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■ Collision Analysis ■ Engineering ■ Animation

Accident Reconstruction & Vehicle Data Recovery Systems and Uses

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Accident Reconstruction

- The ***Purpose*** of an **Accident Reconstruction**….

….is to Use ***Physical Evidence*** and Properly Apply Engineering and Scientific Principles to Determine what took place in an Incident that Usually Involves a Collision….

Acronyms

- CDR: Crash Data Retrieval
- ACM: Airbag Control Module
- EDR: Event Data Recorder
- SDM: Sensing and Diagnostic Module (GM)
- RCM: Restraint Control Module (Ford)
- ORC: Occupant Restraint Controller (Chrysler)
- ECM: Engine Control Module
- PCM: Powertrain Control Module
- Delta-V: Velocity change as a result of a collision (ΔV)

Acronyms

- PDOF: Principal-Direction-of-Force
- POI: Point-of-Impact
- AOI: Area-of-Impact
- POR: Point-of-Rest
- cg: Center-of-Gravity
- V: Velocity or Speed
- d: Distance
- a: Acceleration
- m: Mass (weight)
- t: Time

Accident Reconstruction

- Requires a **Strong Understanding** of:
  - Vehicle Dynamics
  - Applied Physics *(including theory)*
  - Engineering Principles
  - Vehicle Structures
  - Vehicle Braking Systems – *Especially Trucks*
  - Collecting Physical Evidence
  - Evaluating Scene Evidence

Accident Reconstruction

- Also Requires an Understanding of:
  - Photography (photographic documentation)
  - Various Accident Reconstruction Tools
    - Simulation Software
    - Photogrammetry
    - Surveying & Measurements
  - Vehicle Data Sources
  - Vehicle Equipment
    - EDR Systems
    - ABS Systems

Accident Reconstruction

- Human Behavior
  - Perception & Reaction
  - Environmental Conditions
    - Lighting
    - Weather
    - Construction
  - Collision Avoidance
    - Training
      - Motorcyclists
      - Truck Drivers

The Collision Analysis

Accident Reconstruction

Usually – There are **3** Parts to a Collision

1. **Pre-Collision** Events *(Pre-Impact)*
2. **Collision** *(Impact)*
3. **Post-Collision** Events *(Post-Impact)*

Pre-Collision Events

- Braking / Accelerating
  - Tire Marks *(Supporting Physical Evidence)*
    - ABS / Non-ABS Equipped Vehicle
- Perception and Reaction Phase
- Lighting and Roadway Conditions
- Environmental Factors
- Mechanical Factors
- Other Factors

Collision

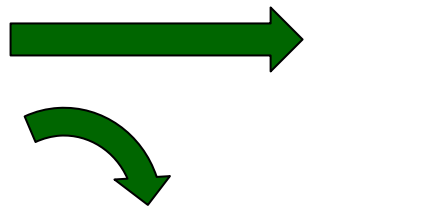
- **Vehicle-Vehicle Collision**
  - ***Delta-V*** (related to collision severity)
  - Impact Direction or **PDOF** (***Principle-Direction-of-Force***)
  - Collision Compatibility - Over-ride/Under-ride
  - ***Secondary*** Impact or Contact Damage
  - Safety Restraint Systems & Air Bags

Collision

- **Point-of Impact (POI)**
  - Gouges & Scrapes
    - What Vehicle Components were Involved?
  - Collision Debris
    - Glass
    - Broken Vehicle Parts
  - Sudden Change in Tire Direction
  - Fluid Stains

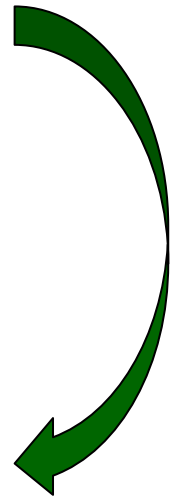
Post-Collision

- Post Collision Vehicle Dynamics
  - Straight or Arced Path
    - Vehicle Rotation?
    - Yawing?
  - Post-Impact Travel Distance(s)
    - On Road / Off Road
  - On/Off Roadway Profile
  - Tire/Axle Condition
    - Any Locked or Partially Locked Wheels?
    - Flat tires?
      - Steering?



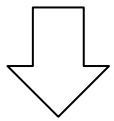
Traditional AR Analysis

1. **Pre-Collision** Events (Pre-Impact)
2. **Collision** (Impact)
3. **Post-Collision** Event (Post-Impact)

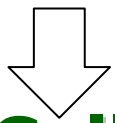


Traditional AR Analysis

1. **Post-Collision** Events (Post-Impact)



2. **Collision** (Impact)



3. **Pre-Collision** Event (Pre-Impact)

Traditional AR Analysis

1. Post-Impact Speeds

2. ***Delta-V*** & **PDOF**

3. Pre-Impact Speeds

Post-Impact Speed

- Post-Impact Travel Path & Distance
  - Terrain & Surface Type & Condition
  - Type of Vehicle Movement
    - Straight
    - Arced/Rotating
  - Condition at Each Axle Position
    - Locked Wheel
    - Turned Wheel
    - Flat Tire

Post-Impact Speed

- How is the Vehicle *Slowing* to Rest
  - Deceleration Rate(s) – g's
  - Coefficient(s) of Friction - μ
  - Drag Factor(s) - f

(All are basically the same…..
….or are used the same way.)

Slowing to Rest

g's ***μ*** ***f***

- Obtain Values from Charts and Published Tests and Papers…
- Using an Instrumented Test Vehicle
  - *Important to have the Same Conditions…*
- Drag-Sled Testing
  - *Dragging a weighted section of tire tread on the roadway surface…*

Slowing to Rest

g's ***μ*** ***f***

- Often – see values that are relatively high that tend to *over-estimate* speed
- Sports Car ≠ Sedan ≠ SUV/PU ≠ MC ≠ Heavy Truck/Tractor-Trailer
- The Values used for *Longitudinal Vehicle Movement*, such as **Hard Braking** ≠ Values used for *Lateral Vehicle Movement*, such as *Sliding Sideways*

Post-Impact Speed

- To evaluate the **Post-Impact Speed** of a Vehicle, it not only is important to carefully consider how the vehicle is *Slowing* as it travels to its Rest Position, but also how accurately one determines the vehicle's **Post-Impact Travel Distance** (**d**) and Trajectory.

Post-Impact

Travel Distance

- Evaluating the Post-impact Travel Distance
  - Typically, this involves Drawing the Collision Scene to Scale….
  - And Drawing the Vehicle(s) to scale to track the movement of the *Center-of-Mass* of that Vehicle (its **cg**) from the Point-of-Impact (**POI**) to its Point-of-Rest (**POR**)… the …Vehicle's Post-Impact Trajectory.

Post-Impact Analysis

- If the Post-Impact Trajectory Analysis is incorrect…..
- The Calculated **Post-Impact Speed** will be wrong…..
- Which will lead to errors in your analysis pertaining to the **Delta-V**, **Impact Speed** and **Initial Speed**

The Collision

Delta-V

- **Delta-V**
  - Change of Speed of the Vehicle that takes place during the Collision
  - Reflects the **Severity of the Collision**
  - The Greater the Delta-V, the more likely there will be Injuries…
  - Often you will see Delta-V written as **ΔV**

Delta-V

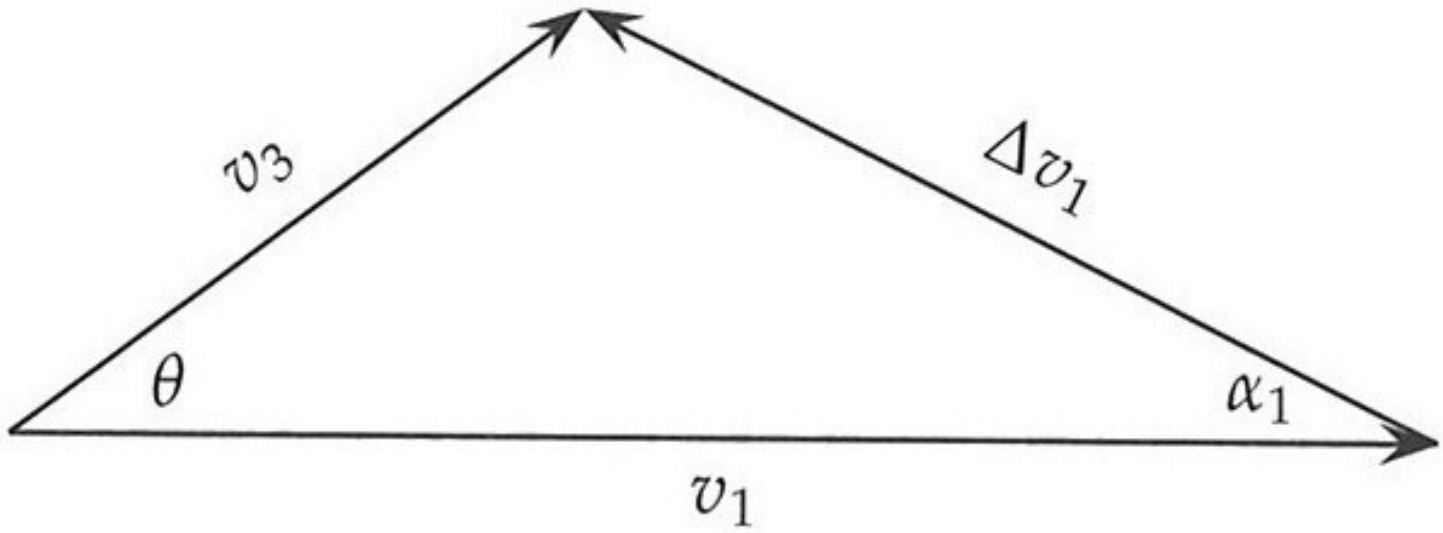
- Conservation of Linear Momentum
- Crush Analysis
  - Damage Energy
  - Crush Energy
- Conservation of Linear and Angular Momentum
- Force Based Collision Modeling

Linear Momentum

Data Needed….

- Mass (m) or Weight of Vehicles
- Some Speed Data
  - Usually **Post-Impact** Speeds….
- Pre-and-Post-Impact Directions
  - Vectors…..
- No Secondary Impact….

Linear Momentum



V1 = Impact Speed and Direction
V3 = Post-Impact Speed and Direction

Crush Analysis

- Engineering Study and Analysis of the Collision Damage that Occurred as a Result of a Collision and the Energy and Forces to Produce that Damage….
- Usually Based on **Crash Tests**….
- And a Strong Understanding of Vehicle Structures….

Other Collision Analysis

Conservation of Linear and Angular Momentum and/or Force Based Collision Modeling….

Is Most Often Applied Using Collision Software….

….which can Readily Apply other Vehicle and Collision Related Parameters…

Other Collision Analysis

.. Such As

- Inertial Properties
- Coefficients of Restitution
- Vehicle-Vehicle Friction
- Tire and Suspension Properties
- 3-D Roadway Information

Pre-Impact

- Usually includes the Engineering and Scientific Principles and Accident Reconstruction Techniques used in the **Post-Impact Analysis**…
- And **Human Behavior** Aspects Surrounding the Incident….

Human Behavior…

- Perception and Reaction….

….***Time***

Human Behavior…

- Perception and Reaction….

….***Time***

Most Traffic Conditions…

… an Average Perception & Reaction Time of **1½ Seconds** is Generally Accepted….

Human Behavior…

- However… There are Instances where the Perception and Reaction Time can be (Reasonably) Greater…
- Such Factors Could be Associated with Age, Weather and/or Lighting Conditions, Unusual Roadway Conditions, Being Under the Influence…

"Black Boxes"

- *Crash Data Recorder…*
- *Pre-Impact Data Recorder*
- *Event Data Recorder…*

Where are EDR's?

In Passenger Vehicles . . .

Incorporated in the Airbag Control Module

(Also referred to as the SDM, RCM, or ORC)

Where are EDR's?

In Heavy Trucks & Buses . . .

Data relevant to a collision or incident can be retrieved from the ECM's of heavy trucks and buses...

(These ECM's are typically mounted to the sides of the diesel engines)

Two types of recorded events *(GM & Ford vehicles):*

- Non-Deployment Event
  - An event severe enough to ***"wake up"*** the sensing algorithm
  - An event ***not*** severe enough to deploy the air bag(s)
  - *Not currently available from Chrysler ACM's*

- Deployment Event
  - **Collision Severity Threshold** has been met
  - Air bags or other restraints are triggered to ***deploy***

Recorded events usually include:

- Pre-Crash Information
- Crash Data

Pre-Crash Data -

5 seconds of pre-crash information

- Vehicle Speed
- Engine Speed
- Throttle Position
- Brake Status* (applied YES or NO)

**8 seconds of data*

Crash Data

- Delta-V plot during the event or collision
  - Forward or Longitudinal Velocity Change
  - Acceleration Pulse – *Ford & Chrysler*
- Data recorded every 10 milliseconds (GM)
- Data recorded as frequently as every 1 millisecond (Ford RCM)
- Impact Speed is NOT recorded
- Crash date and time is NOT recorded

For Ford Vehicles...

The data recorded during deployment events also includes...

- First and Second Stage Deployment Information (time)...

Which have different . . .

Collision Severity ***Thresholds***

Low Speed Collision…

- Would NOT expect ***Airbag Deployment***
- Could very reasonably trigger a ***Non-Deployment Event***

Non-Deployment Event Data

- 5 Seconds of ***Pre-Crash Data***
- Forward Velocity Change or ***Delta-V***
- ***NOT*** *currently available from* **Chrysler** ACM's

In Low Speed Collisions...

The severity of the collision is associated with what?

Delta-V

Collision Analysis

In a two vehicle collision...

If the **Delta-V** of one vehicle is known..

The **Delta-V** of the other vehicle could be determined.

And using the SDM data...

It can be determined with a significant degree of certainty!

CDR Data

- CDR data can and will have technical inaccuracies… & room for interpretation
  - Example: Oversized tires will affect accuracy of speed data…..
- A Proper Collision Analysis and Vehicle Documentation are Necessary…
- The CDR data can then be used to Subsidize and Support an Analysis or Accident Reconstruction.

SDM DATA…

Deployment Data…

Cannot be overwritten…

SDM DATA…

Non-Deployment Event Data…

- Can be overwritten…

(If it has not been locked by a deployment event.)

  - As a result of **another** minor event or collision
  - After the ignition has been cycled **250** times

- Careless removal or handling of the airbag control module…
  - Can <u>erase</u> ***Non-Deployment Event Data***…

PCM & RCM Data

- ***Special Procedures*** Must Be Followed…

…. So that Data does not get **Overwritten** or **Lost**…..

ECM Downloads…

- Would Strongly Recommend that an ECM Download be Performed by a Forensic Engineer with Experience in Investigating Collisions that involve Heavy Trucks

- Would *Not Recommend* that a Regional Service Technician Conduct a Download.

ECM Downloads…

- Often…. Not all the Information is Obtained during the Download…
- Often… the Software is **Set** to ***Reset*** the Data in the ECM….
- Sometimes Service Technicians don't have all the Software to Obtain ALL the Data that Should be Retrieved….

ECM Downloads…

- MACK… the **ECMs** have to be sent to an authorized MACK Representative to have the Data Downloaded….
- One must Retrieve the **ECMs** and have them sent to the Representative…
- Important to note when the **Power** had been Disconnected from the MACK **ECMs**

ECM Downloads…

- The Data that is Analyzed from a Heavy Truck ECM is Often in a Portion of the Downloaded Data Called…
  - **Last Stop** Record
  - **Hard Brake** Record
  - **Sudden Deceleration** Data Report
  - **Incident** Report
  - **Quick Stop** Report

ECM Downloads…

- In these Reports or Records…
  - Vehicle Speed
  - Engine Speed
  - Engine Load
  - Throttle Position
  - Brake Status
  - Clutch Status
  - Cruise Control Status

ECM Downloads…

- In Most Instances… the Record has to be Triggered by a Defined Deceleration Rate…. Before the Data is Recorded…
- There are Instances that Data Surrounding a Collision has not been recorded…
- The Data has to be ***Analyzed*** to determine when the *Collision Occurred*

ECM Data

- Can be Overwritten…
  - If the Truck is Operated following the Collision or Incident….
  - If the Ignition Key is Left On and there is Still Power in the Vehicle…

Therefore:

To retain and secure information associated with an incident...

Data should be retrieved as-soon-as-possible...***and with care!!!***

And….

- Scene and Vehicle Evidence still needs to be Documented and Analyzed….
- Proper and Thorough Accident Reconstruction Techniques are needed to fully understand how an Incident took place….

Additionally….

- Data should only be collected after proper *Authority* or *Permission* has been obtained….

- There are Different Levels of Classes Offered to Help Ensure Data is Properly Collected and Used in an Analysis…

In Summary…

- Recorded Crash Event Data…
  - Can assist an engineer or reconstructionist…
    - Relatively ***high speed*** collisions…

      …where airbag deployment has *(or should have)* occurred.
    - **Low Speed** Collision…

      …where ***Non-Deployment Event*** has been recorded…

It could also document what took place prior to the collision…

Also Note That...

A lot of facts and information can be gained surrounding a multi-vehicle collision...

...even if just one of the vehicles involved has a CDR system...and this information has been properly retained and analyzed.