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1. Are there any EDR's available from any of the vehicles involved that are supported by CDR?
2. Is there more than one EDR in any of the accident vehicles? Ford PCM, GM ROS, Pedpro, GM ASCM? (Check help file)
3. Are there any EDR's not covered by CDR that I can get the manufacturer to read for me or read by another tool? Kia/Hyun

How MANY different events can be identified based on physical evidence in this crash? 1 2 3 3+ (Rollover/indeterminate)

How MANY events is this EDR capable of capturing? 1 2 3 4 5 6 ?? Types??

How MANY events has this EDR Captured? 1 2 3 4 5 6 ? Types: D ND DLE Front/Rear Side Rollover
What is the RECORDING THRESHOLD? Wakeup /2G? 5mph? Deploy Don't Know? RECORDING PRIORITY? Most Recent? Largest?
For **EACH** event, determine if the event is from your crash and the data is usable (Big 4)

1. Is it a complete and valid recording? **Yes** (it says so) **No (says not)** **Doesn't Say – check DL for other criteria**
   Any evidence of power loss at impact? YES NO INDETERMINATE BATTTERY? FUSE BOX(s)? Shorts/Blown Fuses?
   If power loss, is this a 563 intent recorder with possible backup power supply for recording? YES NO NOT SURE
2. Key Cycles or Key On Time match? _____@event _____@imaging (for EACH event)
3. Delta V Large and/or consistent with visible crush or momentum analysis within 20%? YES NO INDETERMINATE N/A
4. Speed data consistent with reported facts, crush and postcrash travel? YES NO INDETERMINATE N/A
   Multiple Events where time-distance between events correlates to crash scene

How much data do I have to work with?

Yes No Pre-crash speed and throttle _____ points at _____second intervals
Yes No Pre-crash braking _____ points at _____second intervals
Yes No Post crash data _____ points at _____second intervals
Yes No Any Delta V? Check off how much of that info is in the CDR report below
____ Cumulative ***Longitudinal***? (A single peak value listed in the report) at ____ ms after wakeup
____ Cumulative **Lateral**? (A single peak value listed in the report) at ____ms after wakeup
____ Longitudinal DV **Graph**? Duration ____ to ____ ms Zero = deploy or algorithm wakeup or other?

____ Lateral DV **Graph**? Duration ____ to ____ ms
____ Longitudinal Acceleration? Duration ____ to ____ ms. Zero=deploy or wakeup?
____ Lateral Acceleration? Duration ____ to ____ ms. Zero=deploy or wakeup?
Yes No Belt Buckled data entries in report? If present, Driver Buckled / Unbuckled? Pass. Buckled / Unbuckled?
Yes No Other things this EDR has that matter in this case?
_____ ABS on/off _____Traction Control on/off ____Stability Control on/off ____Speed Control on/off
_____ Steering Angle ___ Yaw Rate ___Roll Rate/Angle ____Lat Accel from Stab.Cont? ___Long. Accel
_____ Passenger Size Empty/Child/Adult? _____ Wheel RPM? _____ Tire Pressure? ____Other?

What is most *important* in this case?		**Value As recorded In EDR**	**Adjustment required? See checklist**	**Adjusted Value or range?**	
Yes No Speed before start of event	If you have it, enter it here	_____	Yes No	_____	+/-4%?+/-2mph?
Yes No Speed at Impact	If you have it, enter it here	_____	Yes No	_____	(see wksht)
Yes No Post impact exit velocity	If you have it, enter here:	_____	Yes No		
Yes No Delta V	If you have it, enter it here	____X__ ___Y	Yes No	_____	+/-10%
Yes No PDOF	If you have it, enter it here	_____		_____	+/- 5 deg
Yes No Other?_____	If you have it, enter it here	_____	Yes No	_____	

What else? Inspect the entire report – evidence of loss of control, swerve before impact?
Speed changes over time greater that allowed by laws of physics without an impact or special circumstances?
(May not be necessary if it does it matter to your main conclusions).

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Are there any *SPECIAL CIRCUMSTANCES* in this case that could affect the EDR data accuracy?
(circle Yes/No/Don't Know)

Speed Data

Vehicle Operational Conditions

Yes No Don't Know 1. Wheels locked by braking without ABS

Yes No Don't Know 2. Wheels slowed by heavy braking (w/ABS?) If yes, Adjustment? _____

Yes No Don't Know 3. Wheels not in contact with ground (airborne) Over/Under report?

Yes No Don't Know 4. Yaw - Wheels scrubbing sideways If yes, Adjustment? _____

Yes No Don't Know 5. Ice/Snow/Hyrdoplaning/Burnout (wheels spinning relative to pavement)

Yes No Don't Know 6. In reverse or otherwise going backwards (spin?)

Yes No Don't Know 7. Data Limitations warn of special condition (i.e. GM last point recorded after AE?)

Vehicle Equipment Modifications

Yes No Don't Know 1. Factory Tire Size? If no, Adjustment? _____

Yes No Don't Know 2. Factory Axle Ratio? If no, Adjustment? _____

Yes No Don't Know 3. Control module reprogrammed for tire or axle size change?

Yes No Don't Know 4. Reprogrammed ACM? (Are Key cycles consistent, no signs of module tampering)

Delta V Data Special Circumstances/Adjustments

Yes No Don't Know 1. Recorder only captures part of crash (slope not parallel to horizontal at end)
Yes No Don't Know 2. Recorder captures data from BEFORE or AFTER crash (esp. 05+ Cr. Vic) Adjustment?____
Yes No Don't Know 3. Missed DV before wakeup? (No for continuously running algorithms) (Small)
Yes No Don't Know 4. + offset in accelerometer (Toyota Gen 1 & 2)
Yes No Don't Know 5. Missed Delta V due to sensor "clipping" (only concern for DV>35 mph)
Yes No Don't Know 6. Offset collision – Need to adjust for Effective Mass Ratio?
Yes No Don't Know 7. Need to consider GROUND FORCES during crash? (For small ΔV's with braking)
Yes No Don't Know 8. Need to consider UNUSUAL DELTA V CURVE SHAPE? (Multiple collisions, rotation)
Yes No Don't Know 9. Event beyond end of graph/capture period (563 regulated)
Yes No Don't Know 10. Small DV magnitude where resolution is integer 1 kph
Yes No Don't Know 11. Crush damage intrudes to ACM mounting
Yes No Don't Know 12. Vehicle in slip angle at impact – EDR not pointing in direction vehicle is moving
Yes No Don't Know 13. EDR not mounted on CG

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Have you considered <u>ALL</u> the possible uses of the data?

<u>SPEED DATA</u>

1. Fastest speed vehicle was traveling before the loss of control or braking? +/-4%? Or +/- 2mph? or +/-1kph?
2. Speed at Impact? Start @ wheel speed = ground speed, use Worksheet to get range
3. Braking rate at different stages – transition from accel applied to normal braking to panic braking?
4. Departure speed (post impact)?
5. Can EDR data support or discredit witness statements?
6. Multiply Speed by time to calculate DISTANCE to impact at key points? Overlay speed data onto scene map. Check for witnesses at the location of illegal or negligent behavior.

<u>ACCEL PEDAL OR THROTTLE DATA</u>

1. Use ***<u>time</u> of accel pedal release*** to impact as first reaction to possible threat condition. Check time between accel pedal release and brake application – if fast, accel pedal release = reaction to perception of pending crash
2. Driver intent: ___0% coast ___1-19% slow down __20-30% maintain __31-50% accel ___ 51-100% heavy accel
3. Calculate **<u>distance</u>** to impact and overly on scene diagram. Use ***non-release or late release*** of pedal as ***possible*** evidence of obstructed vision, driver impairment by substance abuse, medical event, driver distraction (cell?)

<u>BRAKING DATA</u>

1. Brake light on but no decrease in speed - hovering on pedal not applying pressure
2. Two brake switches – one on, other not on – hovering on pedal not applying pressure
3. Calculate distance to impact for first brake pedal touch using speed data, overlay on scene diagram or map, use late reaction or non-reaction as possible evidence of distracted driving. Overlay stop distance @ vehicle speed to avoid collision.

Memo: Avoid saying “NEVER hit brake” – suggest using “No evidence in EDR driver braked prior to impact”

<u>ABS ACTIVE DATA</u>

1. Indicates one wheel turning slower than others – can mean max braking intent OR loss of control. Brake does NOT have to be on for ABS to engage to try and relieve slowest wheel brake pressure.
2. No ABS on = driver did not push on pedal as hard as they could have.
3. Slow decel rate but ABS active may indicate ice, snow , hydroplaning – not enough friction available .

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STEERING ANGLE

1. Sign changes/overcorrection leading to rollover?
2. Swerve just before impact changing approach angle?
3. Swerve well before impact, in response to path intrusion, leading to going off road or crash into another object?
4. No visible input may indicate no clear alternative path available, or falling asleep, or medical event (check resolution before reaching conclusion of no input– early GM 16 degrees) .
5. Left turn initiation point?

YAW RATE

1. When/how far from impact did vehicle first begin to yaw?
2. Integrate yaw rate to calculate cumulative yaw angle/heading change prior to impact. In a left turn, heading change closely approximates approach angle change. In swerve, CG path lags heading change, approach angle change is less than heading change. If CG path does not change, then yaw angle approximates slip angle. In a yaw the true ground speed is the reported speed divided by the cosine of the slip angle.

LATERAL ACCELERATION (PRE crash from stability control, not crash accelerometer)

Is vehicle in a yaw? G's show how far sideways it got – sideways if => drag factor 0.7G = 22ft/sec^2

LONGITUDINAL ACCELERATION (PRE crash from stability control, not crash accelerometer)

If in max braking, average of Longitudinal Accel should be equal to drag factor.
Calculate speed loss from each time interval, subtract from start speed, get speed at impact

TIRE PRESSURE - Did low tire pressure contribute to heat buildup causing blowout followed by rollover?

TRACTION CONTROL

Did tires enough friction available to prevent wheel slip due to torque application?

ELECTRONIC STABILITY CONTROL ACTIVE -Use to indicate vehicle is yawing out of control

ROLL RATE OR ANGLE

Use to determine how quickly or slowly the trip or ramp roll initiating the rollover began. Integrate roll rate to get roll angle versus time. Be aware of max values, some clip at +/-240 degrees /sec or +/-60 degrees

ACM RECORDER ACCELERATION DATA

Use to determine if clipping occurred – look for flat lines at values at or above 32G (most are above 50)

RPM – Calculate Speed IF manual trans & clutch engaged OR auto trans torque converter is locked (not in 1st gear, not within 2 seconds of a shift, accel pedal applied 1-99%. Speed = RPM/trans gear/final drive gear/tire revs/mile*60min/hr = MPH

Example: 3200 rpm/0.7 overdrive/3.23 final drive/(750 revs/mile)*60 min/hr = 113 mph.

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Speed at Impact from Speed Data Worksheet

	MIN	MAX
Last Data Sample When wheel speed equals ground speed except for ABS slip	_____	_____
Speed Change from last sample To time of impact (if any) (Time Interval x Accel Rate) For Braking: Drag Facor*G/1.466 fps/mph EX: 1.0 sec * -0.7g*32.2/1.466 = -15.4 mph Can be positive if vehicle is speeding up If driver is still on accel pedal at last sample then allow 0.5 sec to move foot accel to brake pedal	-____	_____
SLIP of wheel in ABS braking +5% (more during initial engagement)	+____	+____
Speedometer Error +/- 4% (unless there is data indicating it's better)	-_____	+_____
Range of Speeds at Impact (from the speed data alone)	_____ MIN	_____ MAX

Last sample before impact means last data point where wheel speed equaled ground speed except for stabilized ABS wheel slip, either during max ABS braking after initial engagement, or before wheel lockup in non-ABS vehicles. If you are not sure a vehicle is in max braking, run the worksheet both ways, first in max braking (usually results in most conservative value) and again without max braking.

Vehicles without ABS have little wheel slip (approx. 1%) until lockup is imminent, do not use 5% adjustment on non-ABS vehicles. When wheel lockup is imminent the speed drop from the prior point may appear to violate laws of physics, disregard these points and start from prior (last good) point.

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SPEED AT IMPACT FROM DELTA V WORKSHEET

Speed at Impact $= |V_3| Cos(\beta) - \Delta V_1$

Where

ΔV_1 = The Longitudinal ΔV of the Vehicle of Interest

$|V_3|$ = The absolute value of the post crash speed of the Vehicle of Interest (some use V_1')

β = (Beta) The angle measured between the approach and departure of the Vehicle of Interest. Beta can be between 0 and 360 degrees. For inline collisions cos β is 1..

This equation can be used in an inline or angular collision to calculate the Speed at Impact along the approach axis of either vehicle when the ΔV, the post collision speed and the departure angle Beta are known. It is necessary that the vehicle of interest is not side slipping (must be pointed in the +X direction) at impact. It is important to pay attention to the sign of the ΔV and the post crash velocity by carrying the sign of the cosine of Beta. For example if Beta = 135 degrees then Cos(135) = -.707

EXAMPLE:

1. Vehicle travels 42 feet with an equivalent drag factor of 0.35
   $|V_3| = \sqrt{30Df} = \sqrt{30*42*0.35} = 21.0$ mph
2. Departure angle β is 40 degrees relative to approach angle
3. ΔV_x = -31.0mph from EDR

$V_1 = 21.0mph*(Cos\ 40^o) - 31.0mph\ \Delta Vx$
$V_1 = 21.0*(.766) - (-31.0)$
$V_1 = 47.1$ mph

Range of speeds at impact = +/-10% of ΔV plus any range due to drag factor uncertainty
Range = +/- 10% of -31 mph ΔV = +/- 3.1mph = 44.0 to 50.2 mph plus any range due to drag factor.

<u>ΔV OF OTHER VEHICLE FROM SUBJECT VEHICLE ΔV</u>

ΔV of other vehicle is inversely proportional to mass

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

Combine the two Delta V's to get closing speed in the direction of the PDOF:
The vehicles must reach a common velocity at the damage centroid or CS is understated.

$$CS_{\Delta V} = \frac{1}{1+e}\left(\frac{|\Delta V1|}{\gamma_1} + \frac{|\Delta V2|}{\gamma_2}\right)$$

$CS_{\Delta V}$ is ***in the direction of the PDOF – (OK*** for ***IN-LINE*** crashes).

CAUTION: In intersection crashes the CS vector may NOT be in direction of PDOF, further adjustment needed!
Combine closing speed with speed of known vehicle speed at impact to get speed of unknown.

Consider using TRIANGULAR VELOCITY VECTOR METHOD for intersection crashes
It works regardless of central vs offset collision and does not require common velocity to be reached.

