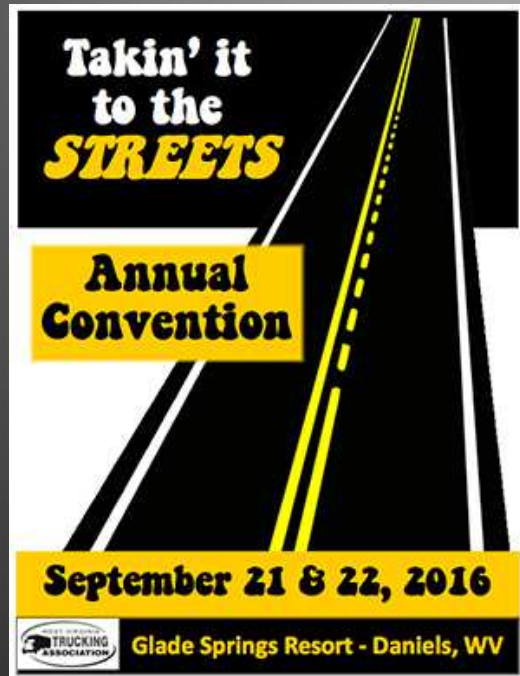


# Accident Reconstruction Tech and Heavy Trucks



*September 22,  
2016*



*Ashley (Al) Dunn, Ph.D., P.E.*

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# We're All Here...

Because ..... "Stuff Happens..."



# Accident Reconstruction

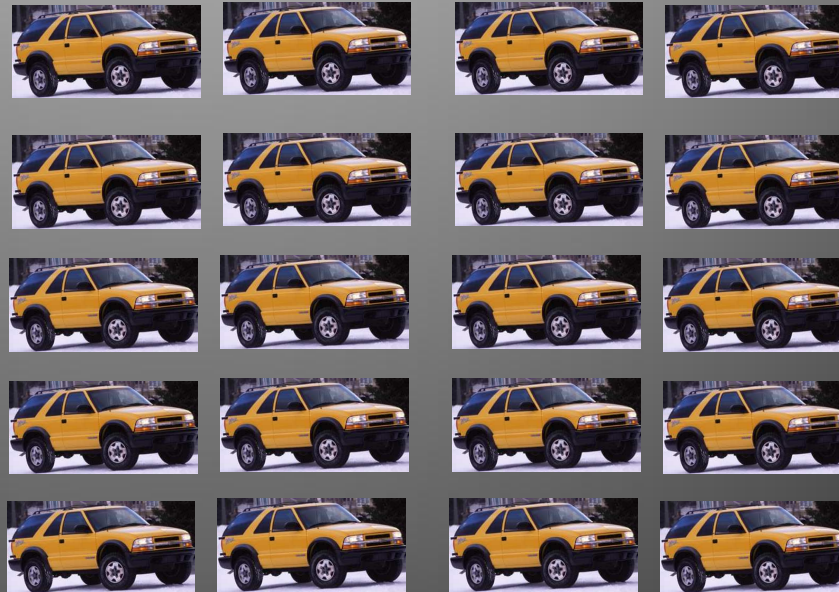
## Trucks are Different



# The Truck is 20 TIMES Heavier than your SUV!



=



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# Heavy Truck Accidents

- Injury severity is >20 times higher for passenger car occupants – versus truck occupants. Why?
- Mass ratio - can exceed 20:1
- Stiffness: Heavy trucks and trailers are primarily designed to haul weight – not absorb collision energy
- Bumper heights: Front bumpers, tractor frame, trailer deck and rear ICC bar are higher than passenger car bumpers. Results in engagement of comparatively weaker structures.





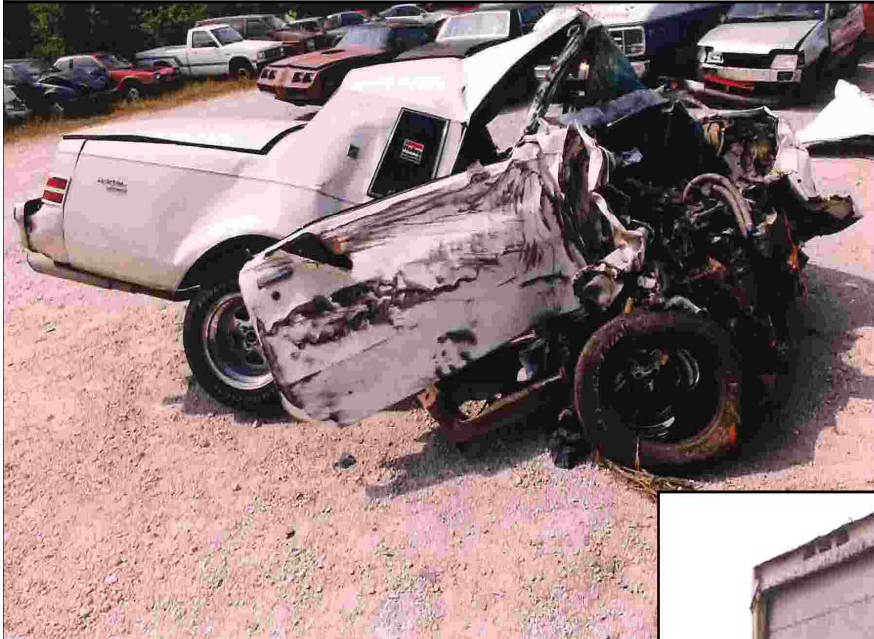
# Effect of Mass and Stiffness Disparity

Collision forces between vehicles are *equal and opposite*.



# Effect of Mass and Stiffness Disparity

Collision forces between vehicles are *equal and opposite*.



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# What is Accident Reconstruction?

- *The who...*
- *The when...*
- *The where...*
- *The what...*
- *The how...*





# DATA COLLECTION

## Commercial Vehicle Inspection Report

### Objective Truck-Related Information:

- Brake Conditions
- Brake Adjustments\*
- Axle Weights
- Crash Damage
- Other deficiencies, such as structural issues with frame

Caveat: this information is not always correct!



# DATA COLLECTION

## Commercial Vehicle Inspection Report

### VEHICLE IDENTIFICATION:

Unit	Type	Make	Year	State	License#	Company #	Unit VIN	GVWR	Issued Decal#	Existing Decal#	OOS Stkr.#
1	TT	INTL	1993	AL	7X900089	NONE	2HSFBBJR1PC074700	0			
2	ST	PITM	1993	AL	7TR00951	62829-2	PE9LT40T3PP100068	0			

### BRAKE ADJUSTMENTS:

Axle #	1	2	3	4	5
Right	2 1/2	1 3/4	2 1/2	2 3/4	3
Left	2 1/2	2 1/4	2	2 3/4	3 1/4
Chamber	C-20	C-30	C-30	C-30	C-30

>2 outta 10 ain't bad! Is it?

### VIOLATIONS :

Section Code	St	Unit	OOS	Lvl 6	Citation #	Verify*	Crash	Violation Description
393.9H		1	N	N		N	Y	**Inoperable head lamps, missing from housing
393.60(b)		1	N	N		N	Y	**Windshields required
393.80		1	N	N		N	Y	**No or defective rear-vision mirror
393.81		1	N	N		N	U	Horn inoperative
393.82		1	N	N		N	Y	**Speedometer inoperative / Inadequate
393.75(c)		1	Y	N		U	N	Tire-other tread depth less than 2/32 of inch axle 1 right side more than three area on tire
393.9T		1	N	N		N	U	Inoperable tail lamp
393.25(f)		1	N	N		N	U	Stop lamp violations
393.9TS		1	N	N		N	U	Inoperative turn signal
393.95(a)		1	N	N		N	N	No/discharged/unsecured fire extinguisher
393.28		1	N	N		N	U	Improper or no wiring protection as required, electrical line on deck
396.3A1B		1	N	N		N	N	Brakes (general), bolt not bolted into proper housing on brake chamber



# Accident Reconstruction

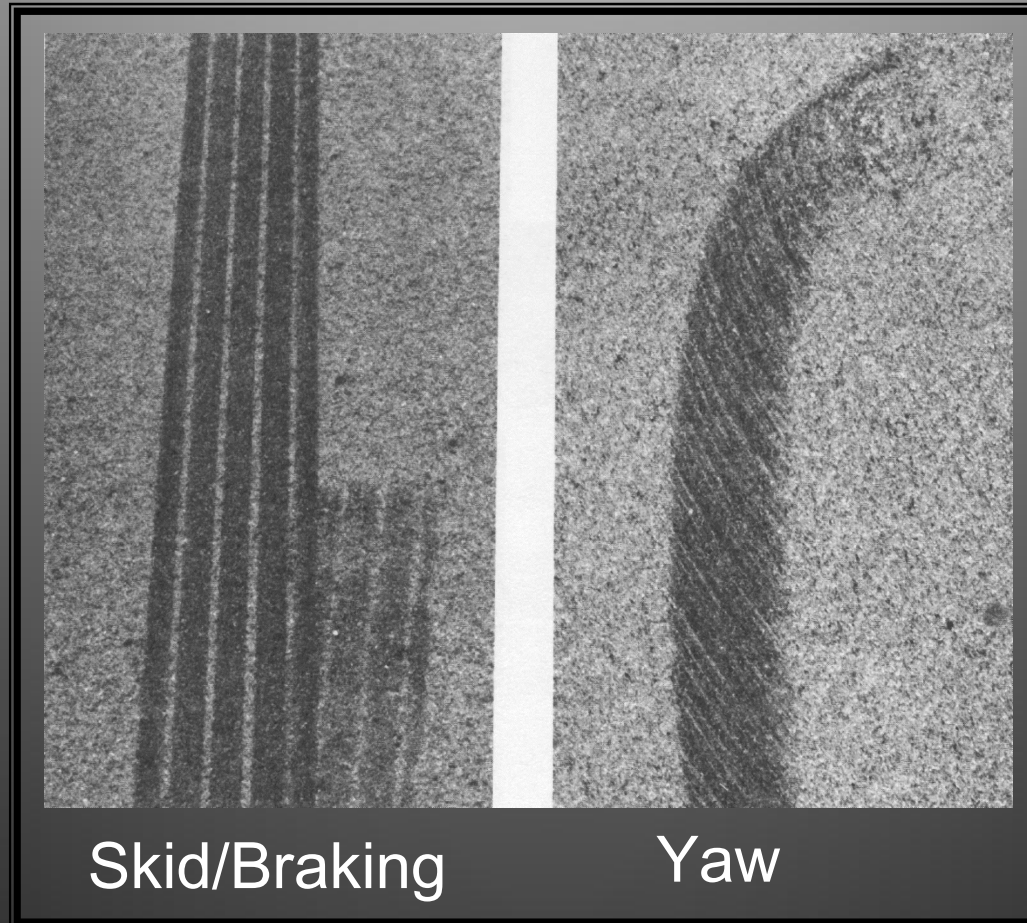
## Step 2: Document Evidence

...measure, photograph, collect, PRESERVE



# DOCUMENT EVIDENCE ASAP

Roadway evidence (tire marks, scratches / gouges)



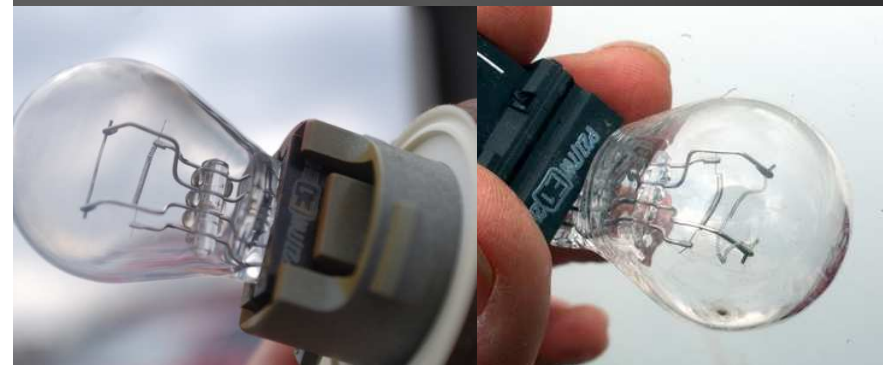
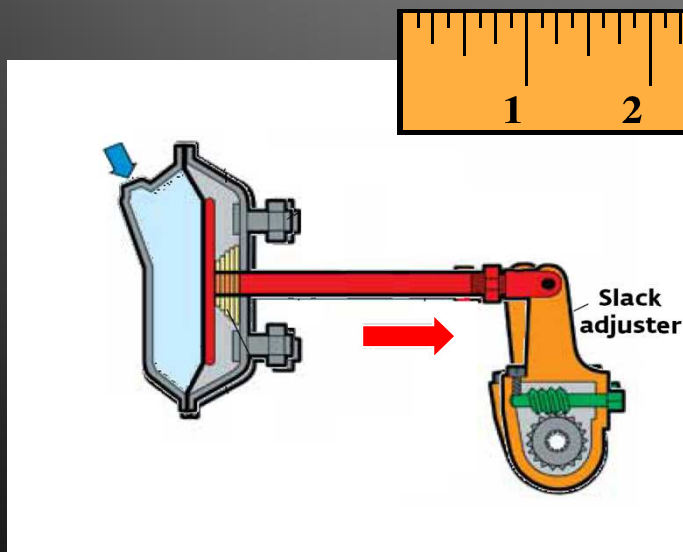
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# DOCUMENT EVIDENCE ASAP

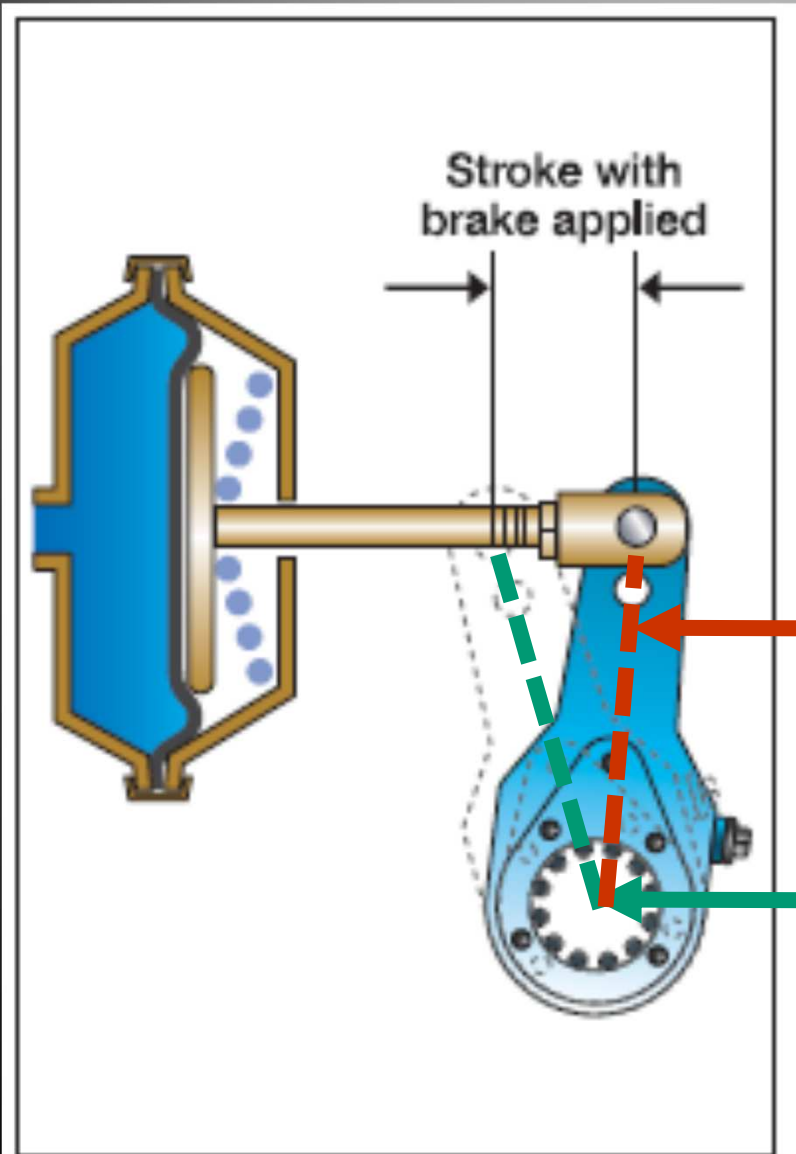
## Vehicle Inspection (Special Circumstances):

- Brakes
- Conspicuity (Lighting, reflectors, clothing)
- Seat Belts, Guides
- Others (Suspension, Tire)?





# The Infamous Slack Adjuster



“not a lazy person  
who works for an  
insurance  
company....”

applied

released

# Now, we'll put the Brake Together

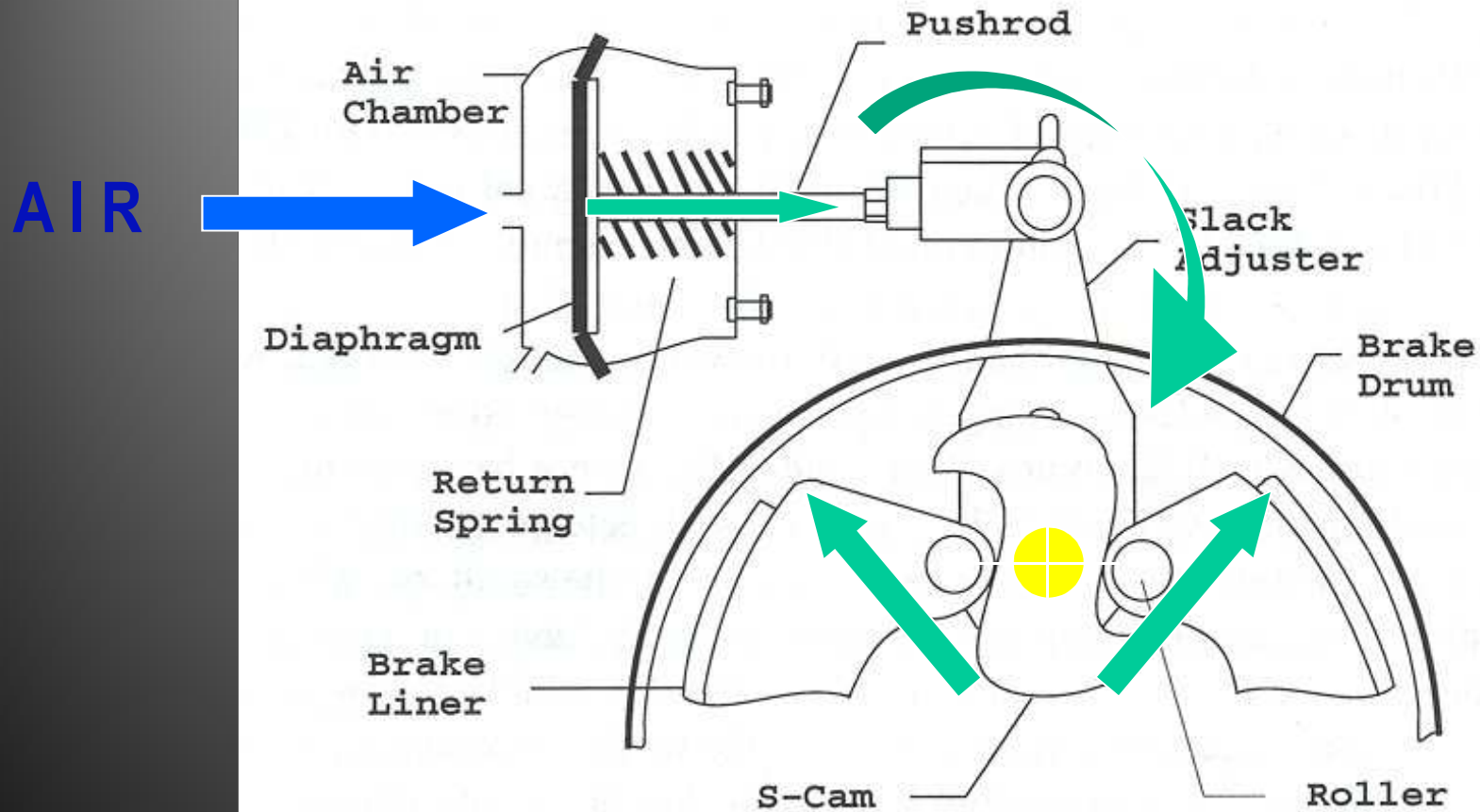
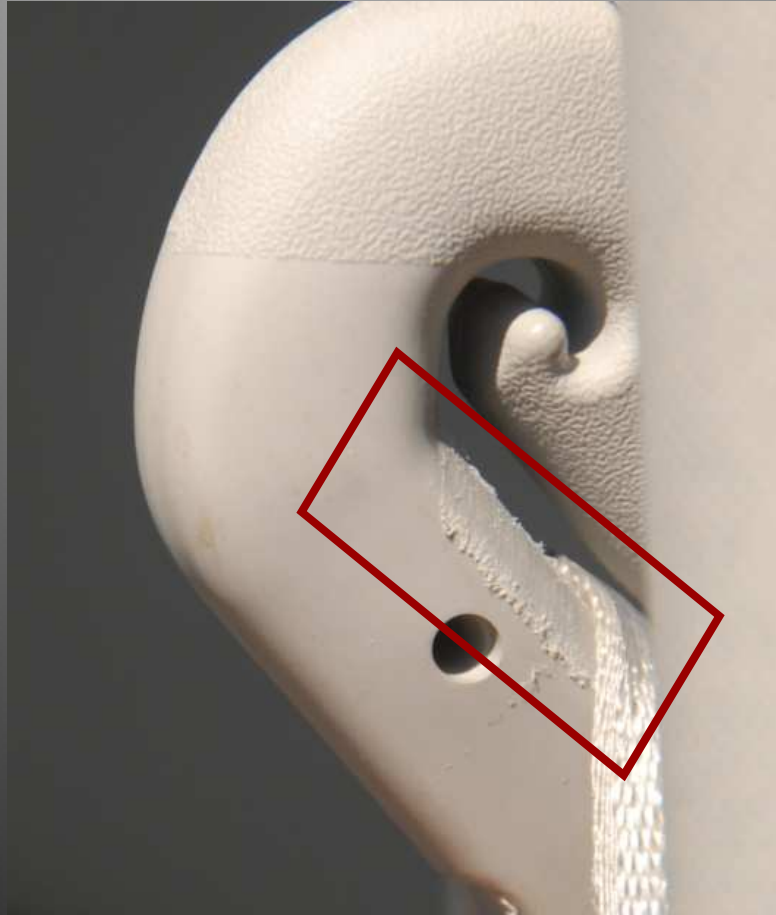


Figure 1: S-cam brake assembly.

# DOCUMENT EVIDENCE ASAP

Vehicle Inspection (Special Circumstances):

- Seat Belts - Evidence of Use – Close-up



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# DOCUMENT EVIDENCE ASAP

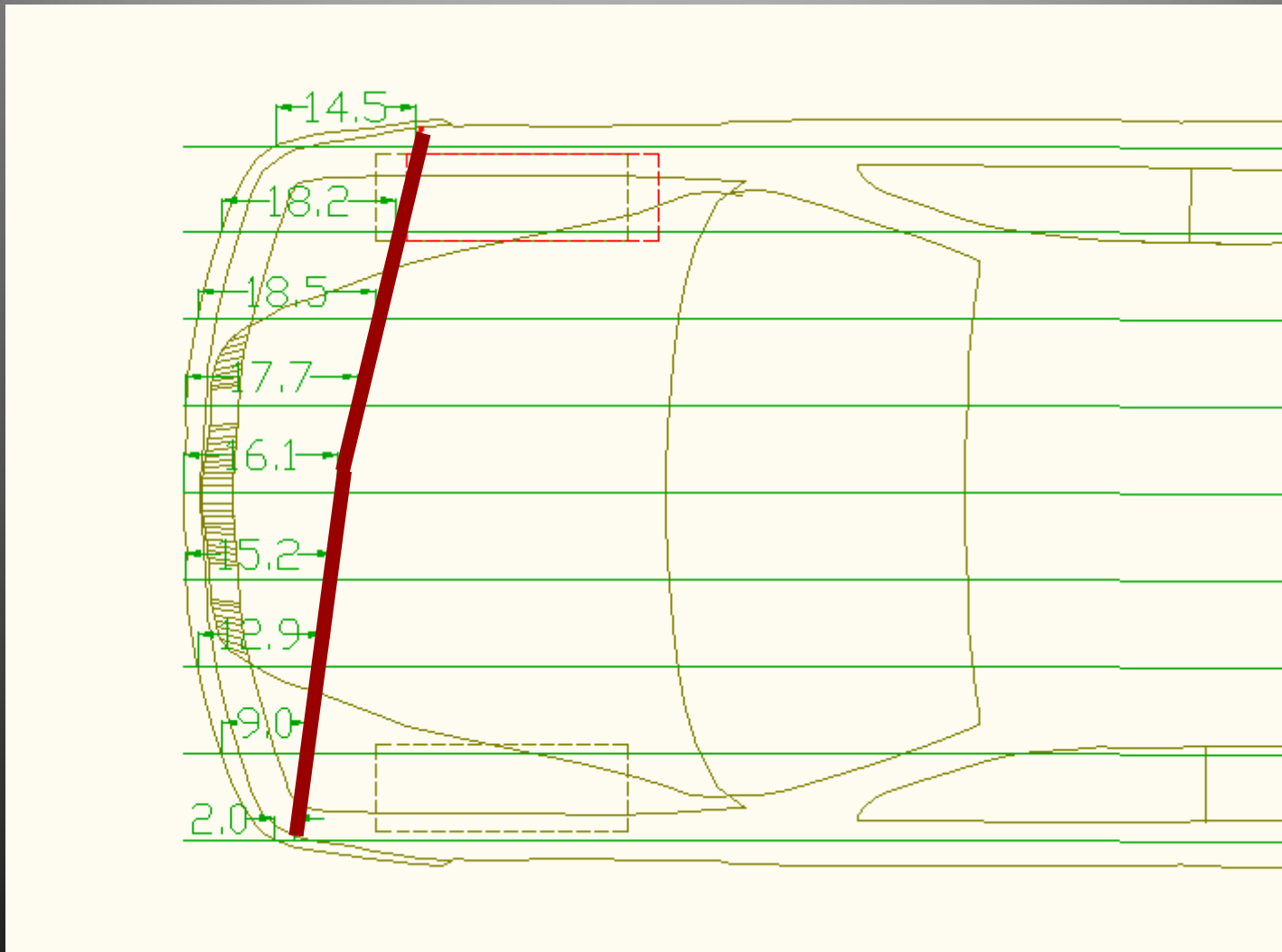
## Engine Control Module Data Extraction:

- It is Engine Specific, not truck specific
  - Cummins, Caterpillar, Detroit Diesel...
- Is the record option activated?
- What data is retrievable?
- What are the best means to extract the NECESSARY data?
  - Onboard
  - Direct to Module
  - Exemplar engine/truck



# VEHICLE DRAWING

## Measure and Document Crush

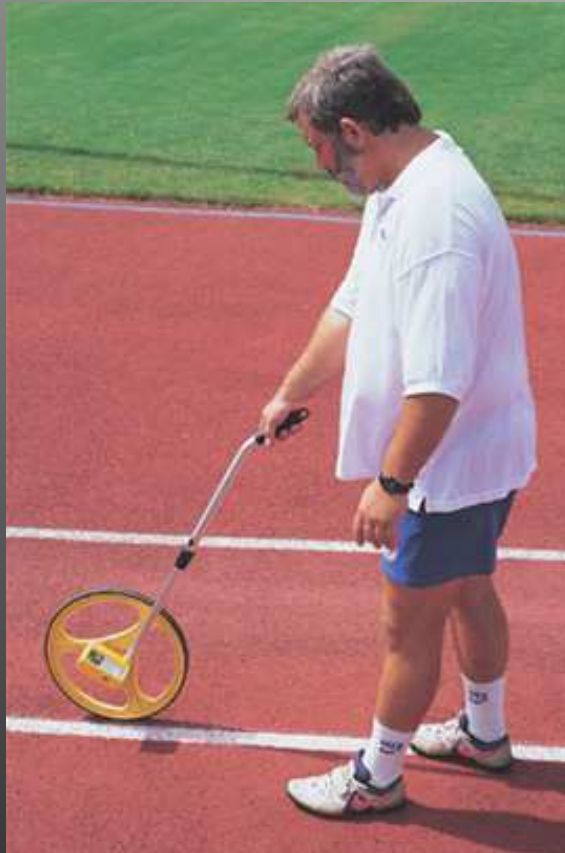




**Tools**  
**Available to Your Expert**  
**Old School and High-Tech**



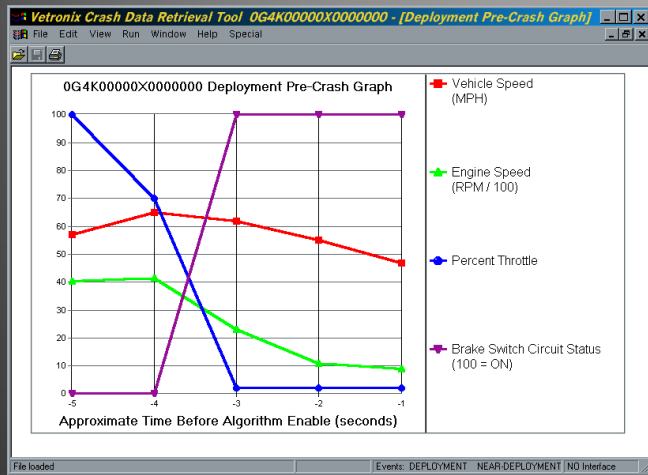
# Traditional Tools



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# High Tech Tools

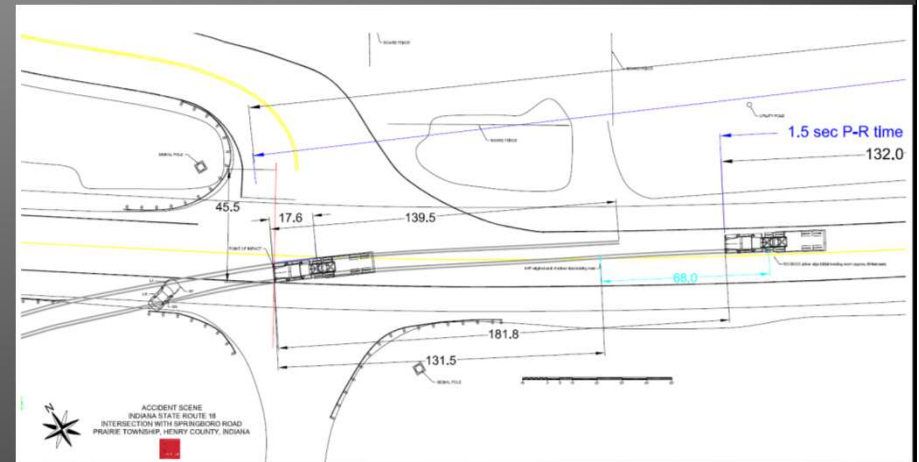
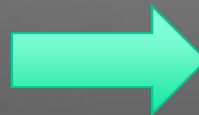


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# Photo Modeling

aka, “Photogrammetry”



SCENE DRAWING



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# Photo Modeling



**ACCIDENT SCENE**



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# ACCIDENT SCENE – Truck POFR

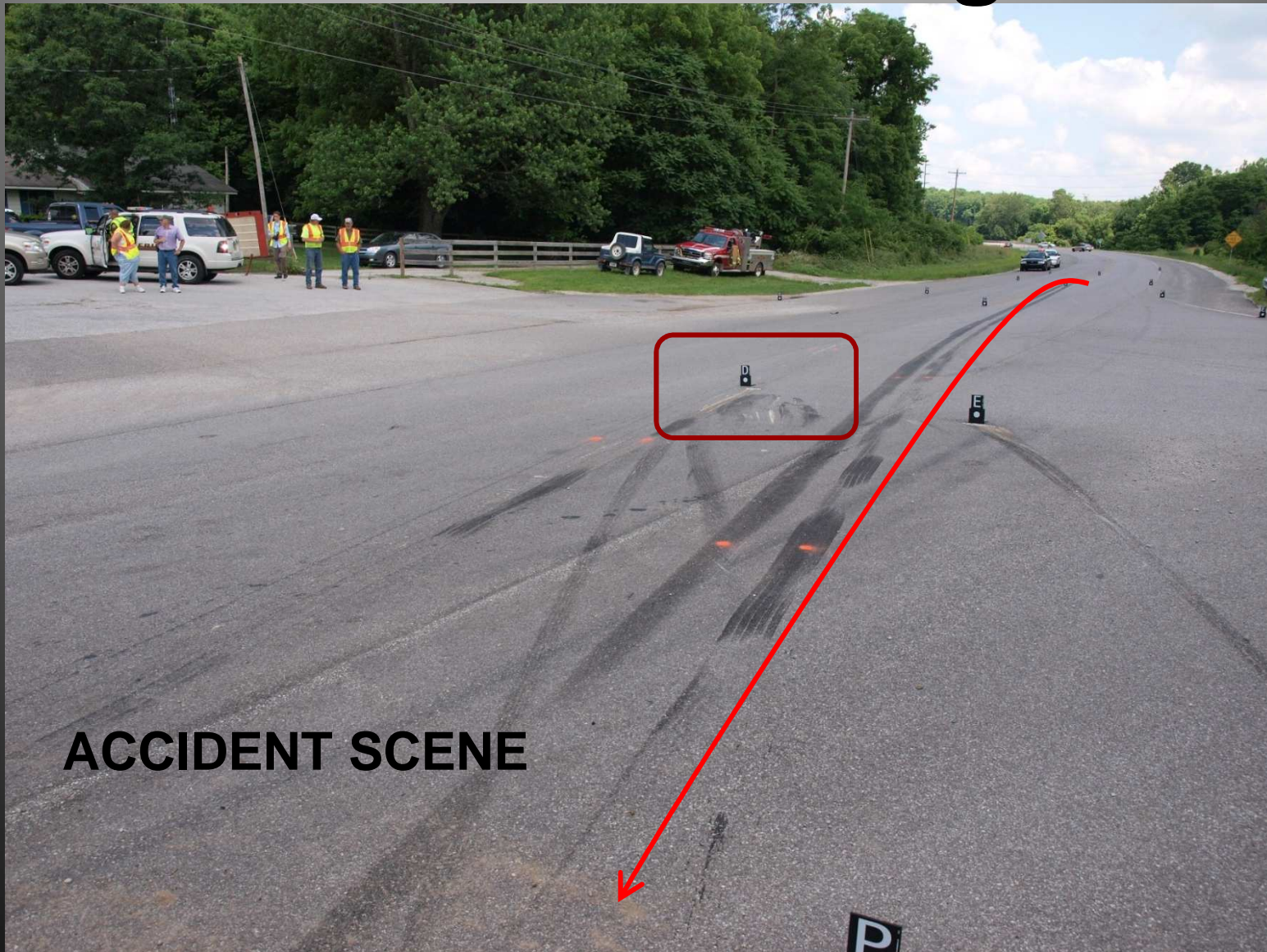


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# Photo Modeling



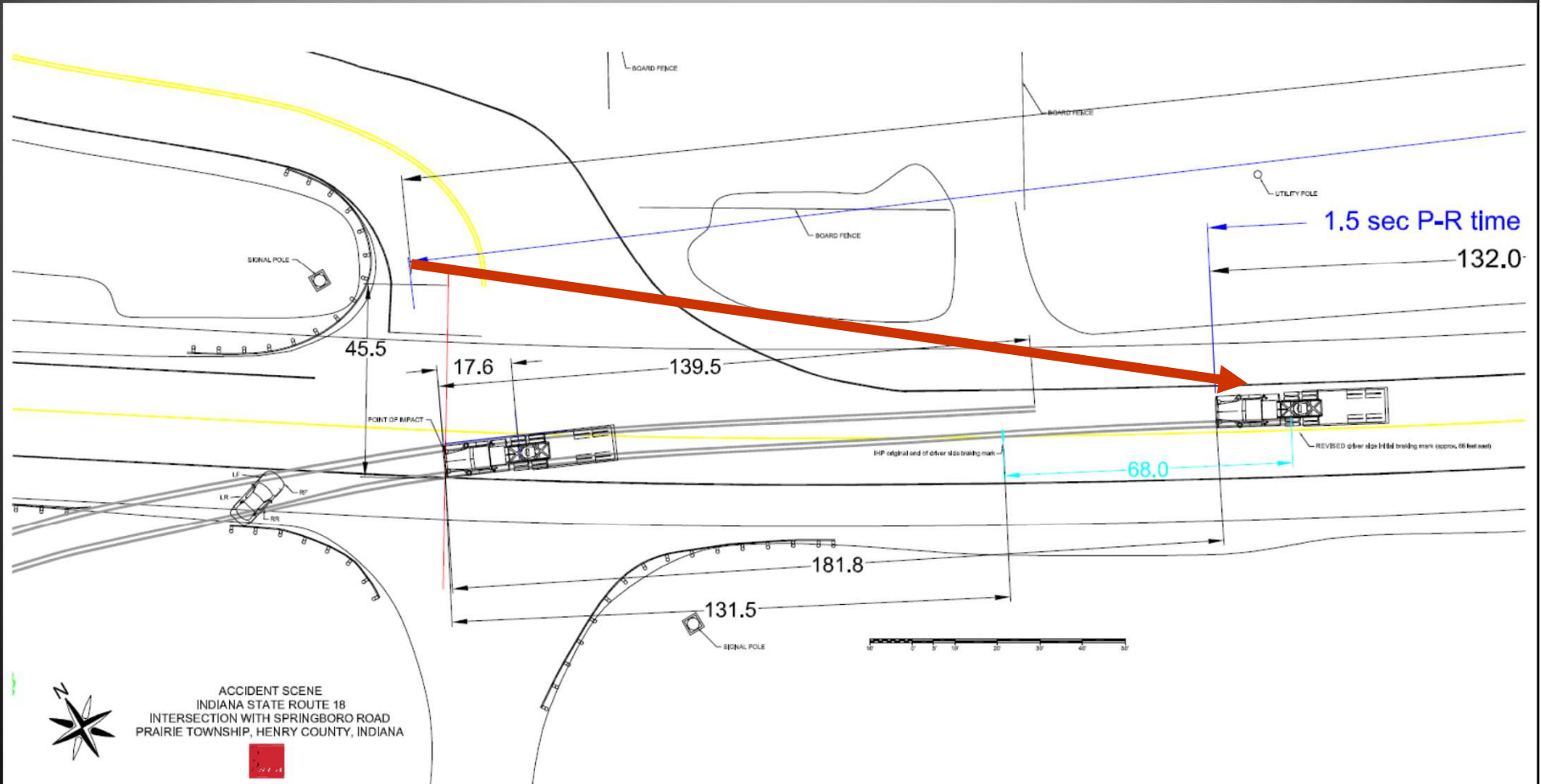
**ACCIDENT SCENE**



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# Scene Diagram



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# Event Data Recorder Heavy Truck ECM Download

Time	Vehicle Speed (mph)	Engine Speed (rpm)	Brake	Clutch	Engine Load (%)	Throttle (%)	Cruise	Diagnostic Code
-0:15	58.0	1293	No	No	68.50	0.00	Yes	No
-0:14	58.0	1295	No	No	69.50	0.00	Yes	No
-0:13	58.5	1302	No	No	68.50	0.00	Yes	No
-0:12	58.5	1302	No	No	70.00	0.00	Yes	No
-0:11	58.5	1310	No	No	71.50	0.00	Yes	No
-0:10	58.5	1311	No	No	72.00	0.00	Yes	No
-0:09	58.5	1308	No	No	72.50	0.00	Yes	No
-0:08	59.0	1312	No	No	73.00	0.00	Yes	No
-0:07	59.0	1313	No	No	73.00	0.00	Yes	No
-0:06	59.0	1309	No	No	73.00	0.00	Yes	No
-0:05	59.0	1326	No	No	67.50	0.00	Yes	No
-0:04	59.0	1188	Yes	No	99.50	100.00	Yes	No
-0:03	59.5	1088	No	No	100.00	100.00	No	No
-0:02	53.0	982	Yes	No	0.00	0.00	No	No
-0:01	49.0	766	Yes	Yes	0.00	0.00	No	No
0:00	45.0	499	Yes	Yes	80.50	0.00	No	No
+0:01	37.0	602	Yes	Yes	11.50	0.00	No	No
+0:02	29.0							
+0:03	20.5							

$\Delta V = 8.0 \text{ mph} - \text{triggers save}$



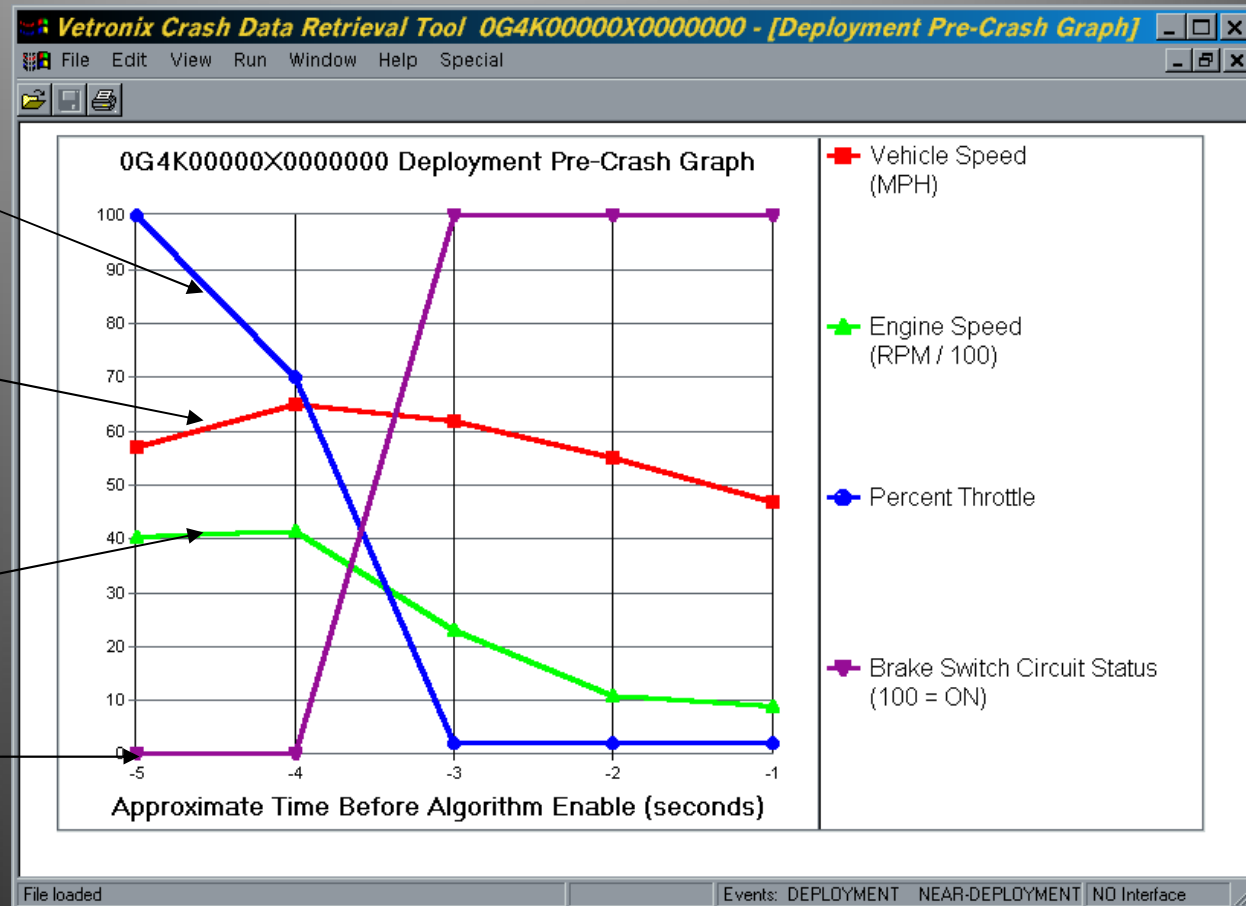
# Event Data Recorder (EDR) Passenger Car

Percent of Wide Open Throttle

Vehicle Speed (MPH)

Engine Speed (RPM)

Brake Switch Status (On or Off)



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# High Tech Vehicle – Site Survey

Vehicle / Scene Scans with FARO Scanner



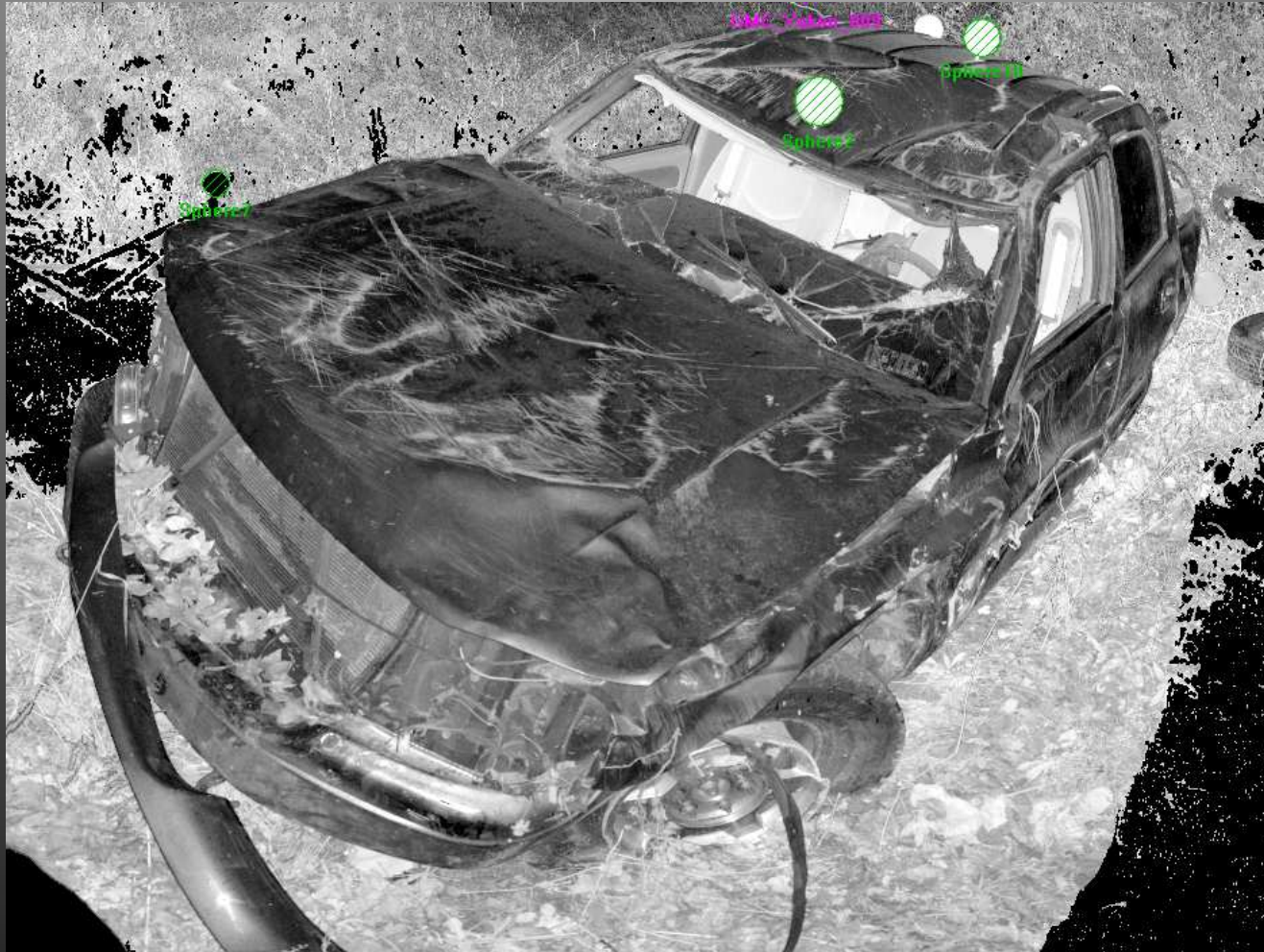
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# DOCUMENT EVIDENCE

## *FARO Scanner*

Vehicle Scan – this is **NOT** a photograph



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# DOCUMENT EVIDENCE

## *FARO Scanner*

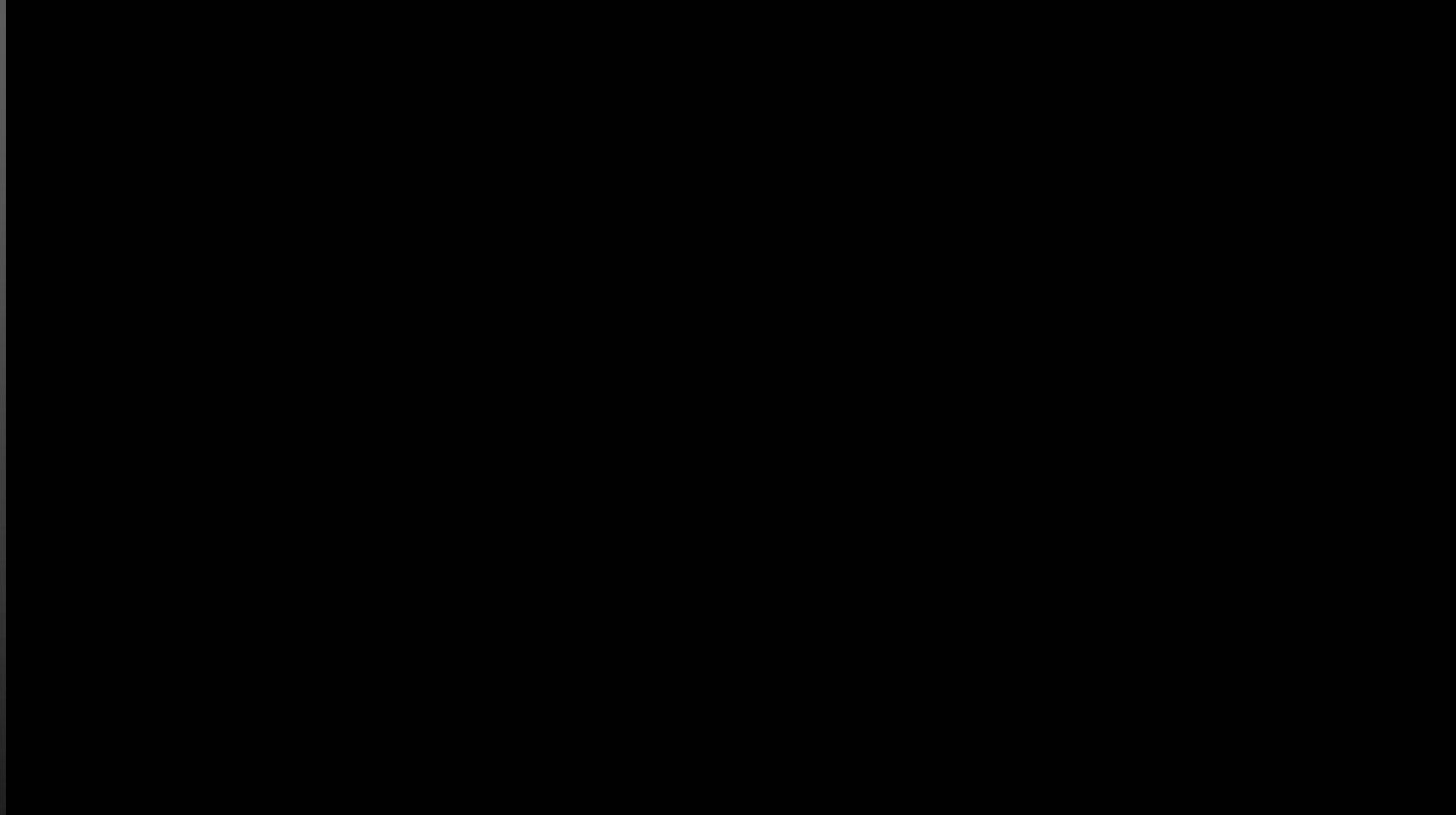


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# DOCUMENT EVIDENCE

## *FARO Scanner*





# DOCUMENT EVIDENCE

## *FARO Scanner Data – Scene – HVE Sim*





# DOCUMENT EVIDENCE

## *FARO Scanner Data – Scene – HVE Sim*



# ANALYSIS OPTIONS

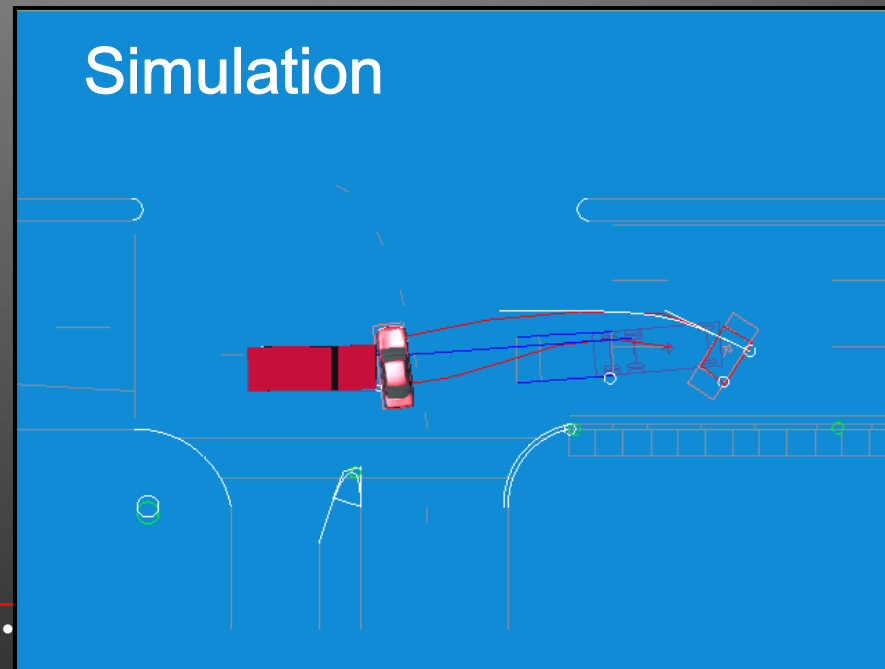
Testing



Calculations

$$\frac{\partial}{\partial a} \ln f_{a, \sigma^2}(\xi_1) = \frac{(\xi_1 - a)}{\sigma^2} f_{a, \sigma^2}(\xi_1) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left\{-\frac{(\xi_1 - a)^2}{2\sigma^2}\right\}$$
$$\int_{R_n} T(x) \cdot \frac{\partial}{\partial \theta} f(x, \theta) dx = M\left(T(\xi) \cdot \frac{\partial}{\partial \theta} \ln L(\xi, \theta)\right)$$
$$\int_{R_n} T(x) \cdot \left(\frac{\partial}{\partial \theta} \ln L(x, \theta)\right) \cdot f(x, \theta) dx = \int_{R_n} T(x) \cdot \left(\frac{\partial}{\partial \theta} \frac{f(x, \theta)}{f(x, \theta)}\right) f(x, \theta) dx$$
$$\frac{\partial}{\partial \theta} MT(\xi) = \frac{\partial}{\partial \theta} \int_{R_n} T(x) f(x, \theta) dx = \int_{R_n} T(x) \frac{\partial}{\partial \theta} f(x, \theta) dx$$

Simulation



# Vehicle Mechanics / Dynamics

## 1. Speed calculations

- *Crush Energy & Force*
- *Conservation of Momentum*
- *Conservation of Energy*
- *Force Balance*



# Vehicle Mechanics / Dynamics

## 2. Time-Speed Distance Calculations

- *Set Bounds on the Possible*
- *Evaluate Perception/Reaction Times*
- *Is a Scenario Physically Possible?*



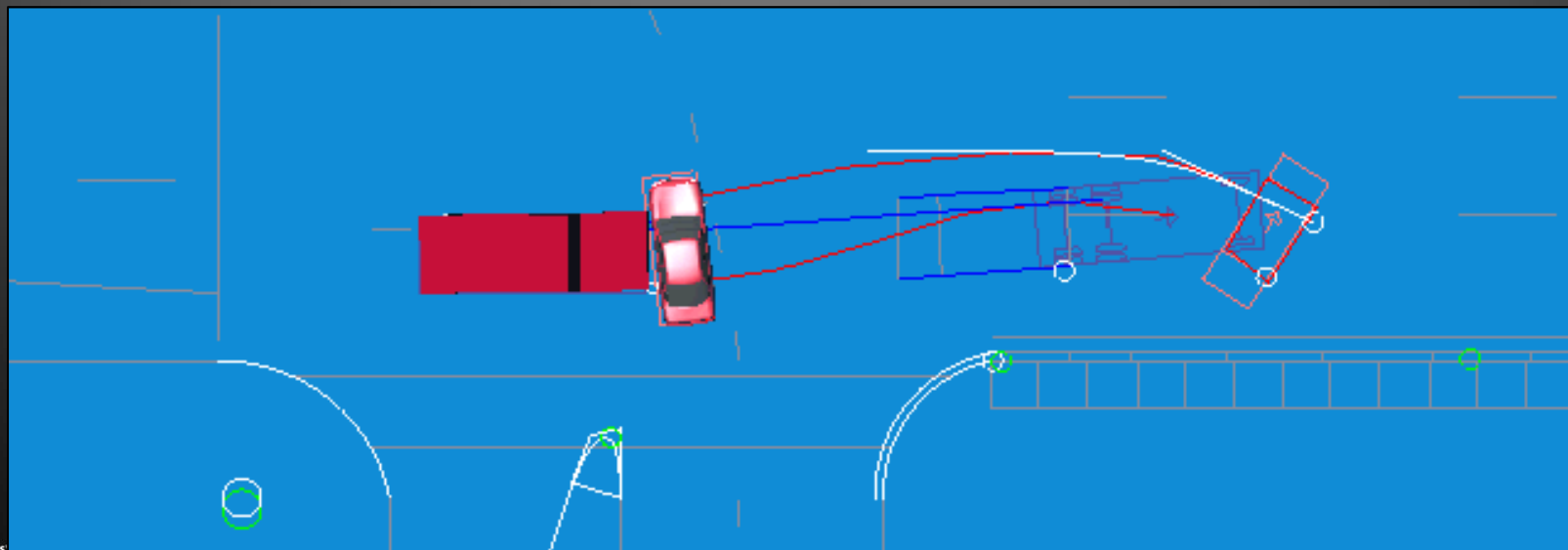
# Vehicle Dynamics and Modeling





# Accident Reconstruction Simulation

## *HVE-SIMON*



# Full Scale Testing



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# Full Scale Testing Suspension Failure?





# The Accident – Rollover - Fire Suspension Failure?



DEF EXH B-9



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# Full Scale Testing Road Edge Recovery



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# Full Scale Testing – Closing Speed Determination

Panning Video



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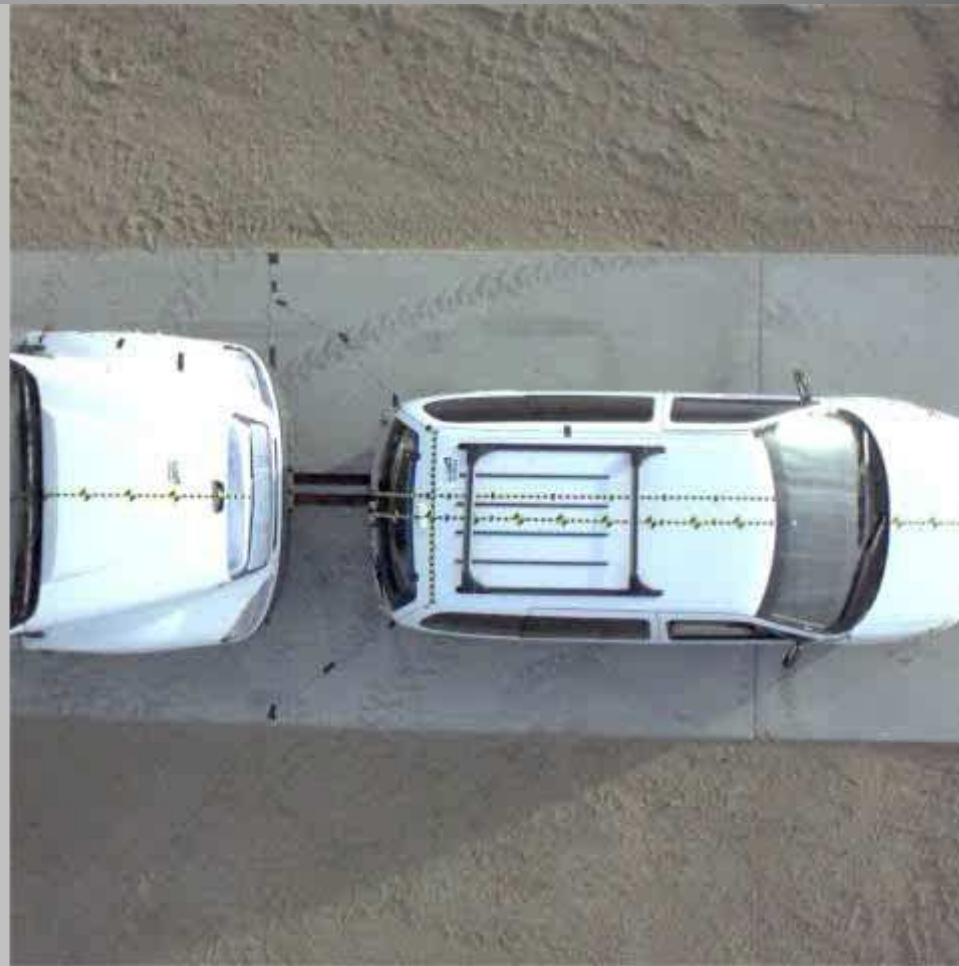
# Full Scale Testing – Closing Speed Determination

Overhead High-Speed Video

Camera  
View # 05

Frame #  
-50

Time  
-0.0500



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# Full Scale Testing – Closing Speed Determination

**Goal:** Duplicate Damage on Subject Vehicle



Accident Vehicle



Test - Target Vehicle



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# Full Scale Testing – Truck ABS

## Wet Braking in a Curve



ABS - Tractor ON / Trailer ON



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# Full Scale Testing – Truck ABS

## Wet Braking in a Curve



ABS - Tractor ON / Trailer OFF



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# ***Trial Exhibits***

## Animation – Oversized Load and Pedestrian



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Thank You for your time today!

Ashley L. (AI) Dunn, Ph.D., P.E.

