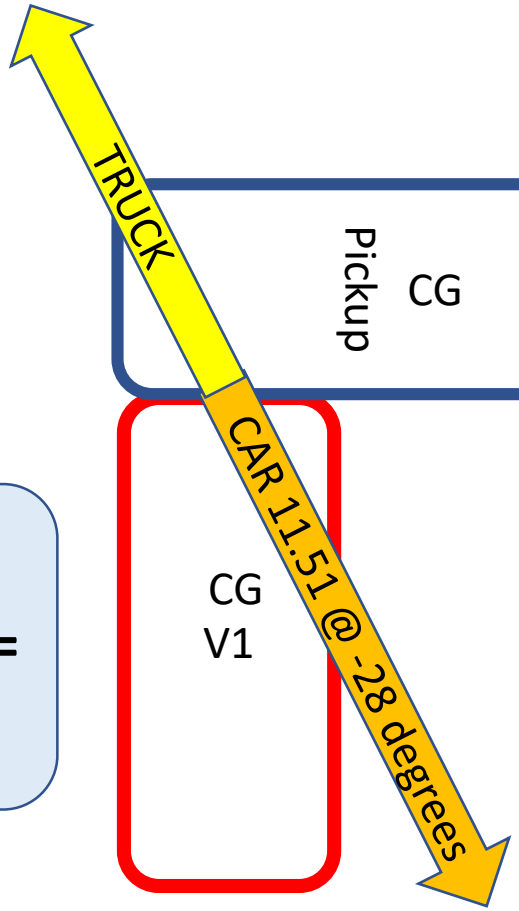
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	-0.68	-1.36	-3.39	-6.10	-8.81	-9.49	-10.17	-10.17	-10.17	-10.17	0.00
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ANALYSIS – IS THIS RECORDING FROM MY CRASH??

- Complete Recording
- Key Cycles Match 20585 vs 20585
- Delta V magnitude 11.51@ 28 degrees fits damage
- Last reported speed of 42 and slowing seems consistent with lifting pickup into air
- It’s a deployment, deployments are rare

MAKE YOUR SKETCH

- Draw Vehicles at Max Engagement and Draw PDOF Line



Total DV = Sqrt(10.17^2+5.42^2)= 11.51

PDOF = ATAN 5.42/10.21 = -28 degrees

Prosecution Dilemma

- In this jurisdiction, you cannot get Reckless Homicide by SPEED Alone
- + Limited sightline due to hill enough???
- Defense is prepared to concede 48 mph EDR speed, but will argue Defendant **reacted appropriately** by braking after seeing stop sign and that prosecution ONLY has speed
- But **did he**????

Defense Expert Calculations

Speed at Impact method 3 = Speed from last Edr reported speed data

	MIN	MAX
Last speed reported in EDR	42	42
Change since last reported speed	-18.2	0
Wheel Slip adjustment	0	0
Speedometer Error	-1.68	1.68
Speed at Impact	22.1	43.7 mph

Defense Logic

- 3 seconds from when stop sign was first visible
- 48 mph at first visibility
- Perception Reaction time 1.5 seconds
- Speed loss 1.5 sec * 18 mph/sec = 27 mph
- 48 mph – 27 mph = 21 at impact
- Speed at impact calc from last speed data point of 42 yields 22 mph = Reacted Normally
- Defense further says momentum , while not impossible, would be very difficult due to airborne truck and 3rd vehicle, range on answer would be wide.

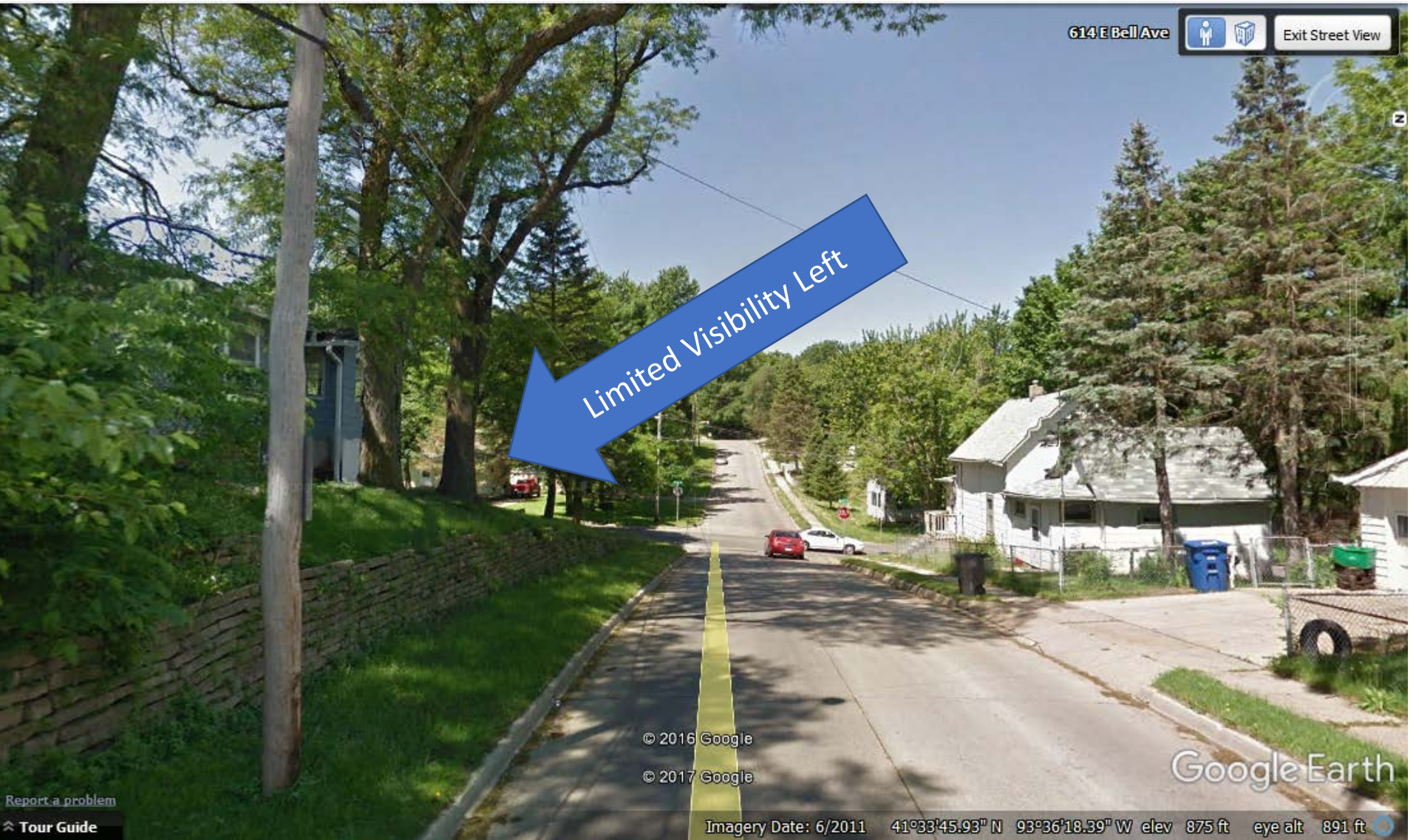
Defense Stopped There

Stop sign visible at 200 feet (3 sec)


620 E Bell Ave
Exit Street View
© 2016 Google
© 2017 Google
Google Earth
Report a problem
Tour Guide
Imagery Date: 6/2011 41°33'45.02" N 93°36'19.77" W elev 1008 ft eye alt 886 ft


618 E Bell Ave
Exit Street View
© 2016 Google
© 2017 Google
Google Earth
Report a problem
Tour Guide
41°33'46.56" N 93°36'20.34" W elev 904 ft eye alt 890 ft

Note Limited Visibility Left due to mound



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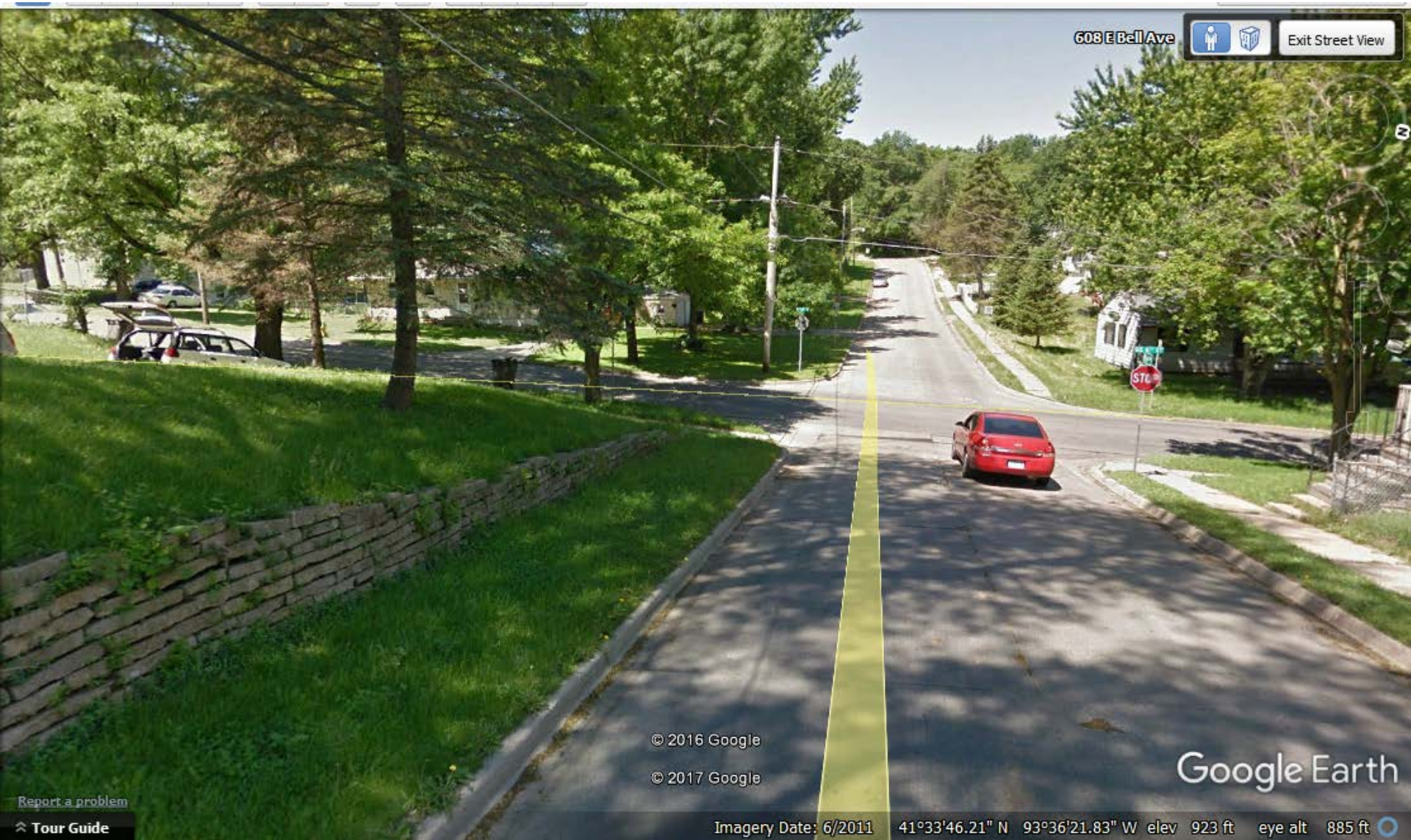
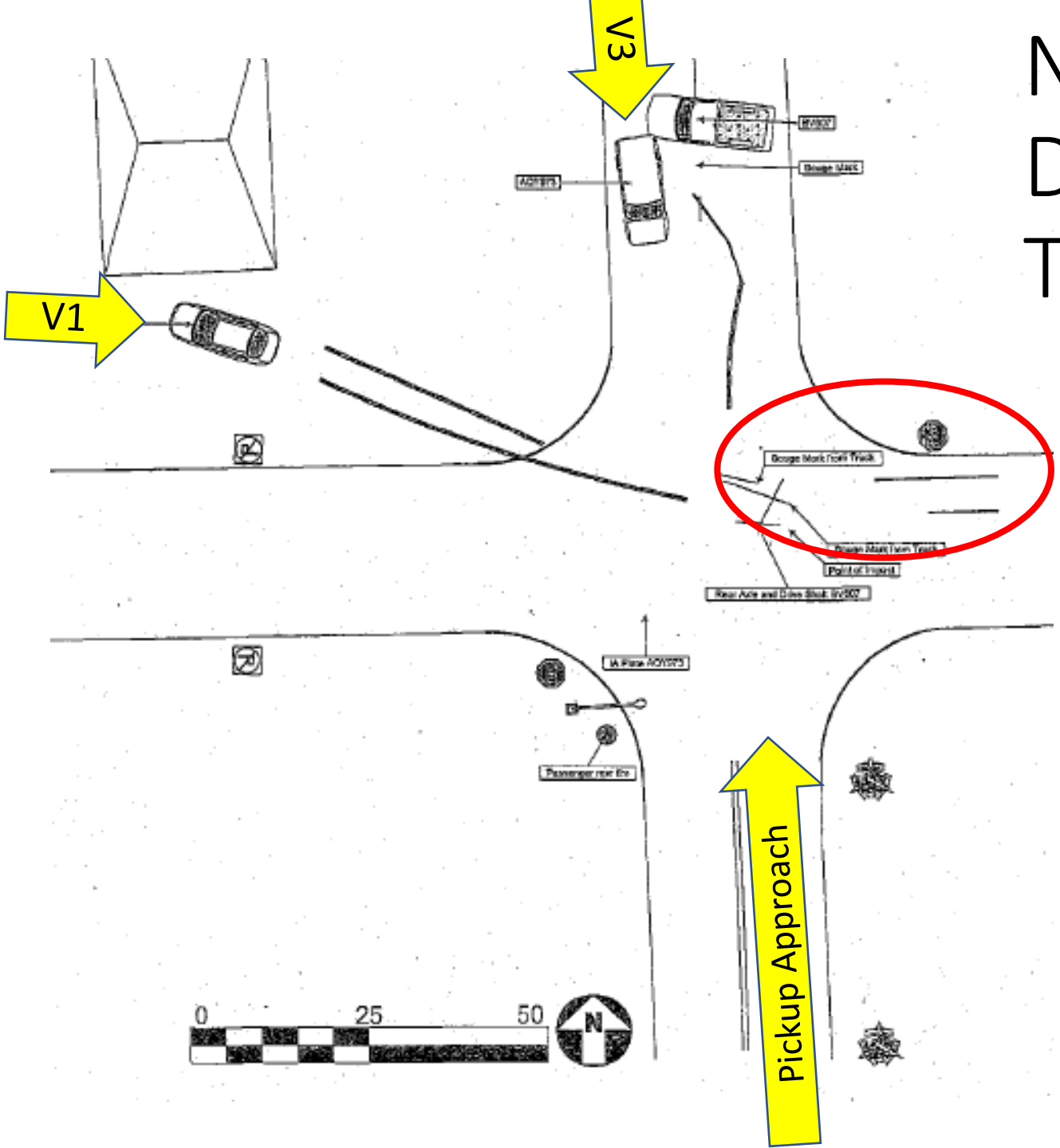


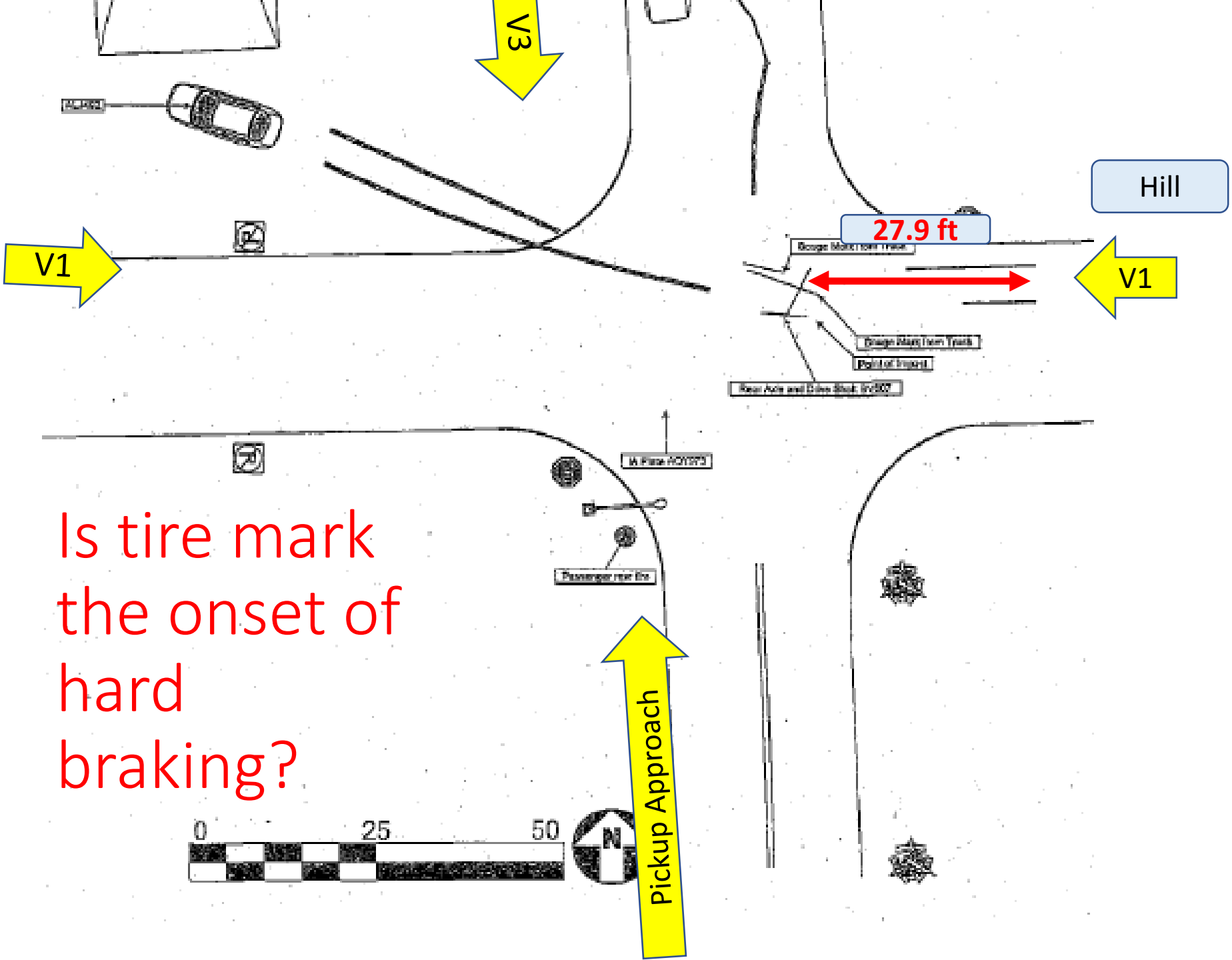

602 E Bell Ave
Exit Street View
© 2016 Google
© 2017 Google
Google Earth
Report a problem
Tour Guide
41°33'45.79" N 93°36'23.14" W elev 883 ft eye alt 879 ft

Note Short Distance of Tire Marks



Prosecution Working Theory

- Defendant did NOT begin braking in response to seeing stop sign- he PLANNED to blow thru it.
- Defendant braked when he saw the pickup coming from the right side.
- Tire marks indicate onset of braking


V3
V1
Hill
27.9 ft
V1
Is tire mark the onset of hard braking?
0
25
50
N
Pickup Approach

Speed@impact from speed loss due to braking from start of tire mark

- Energy equivalent speed loss = $\sqrt{30 * D * f}$
- S = $\sqrt{30 * 27.9ft * 0.80g}$ = 25.92 mph

- Combined Speed Formula – start from last speed before onset of braking 46 mph

- S = $\sqrt{46^2 - 25.92^2}$ = 38.0 mph

- Do sensitivity with drag factor – get range 37.5-38.5

Other Methods of Getting Speed at Impact in intersection collisions – using Delta V– "Tools in your tool bag"

- **Angled Departure – Postcrash speed - Delta V + Cos Θ postcrash**
- **90 Degree Intersection – Inline approx. CS**

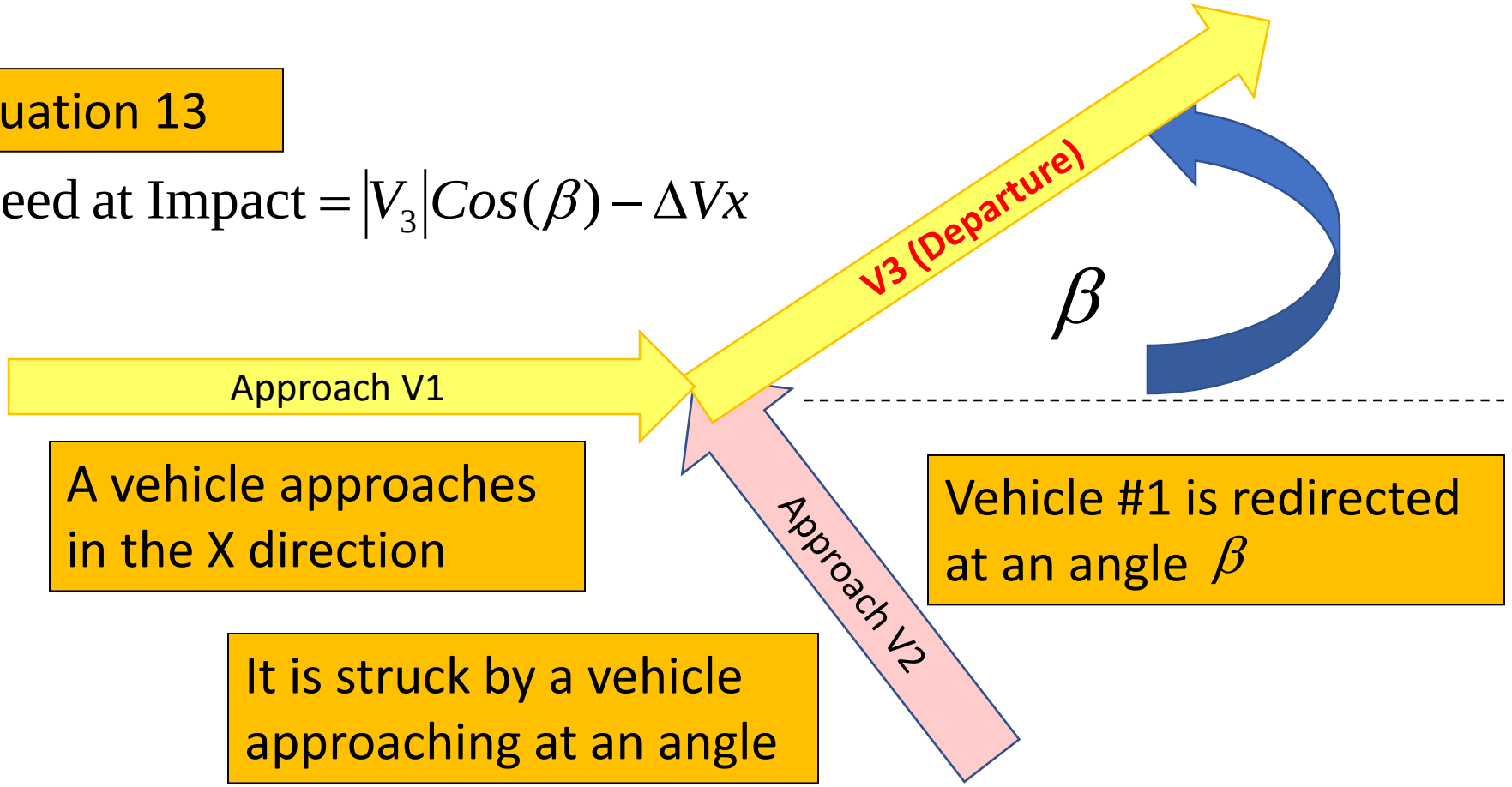
  Effective mass ratio adjustments closing speed
- Angular – triangular velocity vectors ????? (uses inv. Prop DV + postcrash)

  (DON'T KNOW ENOUGH ABOUT PICKUP)

Tool in Our Tool Bag:
Longitudinal DeltaV and Angled Departure

Equation 13

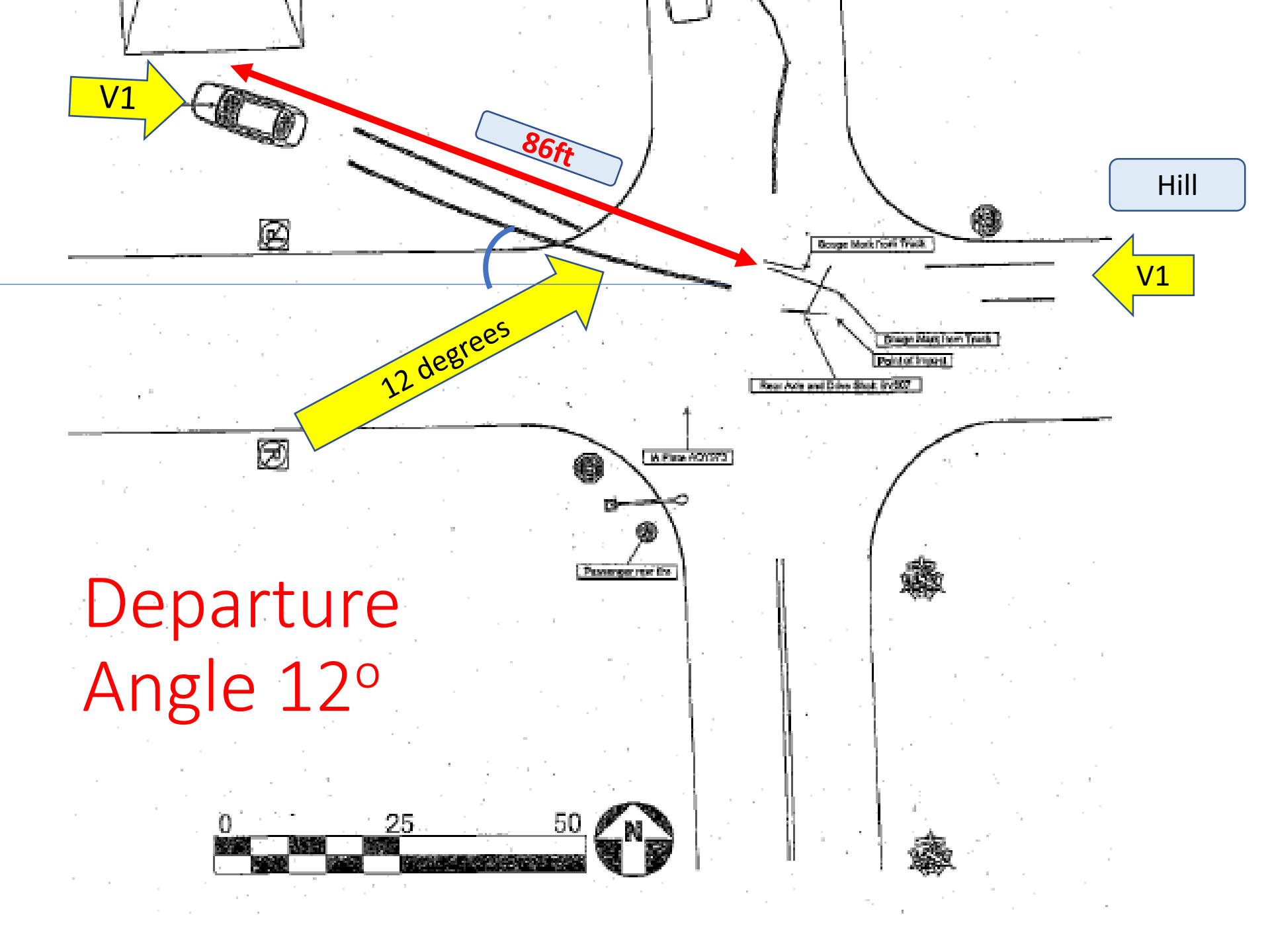
$$\text{Speed at Impact} = |V_3| Cos(\beta) - \Delta Vx$$



A vehicle approaches in the X direction

Vehicle #1 is redirected at an angle β

It is struck by a vehicle approaching at an angle


V1
86ft
Hill
V1
12 degrees
Departure
Angle 12°
0
25
50
N

29	**Method 2 - Speed at Impact = Postcrash speed * (cosine departure angle)-Delta V**								
30	** Assumes vehicle came to an uncontrolled rest - will underestimate if controlled rest**								
31	Estimated post crash travel distance based on diagram approx 86 feet								
32	departure angle from tire mark post impact at 12 degrees. Cosine 12 degrees = 0.978 (almost 1)								
33									
34	Estimate drag factor ***based on two front tires not rolling*** after crash, 0.74 drag factor times 50% of weight on front = 0.37								
35	(ASK troopers to verify the front tires are pinched and not rolling freely).								
36	0.37 for two fronts plus .015 times two for rear tires rolling = 0.40g total drag factor							N	W
37	Consider part of path was off roadway on grass at a lower drag factor - use range							75.03	55.155
38	Distance scaled as 81 feet - check fror	2					Ref	26.2	-8.5
39									
46	Minimum slide to stop with greater precision								
47	Breaks slide to stop into smaller pieces, grass, tire marks		With two locked whls			28.5			
48	Last 20 ft at 0.2	7.7	33 ft at 0.45 (road), 53 ft at 0.23 (grass)						
49	Prior 33 ft at .5*.36	14.9				10.17			
50	Prior 22 ft one tire locked 0.24	12.7							
51	Prior 11 ft all 4 rolling .06	4.4			MIN	MAX			
52	Combined speed formula	21.2 mph	+10.17 DV=		31.4	38.7			

Speed from Delta V and Postcrash Travel (Estimate Drag Factor by Segment)

- Break Slide to stop into 4 segments – **MINIMUM** speed loss
- Grass no mark = $\sqrt{30 * 20ft * 0.10g}$ = **7.4 mph**
- Grass w mark = $\sqrt{30 * 33ft * 0.23g}$ = **14.9 mph**
- Pavement 1 mark = $\sqrt{30 * 22ft * 0.245}$ = **12.7 mph**
- Pavement no mark = $\sqrt{30 * 11ft * 0.06g}$ = **4.4 mph**

- **Combined speed $\sqrt{7.42 + 14.92 + 12.72 + 4.42}$ = 21.2**

$$\text{Speed at Impact} = |V_3| Cos(\beta) - \Delta Vx$$

- SAI = 21.2 mph*cos12 – (-10.17) DVx = **31 mph min**

Speed from Delta V and Postcrash Travel (Estimate Drag Factor by Segment)

- Break Slide to stop into 2 segments – MAXIMUM speed loss
- For Max, use 2 front wheels locked post crash
- For grass 0.36g*0.5 (two wheels sliding) + .05 (two rolling)
- Grass = $\sqrt{30 * 53ft * 0.23g}$ = **19.1 mph**
- Pavement = $\sqrt{30 * 33ft * 0.45g}$ = **21.1 mph**

- **Combined speed $\sqrt{19.12 + 21.12}$ = 28.5 mph**

$$\text{Speed at Impact} = |V_3| Cos(\beta) - \Delta Vx$$

- SAI = 28.5 mph*cos12 – (-10.17) DVx = **38.0 mph MAX**

RANGE OF SPEED AT IMPACT IS 31 MIN TO 38 MAX BY THIS METHOD

CLOSING SPEED METHOD

- INLINE COLLISIONS CAN BE EASILY ANALYZED USING DELTA V, VEHICLE WEIGHTS AND RESTITIUTION
- FOR CENTRAL COLLISIONS THE FORMULA IS

$$\text{Closing Speed} = \left[\frac{1}{1+e}\right]\left[\left|\Delta V_1\right| + \left|\Delta V_2\right|\right]$$

IT IS NORMALLY APPLIED IN INLINE COLLISIONS

THE INVERSELY PROPORTIONAL TO WEIGHT FORMULA IS USED TO CALCULATE THE 2ND DELTA V

CLOSING SPEED METHOD

- FOR **OFFSET COLLISIONS**, THE FORMULA IS *MORE COMPLICATED*.
- FOR OFFSET COLLISIONS WE MUST USE THE **EFFECTIVE MASS RATIO *(EMR)*** ADJUSTMENT
- WE TAKE THE DELTA V AT THE CENTER OF MASS AND ADJUST IT TO THE DAMAGE CENTROID, WHERE THE CLOSING SPEED IS ACTUALLY TAKING PLACE
- THE FORMULA IS

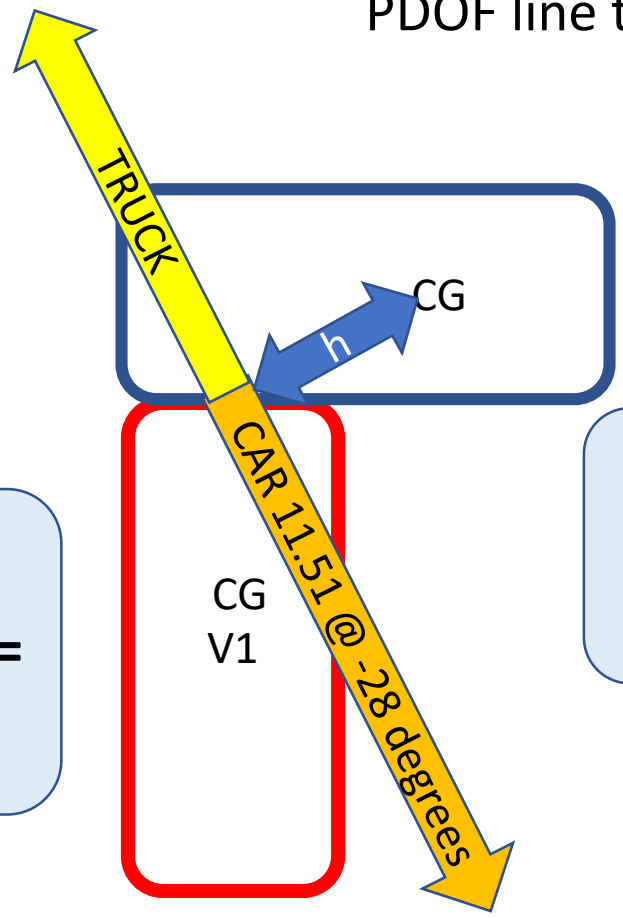
$$\text{ClosingSpeed} = \left[\frac{1}{1+e}\right]\left[\frac{|\Delta V_1|}{\gamma_1} + \frac{|\Delta V_2|}{\gamma_2}\right]$$

WHERE GAMMA IS THE **E**FFECTIVE **M**ASS **R**ATIO **(EMR)**

IT IS ***NORMALLY*** APPLIED IN **INLINE** COLLISIONS

NORMAL APPLICATION OF EMR

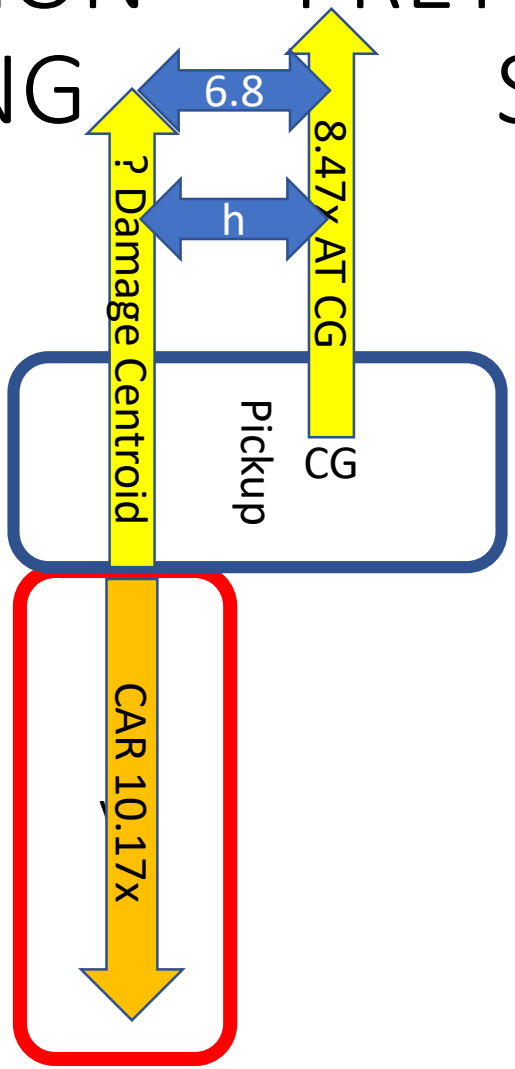
- Draw Vehicles at Max Engagement and Draw PDOF Line
- Take perpendicular distance from PDOF line to Center of Gravity to get h



Total DV = Sqrt(10.17^2+5.42^2)= 11.51

PDOF = ATAN 5.42/10.21 = -28 degrees

"INLINE INTERSECTION APPROXIMATION" – PRETEND PICKUP WAS STANDING STILL



THIS IS NOT YET PUBLISHED OR PEER REVIEWED AT THIS TIME

ISOLATE V1 ΔV_X AND CALCULATE PICKUP ΔV_Y

Step 1 – Find DV *at Center of Mass* of Pickup using the inversely proportional mass ratio

$$\Delta V_1 = -\Delta V_2 \frac{W_2}{W_1}$$

$$\boldsymbol{\Delta V x_{pickup} = -10.17_x \frac{3820}{4586} = 8.47\ mph_x}$$

Offset Adjusted Closing Speed

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

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

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

$I_y = 1.03(\text{weight in lbs}) - 1206$

FIND Effective Mass Ratio "gamma"

I_y = 1.03(weight in lbs) – 1206 for pickup

I_y = 1.03(4586) – 1206 = 3517 for pickup

NOW FIND RADIUS OF GYRATION k^2

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

k^2 = $\frac{3517}{4586}$32.2= **24.72** for pickup

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

Gamma = $\frac{24.72}{24.72+6.8*6.8}$= **0.348**

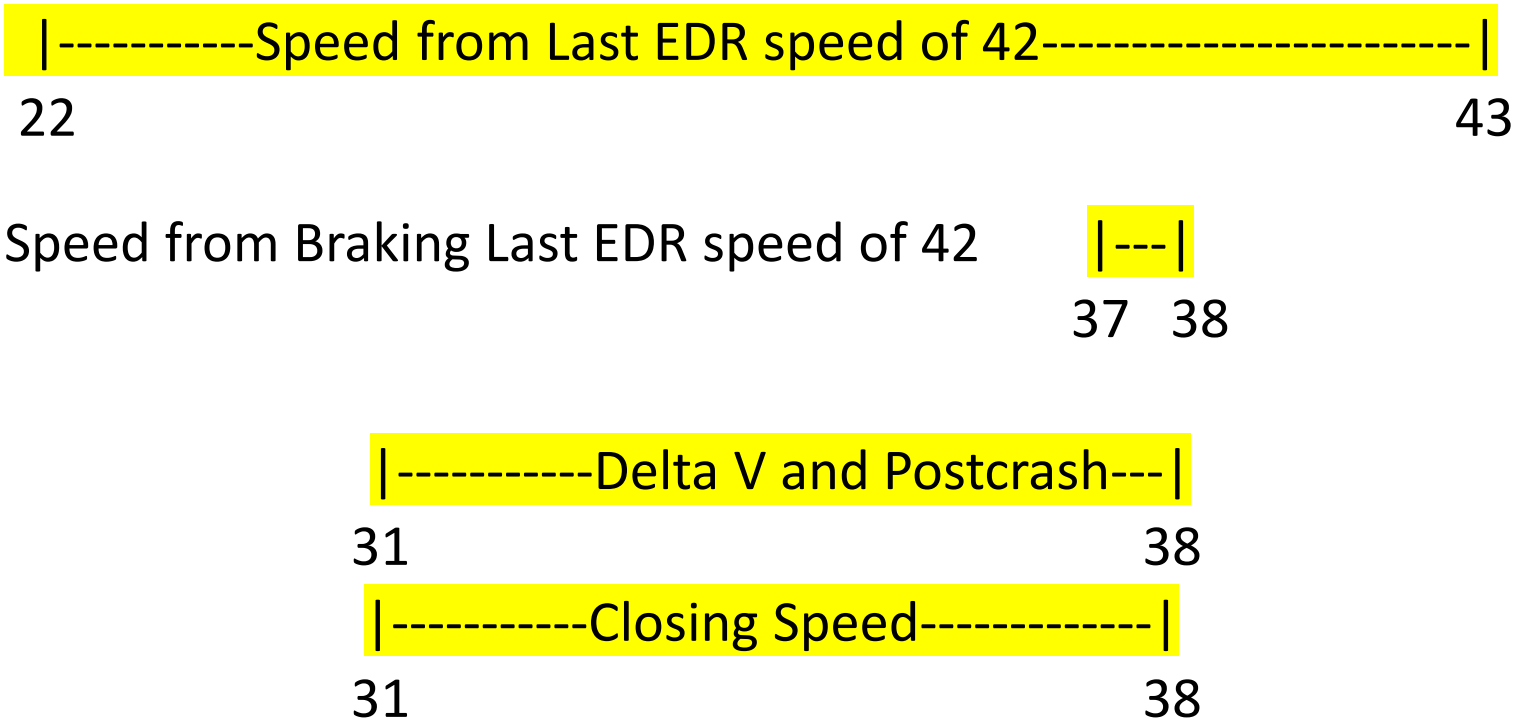
Now Find the Closing Speed

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

- $CS = \frac{\mathbf{1}}{\mathbf{1+0}}\left(\frac{\mathbf{-10.17}}{\mathbf{1.0}} + \frac{\mathbf{8.47}}{\mathbf{0.348}}\right) = \mathbf{34.5\ mph}$

- Note the vehicles did not reach a common velocity so there was no restitution
- Speed V1 = Closing Speed + V2= 34.5 + 0 = 34.5
- Applying +/-10% to the Delta V yields a range of 31.1 to 38.0

Compare the Different Methods



CONSENSUS IS SPEED AT IMPACT IS NEAR 37-38

CONCLUSION

- V1 did NOT begin to brake in reaction to seeing the stop sign (or reacted very late to it)
- V1 likely intended to blow the stop sign
- V1 likely braked in response to the pickup coming from the right
- Whether the braking was late for the stop sign or for the pickup, this adds another degree of Recklessness to V1's driving in addition to speeding with limited visibility coming over the hill top unable to stop

Stopping Distance at Speed Limit vs 48 mph

- Formula for stop distance is $D=S^2/(30*f)$ where

  D is the distance in feet,

  S is the speed in MPH, and

  f is the drag factor in G's (how fast the car can slow down)

- At 25 mph: $D=\frac{25mph*25mph}{30*0.65g}$ = 32 feet

- At 48 mph, $D=\frac{48mph*48mph}{30*0.65g}$ = 118 feet

- 118/32 = ***3.68 times the stopping distance***

Questions???

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