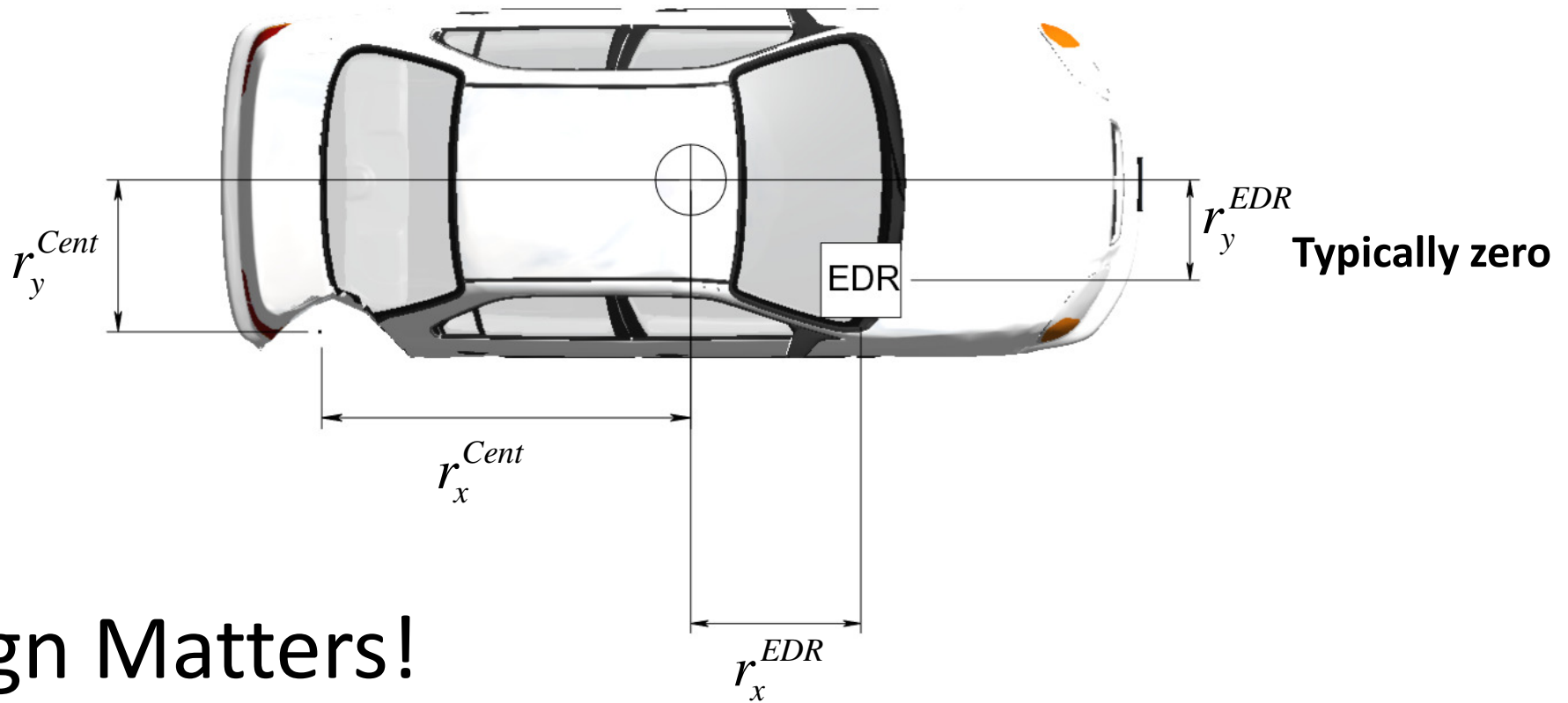


EDR Level II

Final Exam Review

ACM Not at CG Definitions



Sign Matters!

EDR not at CG--Guidance

- Measure location of the ACM
- Measure the dimensions of the ACM
- Measure the location of the damage centroid

ACM Not at CG - Two possible conditions

Force applied
closer to **CG**



EDR under-report
delta-V as compared
to delta-v at CG

Force applied
closer to **EDR**



EDR over-report
delta-V as compared
to delta-V at CG.

ACM Not at CG

- The following equation assumes that the EDR is mounted at the centerline (CL) of the car and that the CG is also at the CL.
- If the EDR is **not at the CL** see

Corrections to Off-Axis Δv Measurements from Event Data Recorders

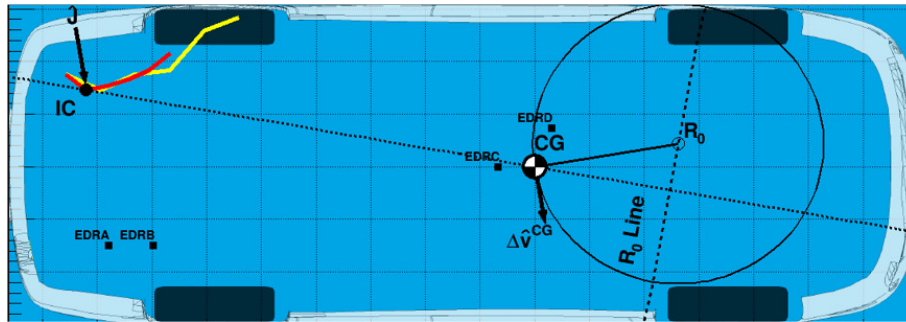
Bob Scurlock, Ph.D., ACTAR, Andrew Rich, BSME, ACTAR, and Kyle Poe

- June 2021 Collision Magazine
- On the Level II class USB drive
- Available at <https://arxiv.org/abs/2001.03165>
- Heavy math needed to handle all EDR locations and CG's— when ACM located on centerline of car it simplifies to.

$$\Delta v_y^{CG} = \frac{\Delta v_y^{EDR} \cdot k^2 + \Delta v_x^{EDR} \cdot r_y^{cent} \cdot r_x^{EDR}}{k^2 + r_x^{cent} \cdot r_x^{EDR}}$$

$$\Delta v_x^{CG} = \Delta v_x^{EDR}$$

Beware the R_0 Line & the R_0 Point!



The R_0 line is a function of

$$r_x^{EDR} \quad r_y^{EDR} = -\frac{k^2}{r_y^{cent}} - \left(\frac{r_x^{cent}}{r_y^{cent}} \right) r_x^{EDR}$$

- There is an imaginary line (the R_0 line) where $\Delta v_y^{EDR} = 0 \text{ mph}$ so we cannot solve for a unique Δv^{CG} .
- When an accelerometer (EDR) is close to the R_0 line, your analysis may be very sensitive to uncertainties in accelerometer location.
- You should do a sensitivity analysis considering actual accelerometer position in EDR may be $\pm 3''$ of the module center you measured. If results diverge excessively, use caution.

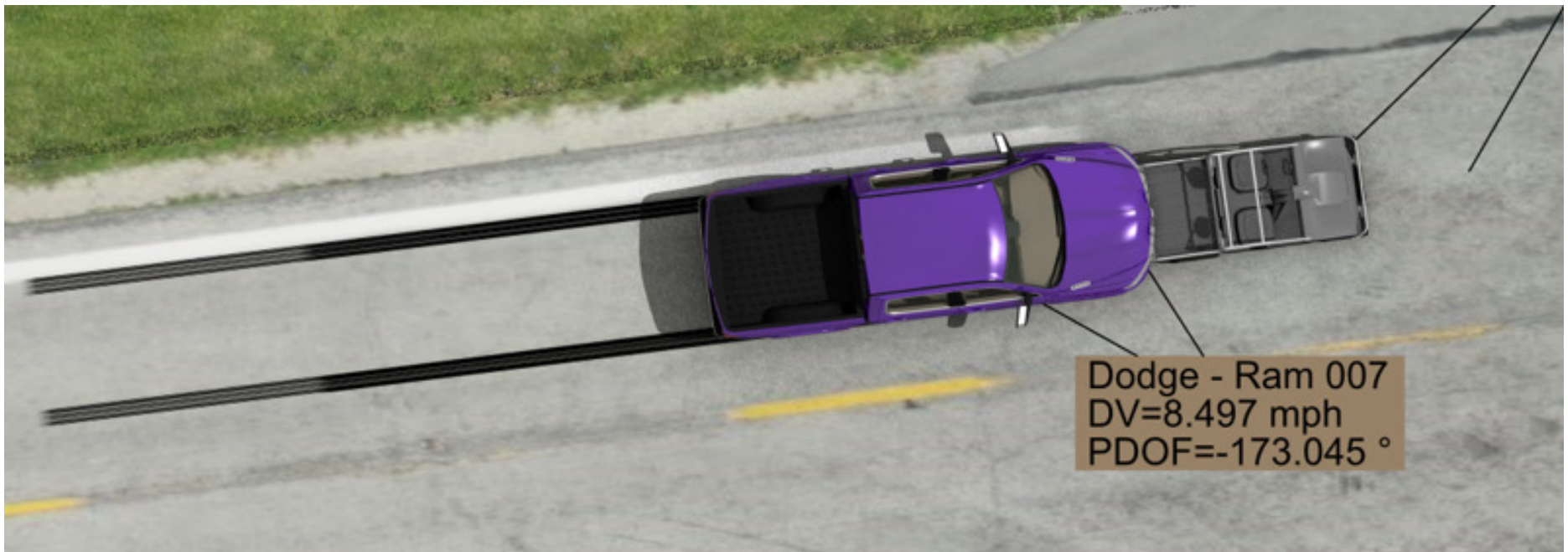
Closing Speed Equation

$$v_{c,\Delta v} = \left(\frac{1}{1+e} \right) \left(\frac{\Delta v_1}{\gamma_1} + \frac{\Delta v_2}{\gamma_2} \right)$$

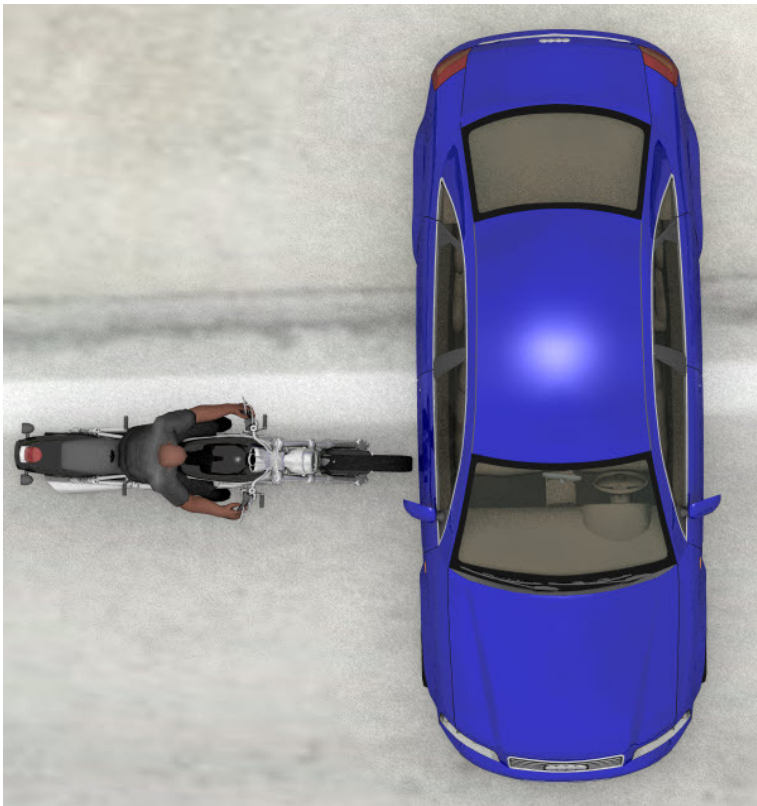
- If you ignore restitution will you **overestimate** or underestimate the closing speed?
- If you ignore EMR will you overestimate or **underestimate** the closing speed

Ground forces

A vehicle with an EDR skids or ABSs into a much lighter vehicle. Do you increase or **reduce** the magnitude of the EDR-reported delta-V?



Ground Forces



A much lighter vehicle strikes an EDR-equipped vehicle. Do you reduce or **increase** the magnitude of the EDR-reported delta-V?

Ground Forces Equations

$$\Delta v_{adj} = \frac{fg \Delta t}{1.466}$$

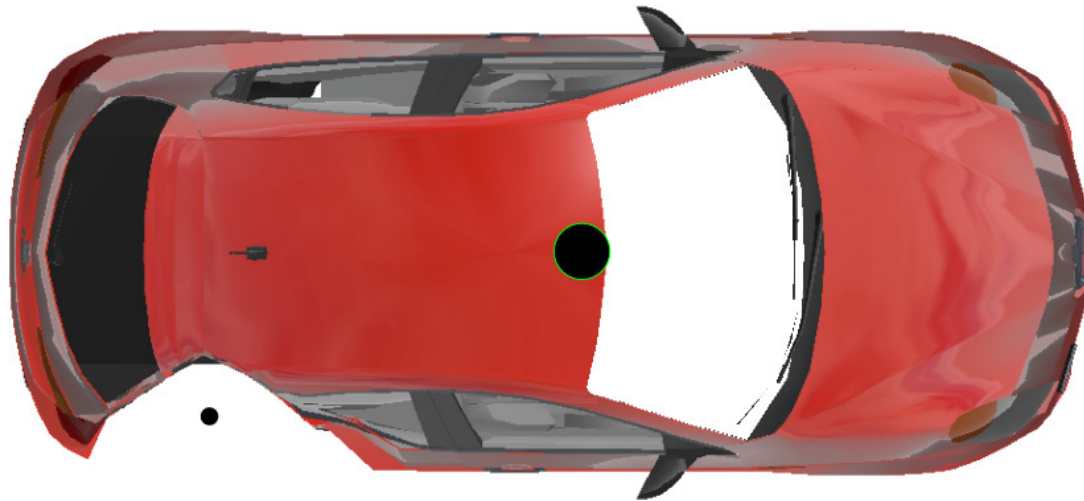
$$\Delta v_{cor} = \Delta v_{EDR} \pm \Delta v_{adj}$$

$$\Delta v_2 = \frac{w_1 \Delta v_{cor}}{w_2}$$

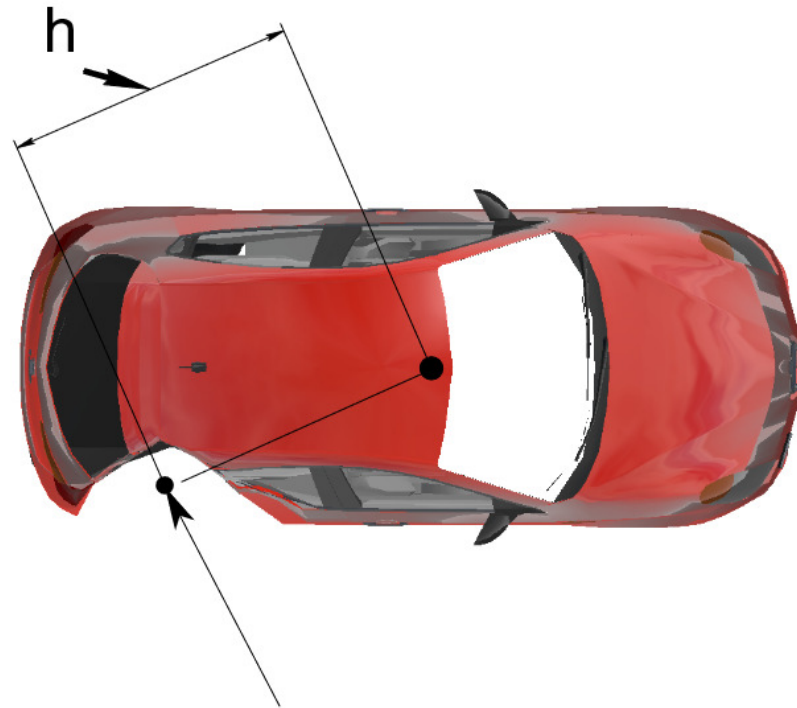
$$v_{c,\Delta v} = \left(\frac{1}{1+e} \right) \left(\frac{|\Delta v_{cor}|}{\gamma_1} + \frac{|\Delta v_2|}{\gamma_2} \right)$$

EMR

The EMR adjusts the delta-V from the **CG** to the **Damage Centroid**



Moment Arm

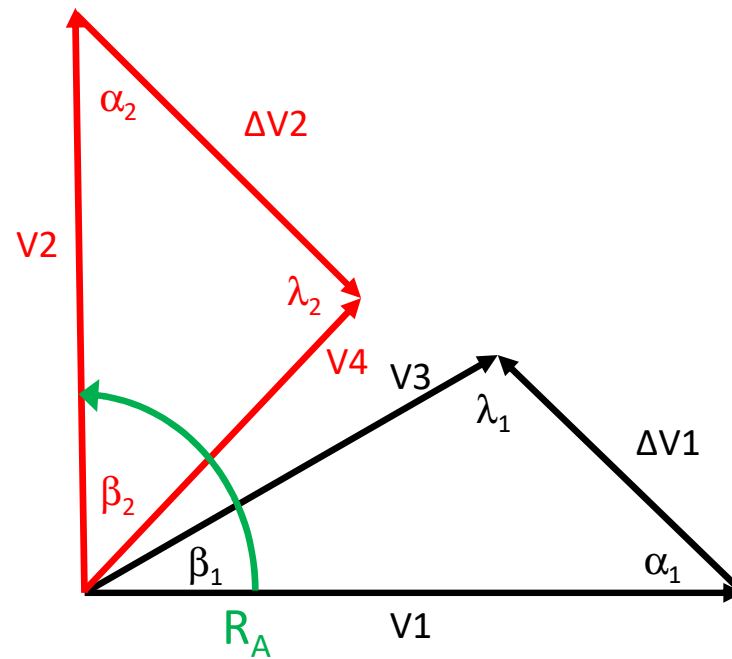


EMR

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

- DO NOT square k^2 . You calculated k^2 .
- h must be in units of feet.
- h must be squared.
- When $h = 0$, $\gamma =$ 1

Velocity Vectors



$$\Delta v_2 = \frac{w_1 \Delta v_1}{w_2}$$

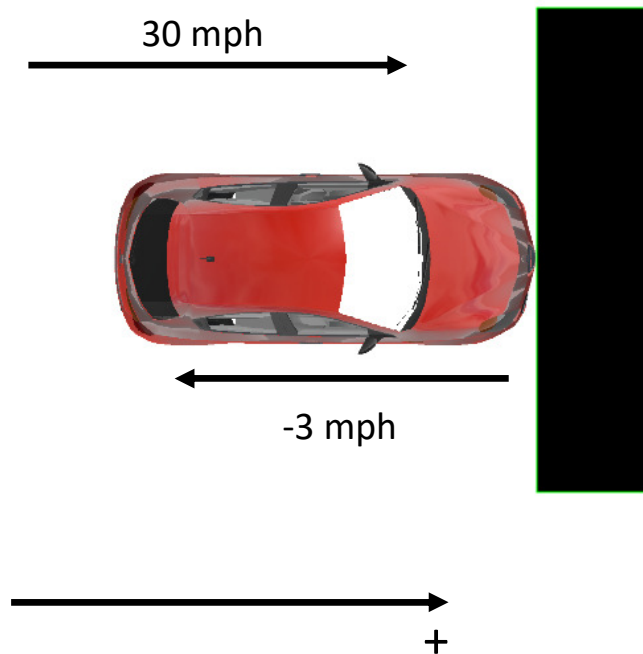
$$\alpha_2 = 180 - R_A - \alpha_1$$

Restitution Values

- Dependent on closing speed
- Dependent on braking vs. no braking
- Dependent on vehicle make/model
- Dependent on part of the vehicle struck
- Monson and Germane (SAE 1999-01-0097)
 - Restitution values for closing speeds between 25 and 75 mph are 0.15 and less

Restitution

Somewhere, in another universe:



$$\Delta v_1 = v_3 - v_1 = 0 - 30 = -30 \text{ mph}$$

In this universe the car rebounds from the barrier.

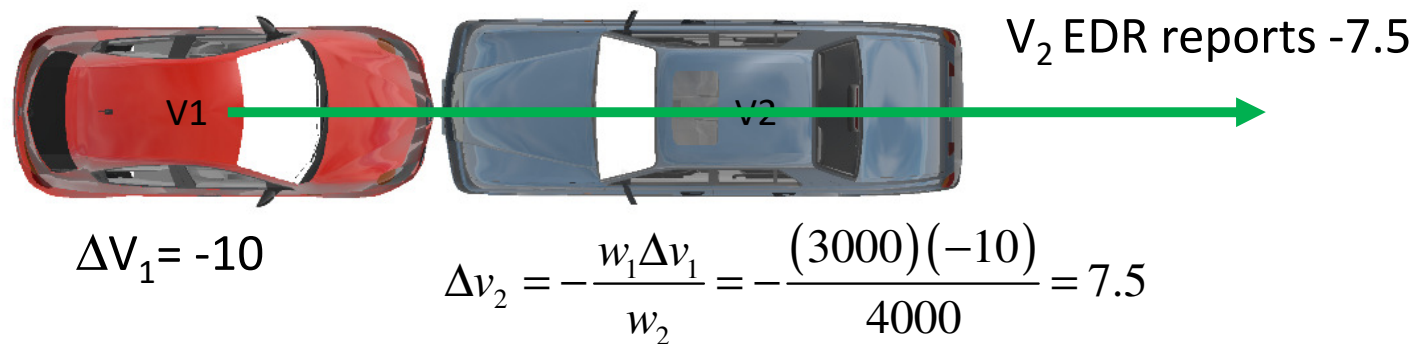
$$\Delta v_1 = v_3 - v_1 = -3 - 30 = -33 \text{ mph}$$

An increase in restitution will increase the delta-V

Equation 12

$$\Delta v_2 = -\frac{w_1 \Delta v_1}{w_2}$$

- Derived from Newton's II and III Laws
- When the weights are equal then the delta-Vs are equal and opposite
- Calculates vehicle 2's delta-V at the CG in vehicle 1's coordinate system



One-Question Class Closing Survey

