

PRE-CRASH PATH DETERMINATION USING STABILITY CONTROL DATA

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Objectives

- ▶ To determine the path of a vehicle prior to the crash without utilizing road evidence
- ▶ To verify the intrusion path and determine exact time and location where the vehicle crossed the centerline

Requirements

- ▶ At least one vehicle with Event Data Recorder (EDR) is required to obtain:
 - ▶ Vehicle Velocity
 - ▶ Electronic Stability Control Data
- ▶ Area of Impact
- ▶ Scaled scene diagram

How does it work?

- ▶ Use Speed of the vehicle over 0.1 second intervals
- ▶ Translate ESC data to lateral and longitudinal “movement” every 0.1 second
- ▶ Assemble the points to form a curve for desired length of time
- ▶ Project the plotted path on the roadway using area of impact as reference
- ▶ Adjust for road geometry
- ▶ Verify movement along a curve using steering data if available

“Movement”

- ▶ Requires:

- ▶ Object to travel from point A to point B
- ▶ Travel the distance between A and B at a velocity during a time interval

BASICALLY, VELOCITY VECTOR WITH DIRECTION AND
MAGNITUDE

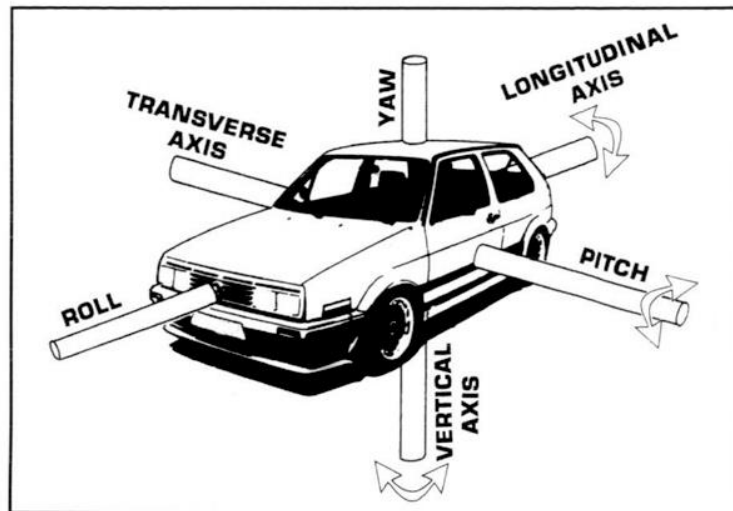
Example

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

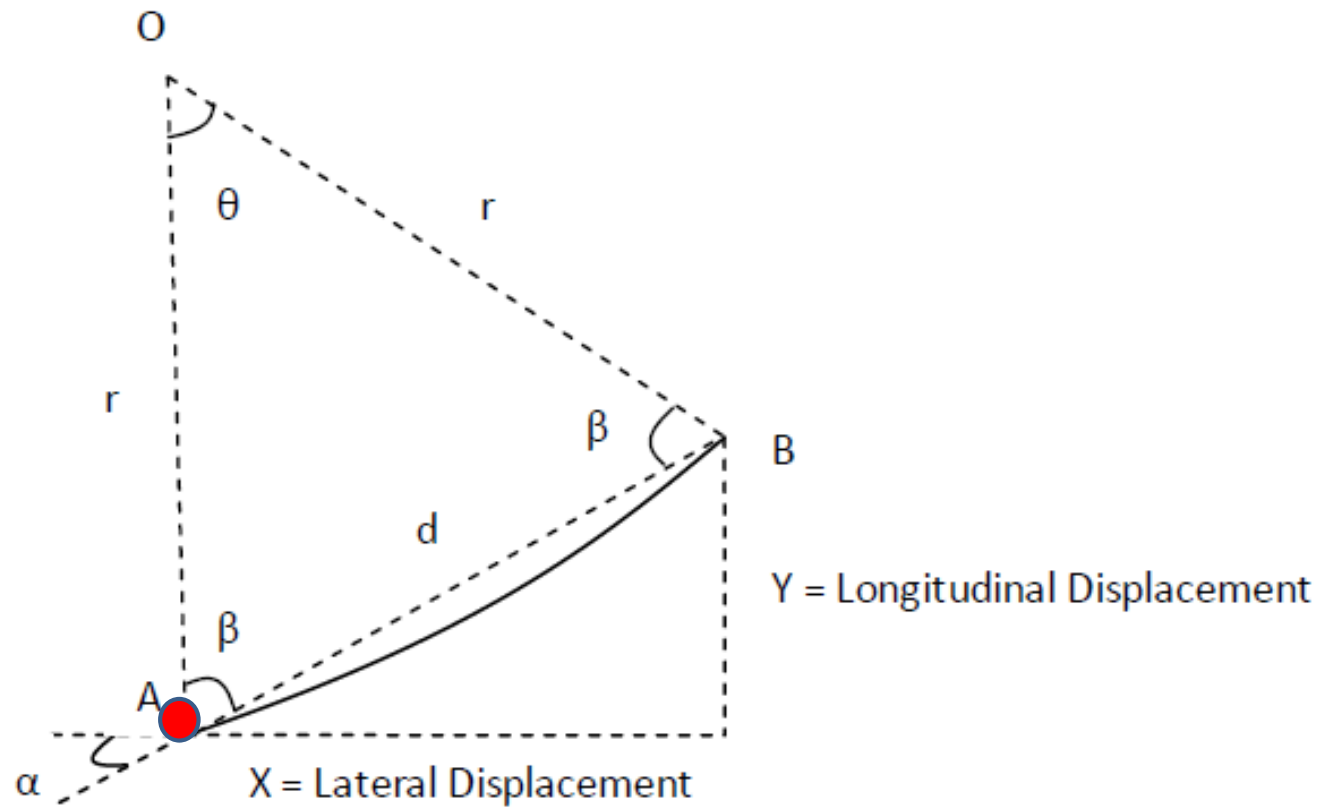
Times (sec)	Steering Wheel Angle (degrees)	Stability Control Lateral Acceleration (g)	Stability Control Longitudinal Acceleration (g)	Stability Control Yaw Rate (deg/sec)	Stability Control Roll Rate (deg/sec)
- 5.0	5.0	-0.085	-0.069	-0.37	0.62
- 4.9	3.7	-0.066	-0.049	-0.12	0.25
- 4.8	4.2	-0.062	-0.09	-1.0	-0.25

Stability Control Yaw Rate (deg/sec)

- Represents the angular velocity (ω) around the vertical axis of the vehicle
- Rate of change in the heading (deg/sec)

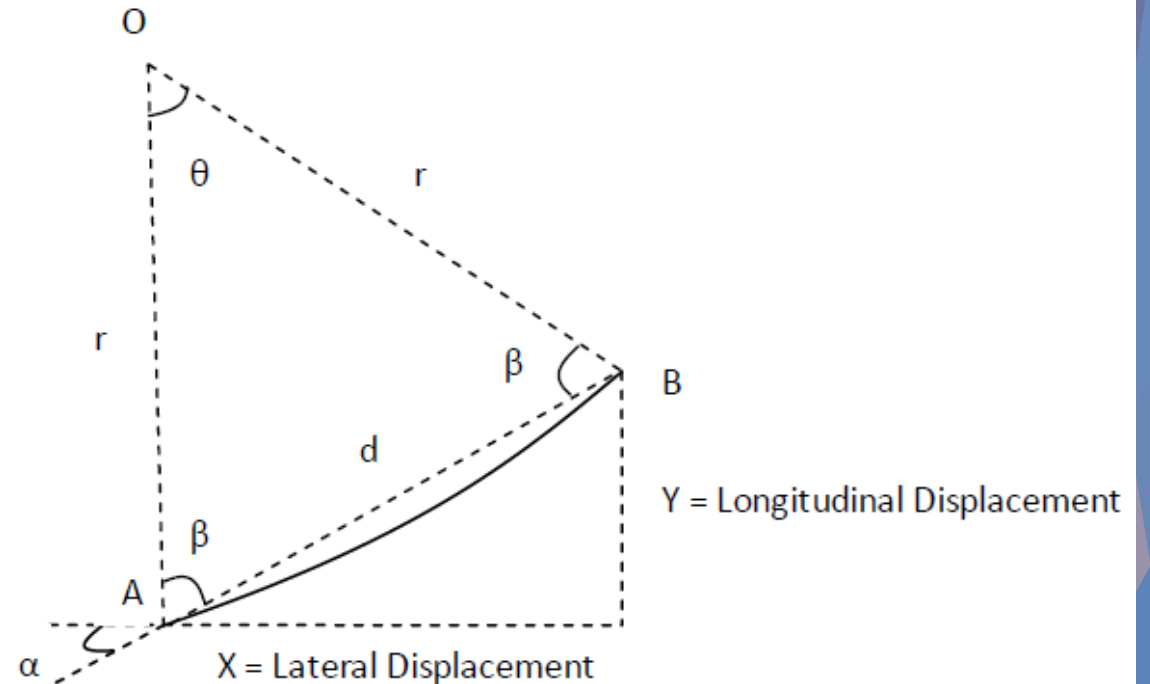


Stability Control Yaw Rate (deg/sec)



Stability Control Yaw Rate (deg/sec)

1. $\frac{v\Delta t}{\theta} = r$
2. $\sin \theta \times r = \sin \beta \times d$
3. $\beta = 90 - \alpha$
4. $\theta = 2\alpha$ or $\alpha = \frac{\theta}{2}$
5. $2 \sin \alpha \times r = d$
6. $d = 2 \sin \alpha \times \frac{v\Delta t}{\theta}$
7. $d = 2 \sin \alpha \times \frac{v\Delta t}{2\alpha}$
8. $d = \sin \alpha \times \frac{v\Delta t}{\alpha}$



X and Y

$$x = d \cos \alpha$$

$$y = d \sin \alpha$$

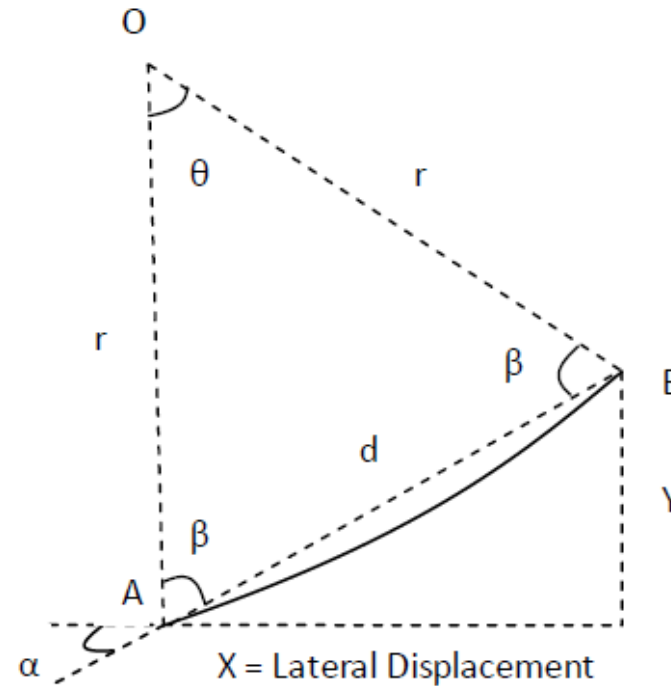
$$d = \sin \alpha x \frac{v \Delta t}{\alpha}$$

Where:

$\alpha = \text{heading change (deg)}$

$v = \text{instantaneous velocity (m/s)}$

$\Delta t = \text{time period (s)}$

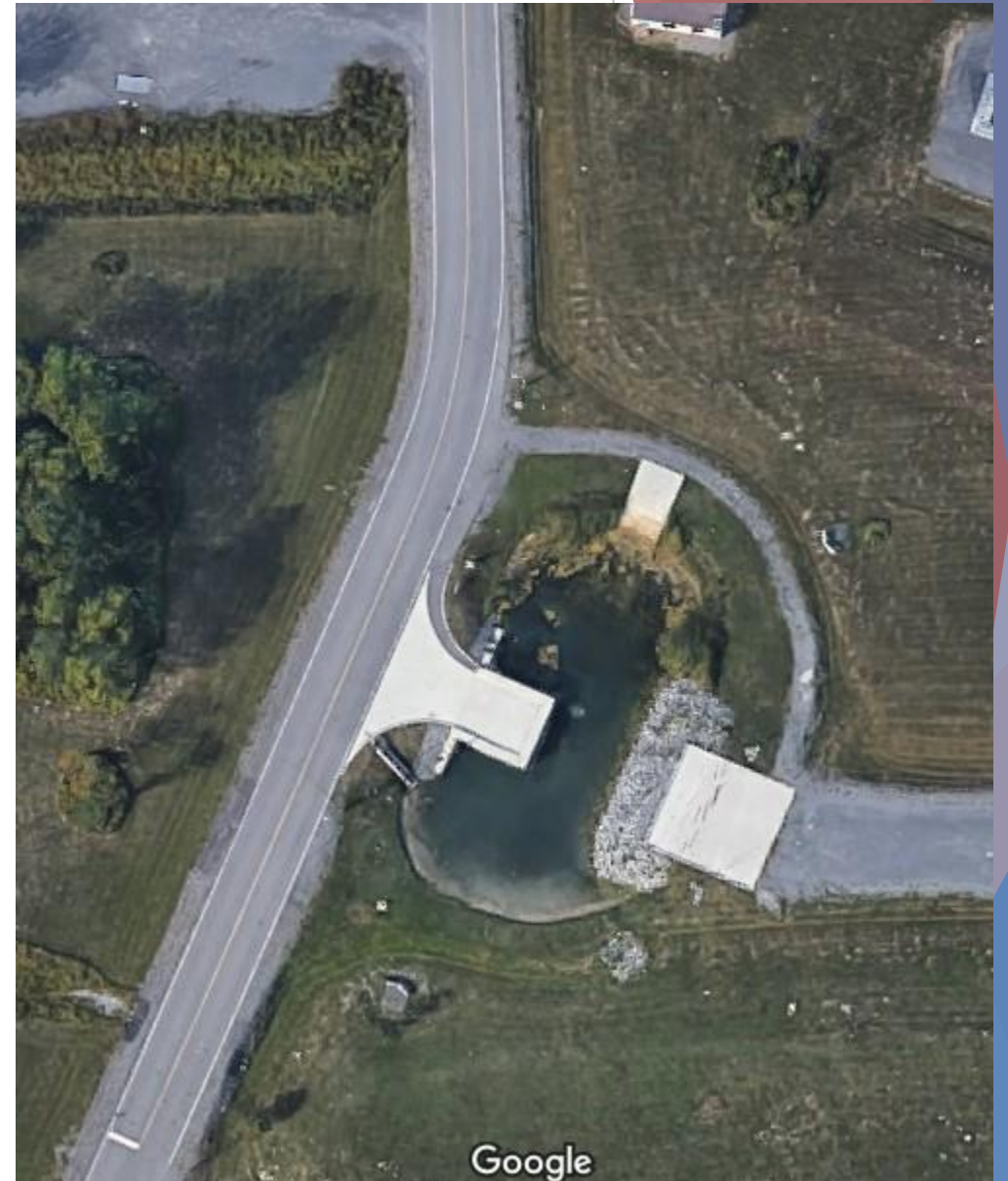


Crash Test

- ▶ Low speed, head-on collision
- ▶ Encroachment of one vehicle into path of another
- ▶ Comparison between EDR data analysis, road evidence and data obtained from onboard data recorders

Test Location

- ▶ City of Kingston, Ontario
- ▶ Fire Department training facility
- ▶ 2 lanes, 3.85 meters each
- ▶ Slight curve to north west



Test Vehicles



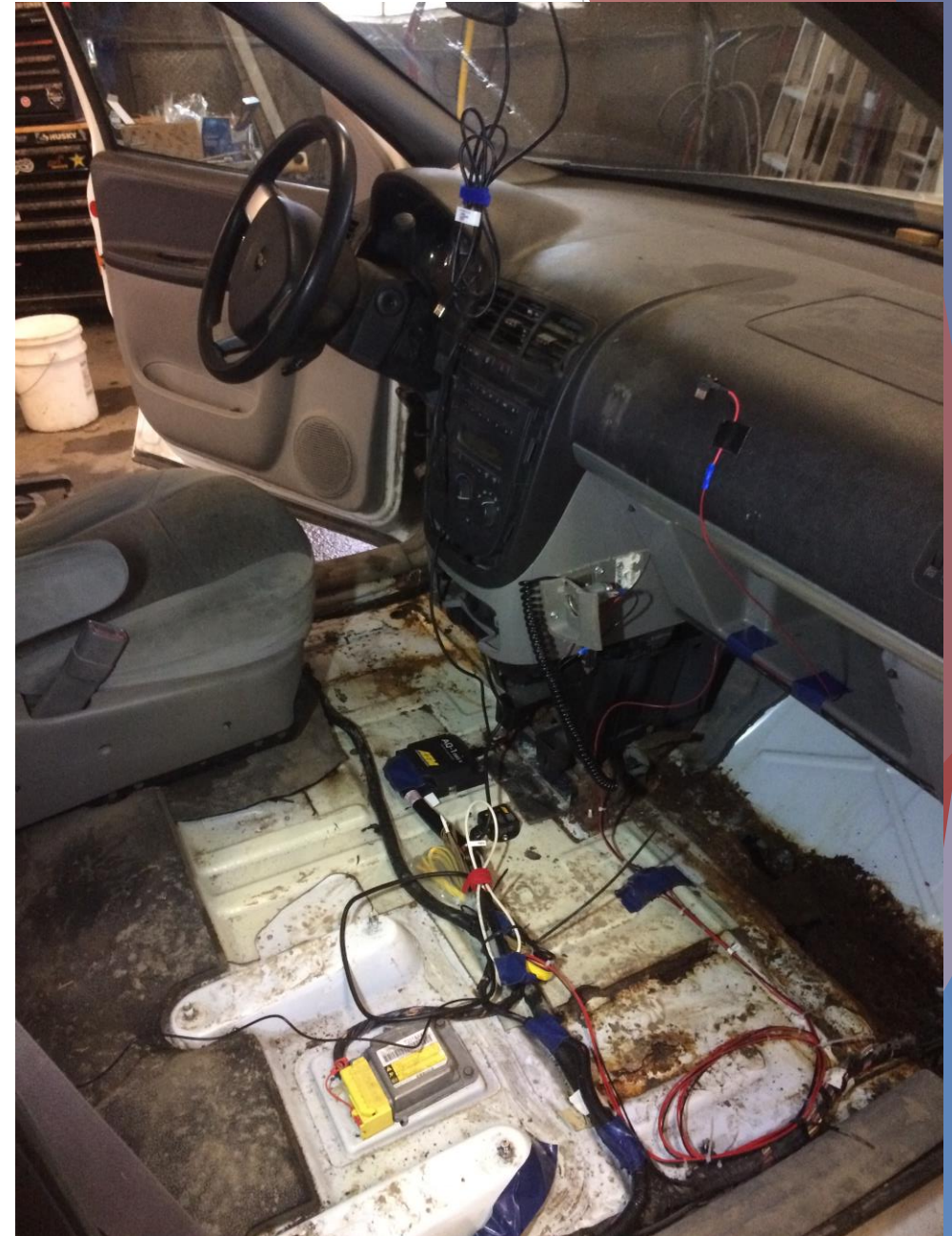
2008 Chevrolet Uplander

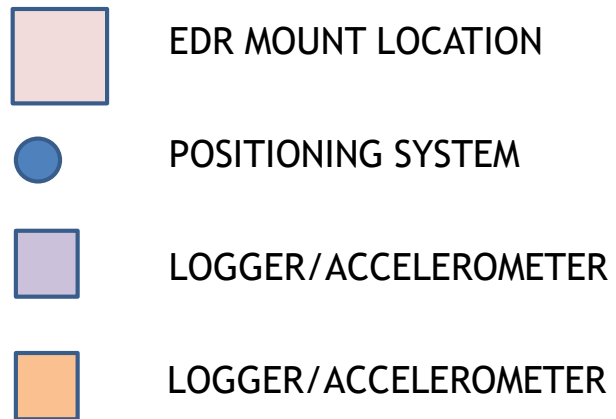


1998 Volkswagen Jetta

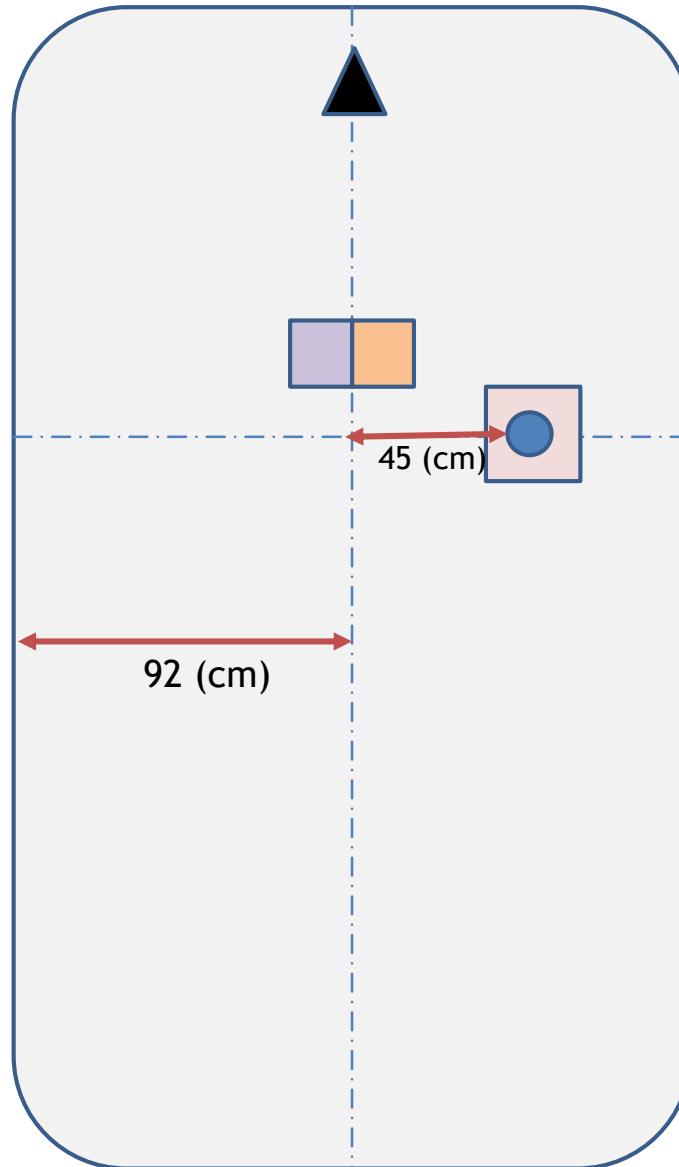
Instrumentation

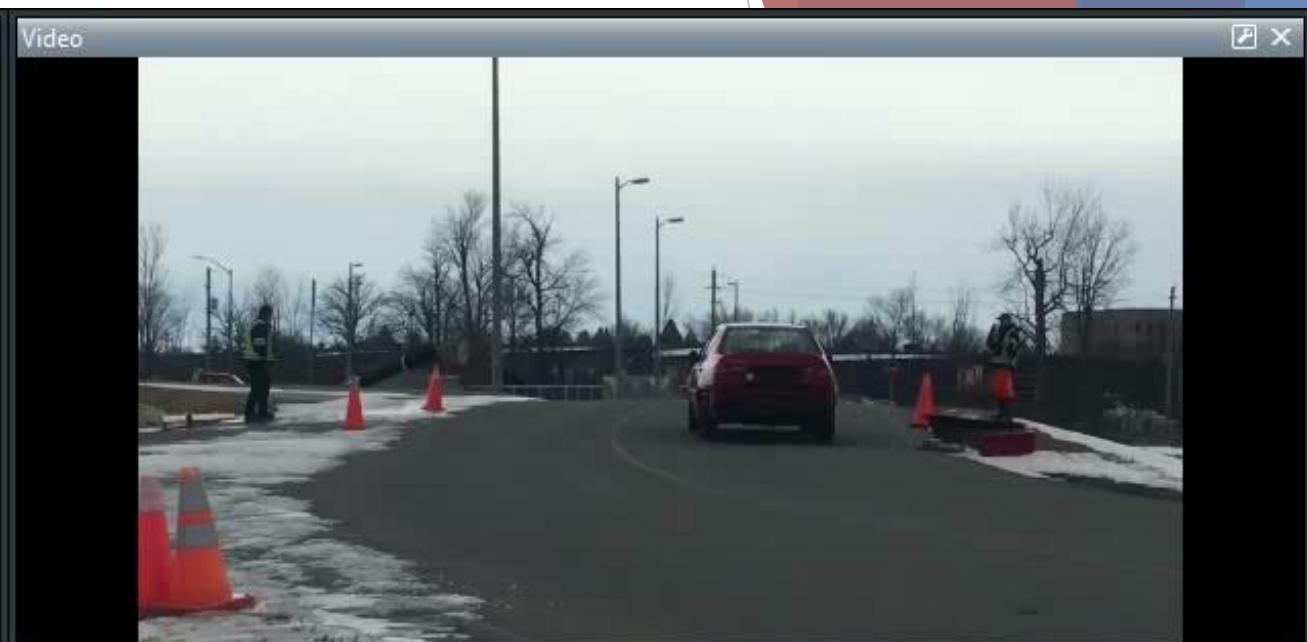
- ▶ Stock EDR
- ▶ CAN BUS data logger
- ▶ Delphi OBDII harness
- ▶ Two 3D accelerometers
- ▶ Positioning/tracking system
 - ▶ 12 satellite GPS
 - ▶ 6 satellite GLONASS





Wheelbase = 287 cm
Overall length = 485 cm
Overall width = 183 cm
Weight distribution 55/44

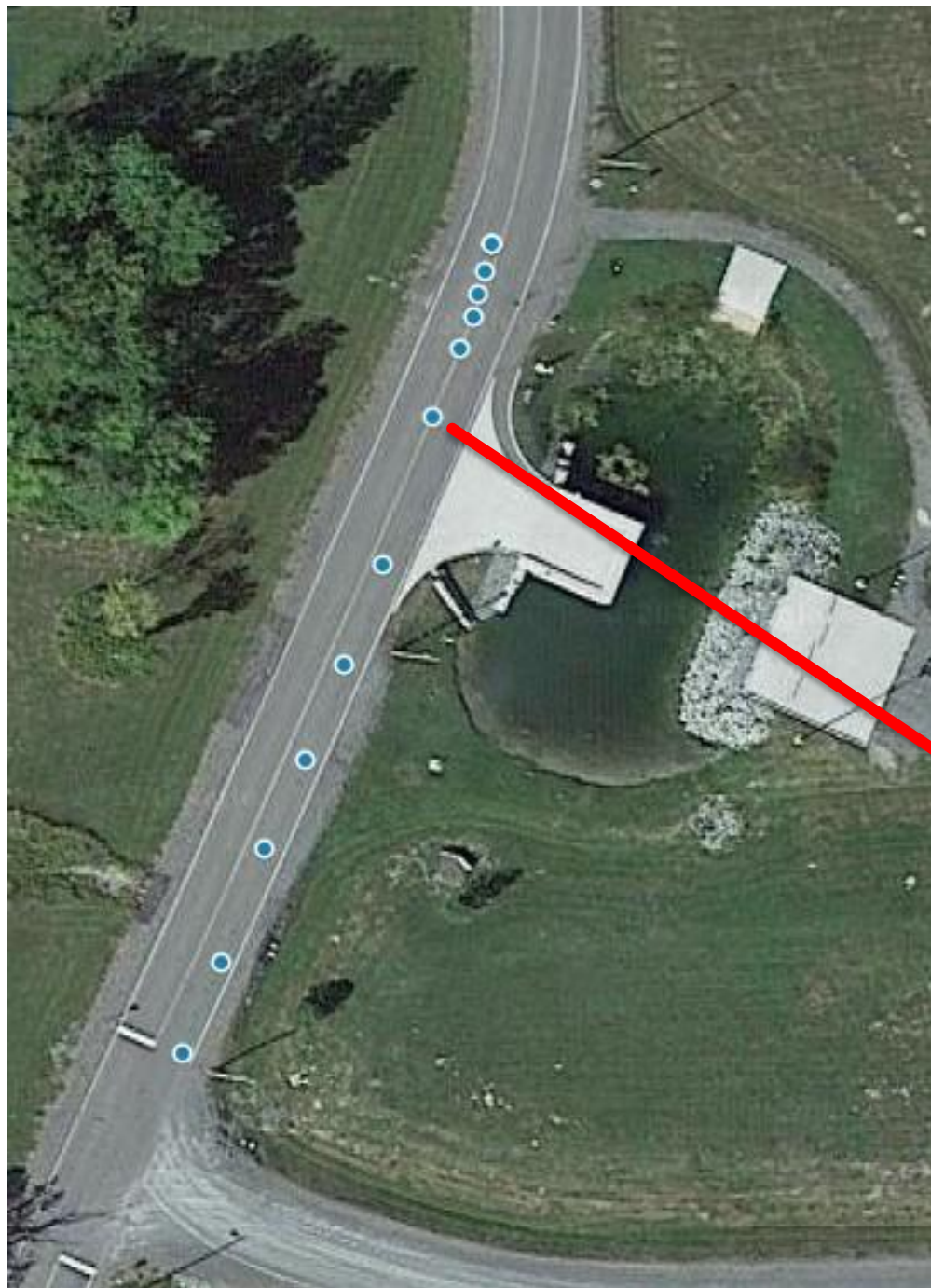




Distance (m)

0





20.48710689

Acceleration X	0.04173265598
Acceleration Y	-0.06053956599
Battery Voltage	12.74937967
Calculated Distance	70.32174848
GPS Latitude	44.2635193
GPS Longitude	-76.5169525
GPS Satellite Count	18
GPS Seconds	18
GPS Speed	30.43992745
YawRate X	-0.7781177278
YawRate Y	-3.204173599
YawRate Z	-0.9763930537

44.26351 -76.51695

Google MyMaps

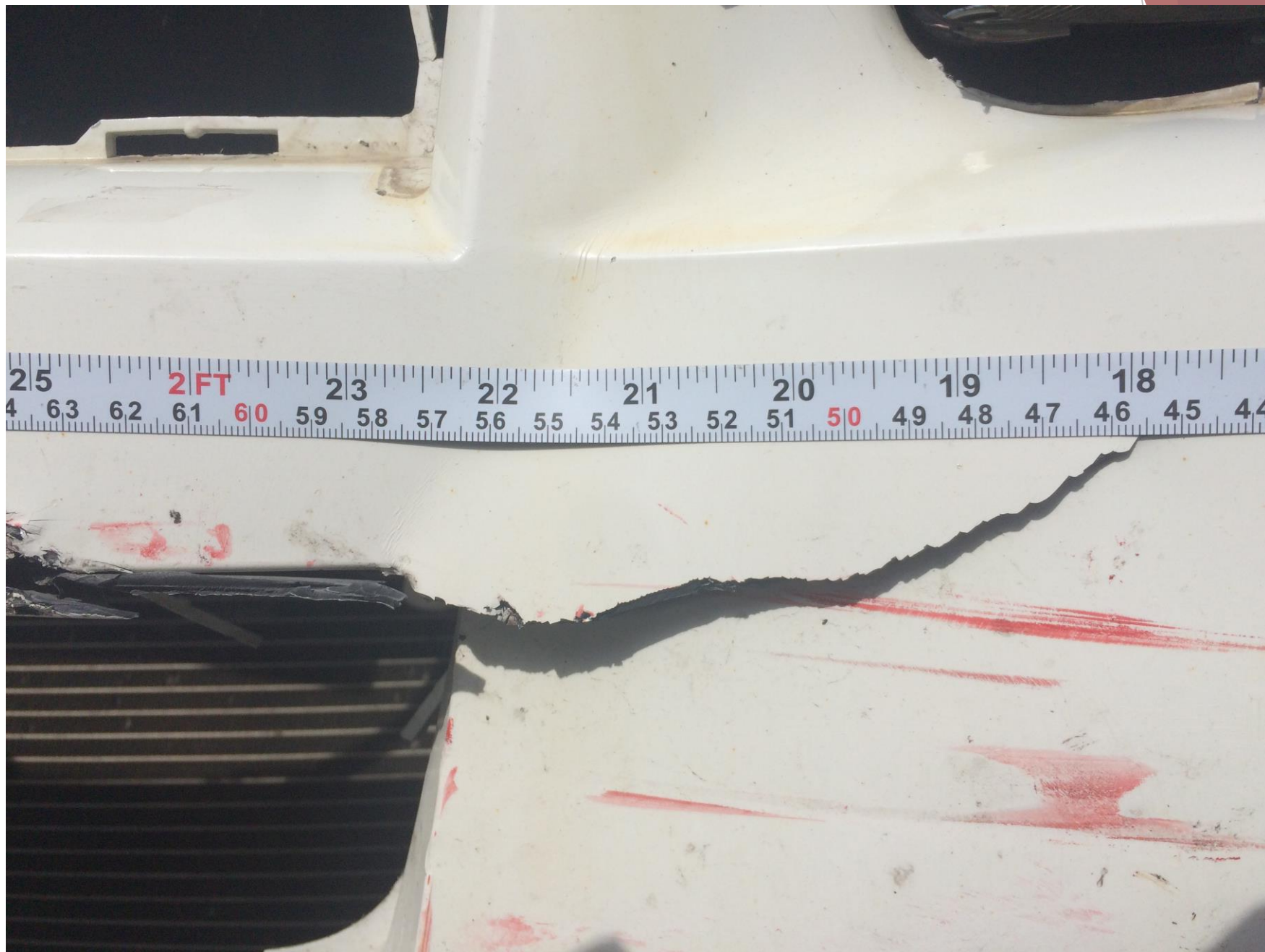
	D	E	G	H	I	N	P	Q	R	S	T	U	V	W	X	Y
	GPS Latitude (deg)	GPS Longitude (deg)	Distance (m)	Speed (mph)	EDR Speed (mph)	YawRate Z (deg/sec) - CCW	Distance Moved (m)	Sideway Movement (cm / - To Left)	Forward Movement (m)	Cumulative Sideways (cm)	Cumulative Forward (m)	CM Adjusted (cm)	Left Front Corner from centre line (cm)	Target Location (cm)	Overlap (cm)	
1																
74	44.2634354	-76.51699066	40.55	30.44		0.78	1.36	0.92	1.36	10.11	40.38					
75	44.2634506	-76.51698303	41.91	30.45		0.50	1.36	0.60	1.36	10.70	41.74					
76	44.2634621	-76.51698303	43.27	30.44		0.41	1.36	0.49	1.36	11.19	43.11					
77	44.2634735	-76.5169754	44.63	30.50	31	0.47	1.36	0.56	1.36	11.75	44.47					
78	44.2634811	-76.51696777	45.99	30.48		0.27	1.36	0.33	1.36	12.08	45.83					
79	44.2634926	-76.51696014	47.35	30.37		-0.27	1.36	-0.33	1.36	11.75	47.19					
80	44.263504	-76.51695251	48.72	30.61		-0.78	1.36	-0.92	1.36	10.83	48.55					
81	44.2635193	-76.51695251	50.08	30.44		-0.98	1.37	-1.17	1.37	9.67	49.92	-45	-137	-96		
82	44.2635307	-76.51694489	51.44	30.54		-0.98	1.36	-1.16	1.36	8.51	51.28	-46	-138	-96		
83	44.2635384	-76.51693726	52.81	30.38		-0.96	1.37	-1.14	1.37	7.36	52.64	-47	-139	-96		
84	44.2635498	-76.51692963	54.17	30.65		-1.14	1.36	-1.36	1.36	6.01	54.00	-49	-140	-96		
85	44.2635613	-76.51692963	55.53	30.20		-1.30	1.37	-1.55	1.37	4.46	55.37	-50	-142	-96		
86	44.2635765	-76.516922	56.86	29.44		-1.19	1.35	-1.40	1.35	3.05	56.72	-52	-143	-96		
87	44.263588	-76.51691437	58.14	27.70	27	-1.07	1.32	-1.23	1.32	1.83	58.04	-53	-144	-96		
88	44.2635956	-76.51690674	59.33	25.56		-1.21	1.24	-1.30	1.24	0.52	59.28	-54	-146	-96		
89	44.2636032	-76.51690674	60.45	24.27		-1.63	1.14	-1.63	1.14	-1.10	60.42	-56	-147	-96		
90	44.2636108	-76.51689911	61.49	22.62		-6.33	1.08	-5.99	1.08	-7.10	61.50	-62	-153	-96	57	
91	44.2636108	-76.51689911	62.50	22.62		-10.35	1.01	-9.11	1.01	-16.21	62.51	-71	-162	-96	66	
92	44.2636223	-76.51689911	63.30	12.93		-12.74	1.01	-11.20	1.00	-27.41	63.51	-82	-174	-96	78	

Amir:
LAT/LONG WHERE GPS
PHASE CENTRE CROSSES
THE CENTRE LINE - SEE
GPS/TRACK MAP

LOCATION OF CM
REALTIVE TO GPS PHASE
CENTRE - SEE SLIDES







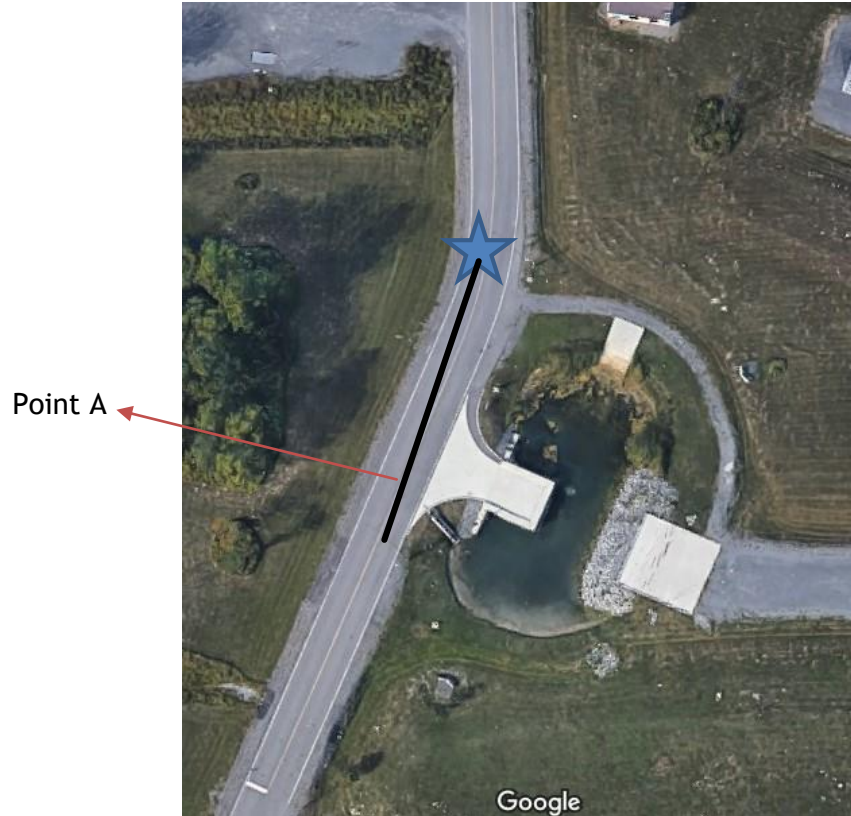
Results of calculated position and data obtained from instruments are in good agreement - within 5 cm both laterally and longitudinally.

For calculations and complete results visit
<https://www.yaworks.ca>

Summary

- ▶ Obtain pre-crash path using stability control data
- ▶ Draw a scaled diagram of the scene
- ▶ Identify the area of impact (this will be your reference point)
- ▶ Place end of the calculated path ($t = 0$) at centermass/location of the EDR of the vehicle at first contact
- ▶ Evaluate the following scenarios
 1. Place the beginning of the path ($t = -5$) on the centerline
 2. Place the beginning of the path ($t = -5$) on the right edge of the roadway
- ▶ Use this method as a tool to compliment your analysis and calculations!

Vehicle crossed the centerline between point A and point B



Point A

Vehicle was travelling on the centerline prior to encroachment



Point B

Vehicle was travelling on the edge of the road prior to encroachment

QUESTIONS?



Special Thanks to:

Provincial Constable Chris Prent - Collision Reconstructionist
OPP East Region Highway Safety Division

Brain Monk - Senior Collision Investigator
Transport Canada

Melanie Jones - Chief Training Officer
Kingston Fire and Rescue

Rogers Towing and Recovery

Carroll Towing and Recovery