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 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 *Slowling* 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

\[ g's \quad \mu \quad f \]

- 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
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.
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 \textit{cg}) from the Point-of-Impact (\textit{POI}) to its Point-of-Rest (\textit{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 $\Delta V$
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....
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....
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...

n Perception and Reaction....

Most Traffic Conditions...

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

1. Would NOT expect *Airbag Deployment*

2. 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...
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 erase Non-Deployment Event Data...
PCM & RCM Data

- Special Procedures Must Be Followed...

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

www.researchengineers.com
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
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!!!*
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.