

New Cars, Old Patients: New Insights into Crash Biomechanics

**“Innovations in Emergency Care”
William Beaumont Hospital
March 12, 2018**

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Subtitle
**What 38 Years of Crash
Investigation Has Taught Me**

*“Innovations in Emergency Care”
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**Unless you become a
farmer.....**



..or a commercial fisherman....



..then riding in a car.....



..is still the most dangerous thing you do on a daily basis



History

1975 Belt Availability Rate: ~50%



History

1975 Belt Use Rate: 5.6%



History

1975 Injury Rate: 185 per 100M VMT



History

1975 Fatality Rate : 2.5 per 100M VMT



History

2016 vs. 1975

- Belt Availability Rate: **99.9% vs ~50%**
- Belt Use Rate: **90.1% vs 5.6%**
- Injury Rate: **79 vs 185 per 100M VMT**
- Fatality Rate: **1.2 vs 2.5 per 100M VMT**

What Has Changed Over the Years?

Environment

Vehicle

Occupant

Environment

Changes in roadside hardware

Improvements in signage, lighting

Standardization in roadway design

Breakaway vs. Non-Breakaway Poles



Breakaway poles dissipate energy so that the vehicle (& occupants) don't experience the full energy load of a crash

Breakaway vs. Non-Breakaway Poles



Non-breakaway pole impacts result in vehicle (and occupants) experiencing the full energy load of the crash

Guardrail End Treatments



Energy absorbing guardrail end treatment

Guardrail End Treatments



“Turned Down” guardrail end treatment

Guardrail End Treatments



Blunt guardrail end treatment

Guardrail End Treatments



Blunt guardrail end treatment

Standardized Roadway Design



Winner of “Save the Trees” award

Standardized Roadway Design



Standardized Roadway Design



Stop sign on entrance ramp to freeway?

Vehicle

Composition of the U.S. fleet

Design of the automobile & light
truck/van/SUV

Safety Features within the vehicle

Composition of the U.S. Fleet

1980 (156 million passenger vehicles)

80% automobiles

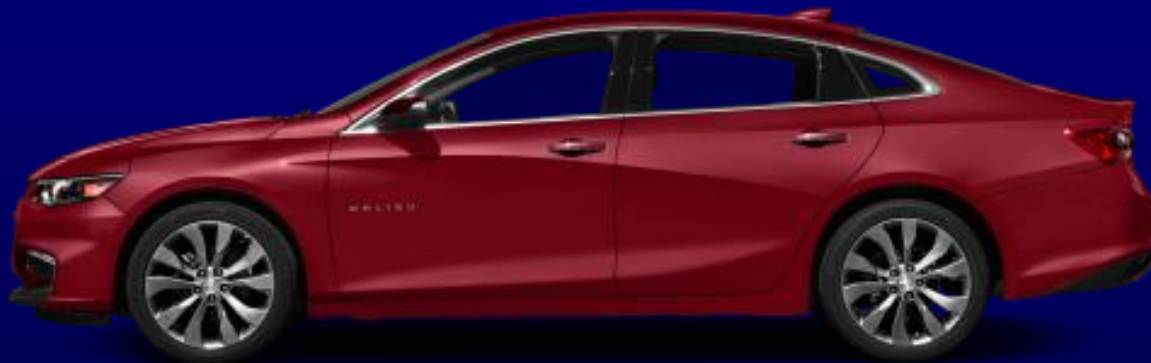
20% trucks

2017 (269 million passenger vehicles)

65% automobiles

35% trucks

1980 Chevrolet Malibu vs. 2016 Chevrolet Malibu



2016 version is:

2 inches longer

1 inch larger
wheelbase

1 inch wider

70 lbs heavier

1980 Ford Mustang vs. 2016 Ford Mustang



2016 version is:

9 inches longer

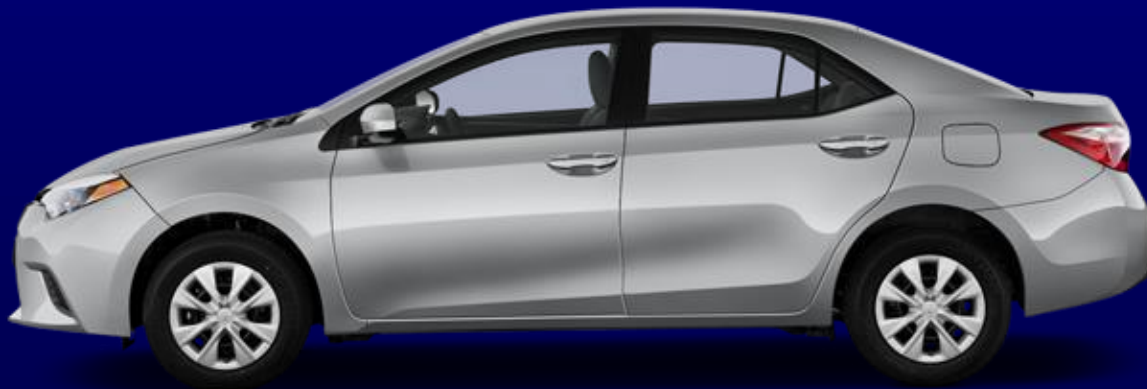
3 inch larger
wheelbase

11 inches wider

950 lbs heavier



1980 Toyota Corolla vs. 2016 Toyota Corolla



2016 version is:

17 inches longer

12 inch larger
wheelbase

7 inches wider

900 lbs heavier

Compatibility Issues



Truck/SUV vs passenger car compatibility in frontal impacts

Compatibility Issues



Truck/SUV vs passenger car compatibility in side impacts

Compatibility Issues

Most countermeasures involve changes to the trucks/SUVs

Lower frontal structure changed to provide better “catchment” of the struck vehicle

Lowers the risk of “overriding” the struck vehicle

Changes in Safety Technology

Crumple zones

Laminated WS (now side glass)

Introduction of side beams in doors

Change in door latches

Introduction of “airbags” as standard equipment (1988) and their continued development

Changes in steering columns to be energy absorbing

Changes in rollover countermeasures

Improvement in seatbelt technology

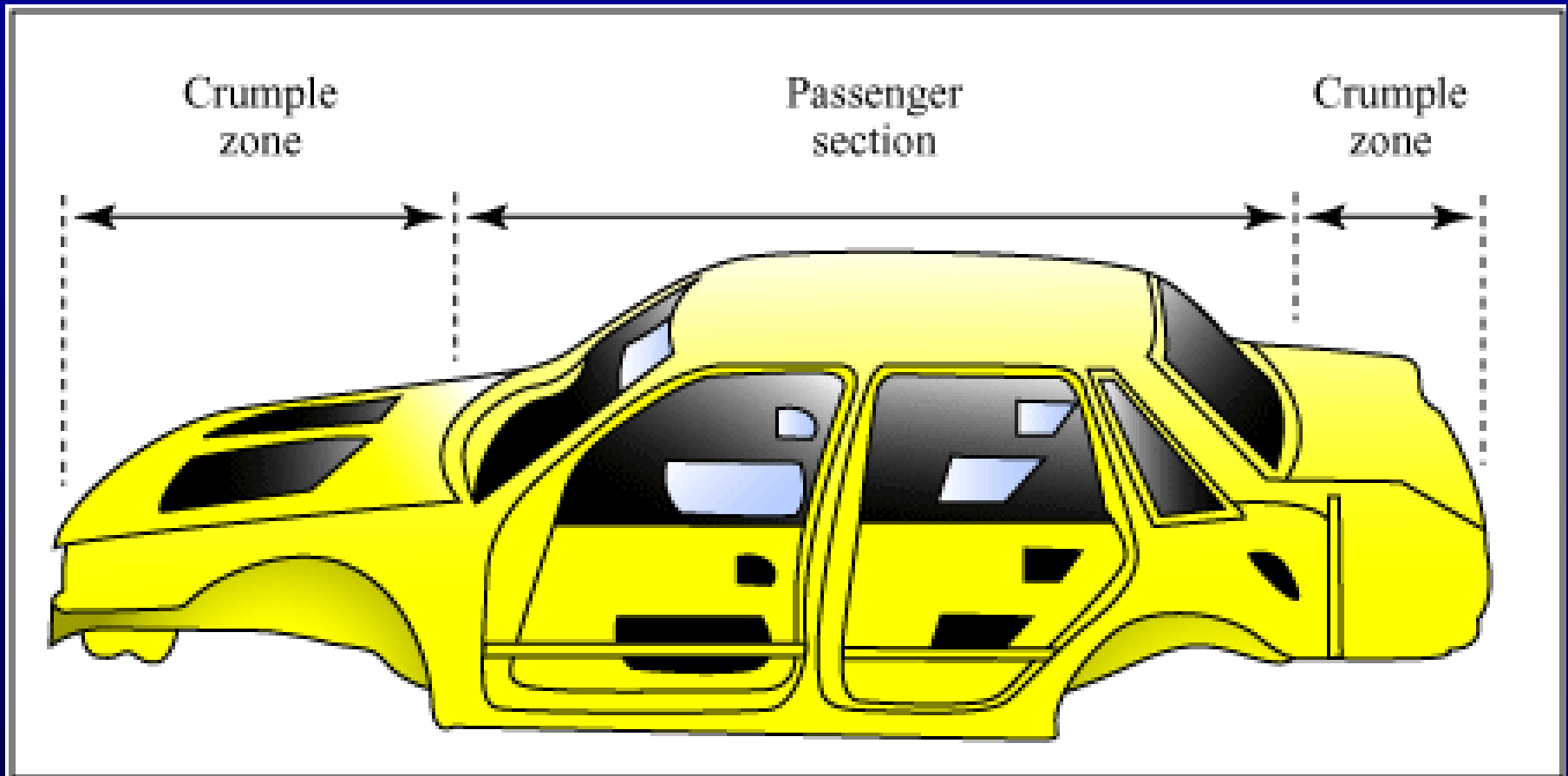
Changes in Safety Technology

Concept of “crumple zones” to dissipate energy

- absorb/dissipate energy by crushing parts of vehicle outside of passenger compartment
- older vehicles were more about reducing damage/repair to vehicle exterior
- save the car, throw away the driver

Changes in Safety Technology

The concept of “crumple zones”



Changes in Safety Technology

Laminated glass windshields

- prevent ejections and intrusions from objects

Changes in Safety Technology

Laminated windshields



Changes in Safety Technology

Laminated side windows prevent ejection but have higher potential for head/brain injury



Changes in Safety Technology

Side impact beams in doors



Changes in Safety Technology

Door latch design



Changes in Safety Technology

Introduction of “airbags” as standard equipment (1988)



Changes in Safety Technology

.....and their continued development



Changes in Safety Technology

Collapsible Steering Columns



Changes in Safety Technology

Deployable head restraints to mitigate roof crush in rollovers



Changes in Safety Technology

“Stiff” seat belts from the 60’s



Changes in Safety Technology

“Modern” seat belts



Occupants

Changes in anthropometry of the U.S.
population

Changes in social behavior with regard to
safety and driving

U.S. Anthropometry

1960

Males

5'8"

166 lbs

Females

5'3"

140 lbs

U.S. Anthropometry

2017

Males

5'9" (+1 inch)

196 lbs (+30 lbs)

Females

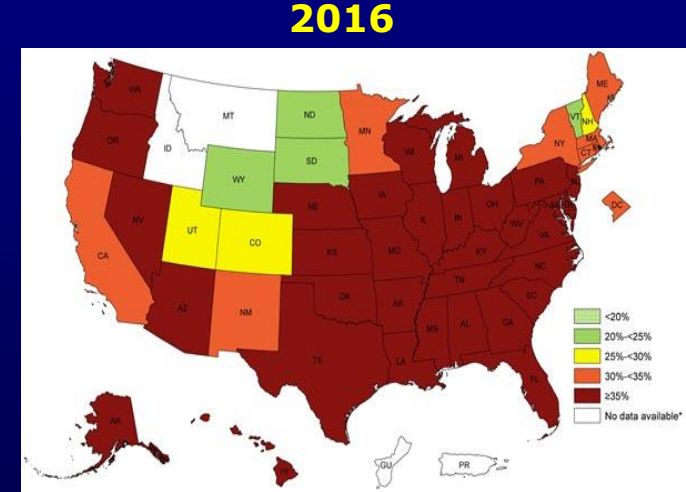
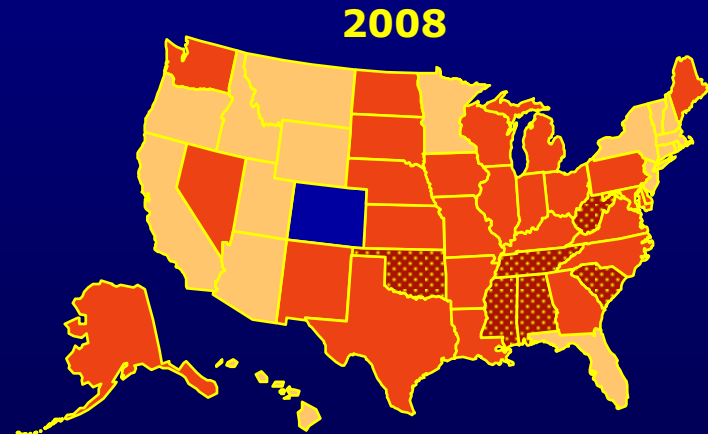
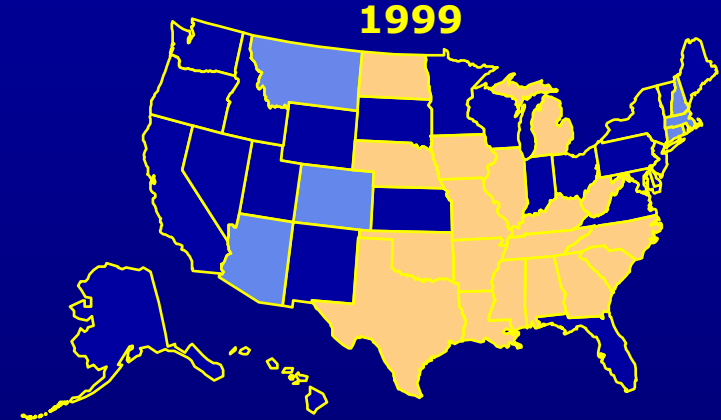
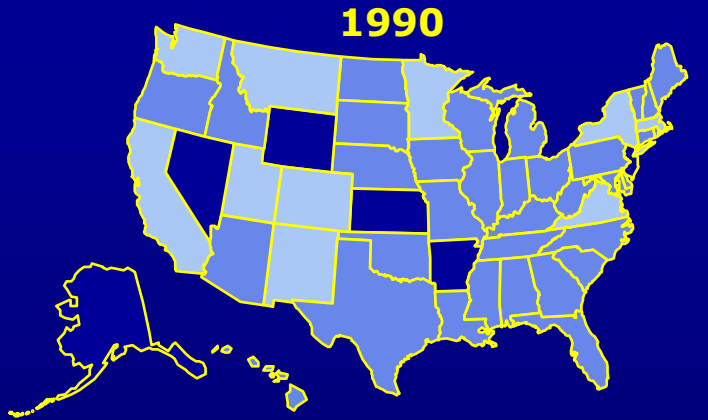
5'4" (+1 inch)

169 lbs (+29 lbs)

Obesity Trends* Among U.S. Adults

BRFSS, 1990, 1999, 2008, 2016

(*BMI ≥30, or about 30 lbs. overweight for 5'4" person)



Obesity Effects in Crashes

Lower Extremity Fractures in Frontal Crashes

- Double the number and severity

Head/Neck Injuries in Side impacts

- Obesity is slightly protective

Social Behavior

Belt Usage significantly higher (saves lives)

Distraction still a problem

- mode of distraction has changed but distraction still a major issue

Child Seat Usage significantly higher

Some Things Never Change

- The elderly have lower tolerance to crash severity than the young adult even under optimal restraint conditions
- Young adults have higher tolerance to crash severity than the elderly even under minimal restraint conditions
- The age of 55 years is the “break even” point with regard to surviving blunt trauma

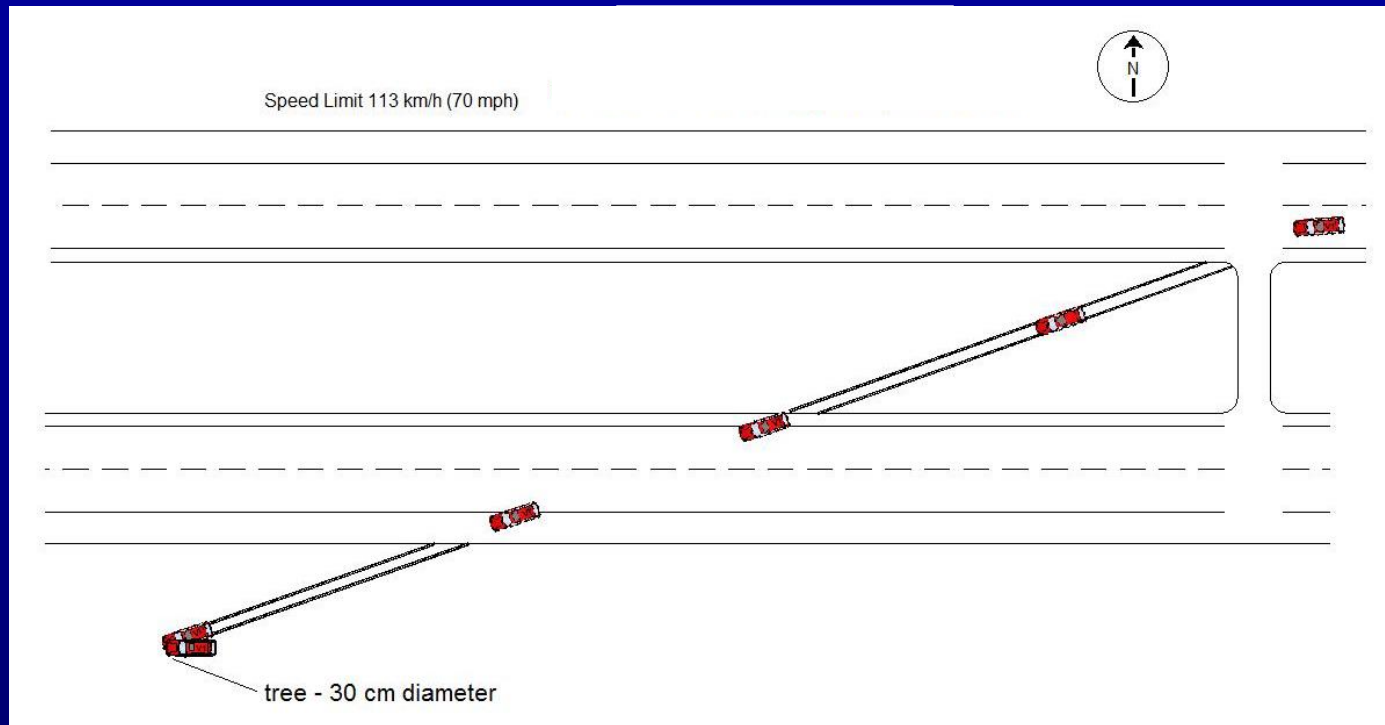
One Final Observation.....

In 1980, a rule of thumb was that 50 mph ΔV frontal crashes is the threshold where backseat people started to die (front seat people already gone)

Today, I have many, many cases of 60+ mph ΔV crashes with no fatalities to front seat occupants

Example Case of 60+ mph ΔV with No Fatalities

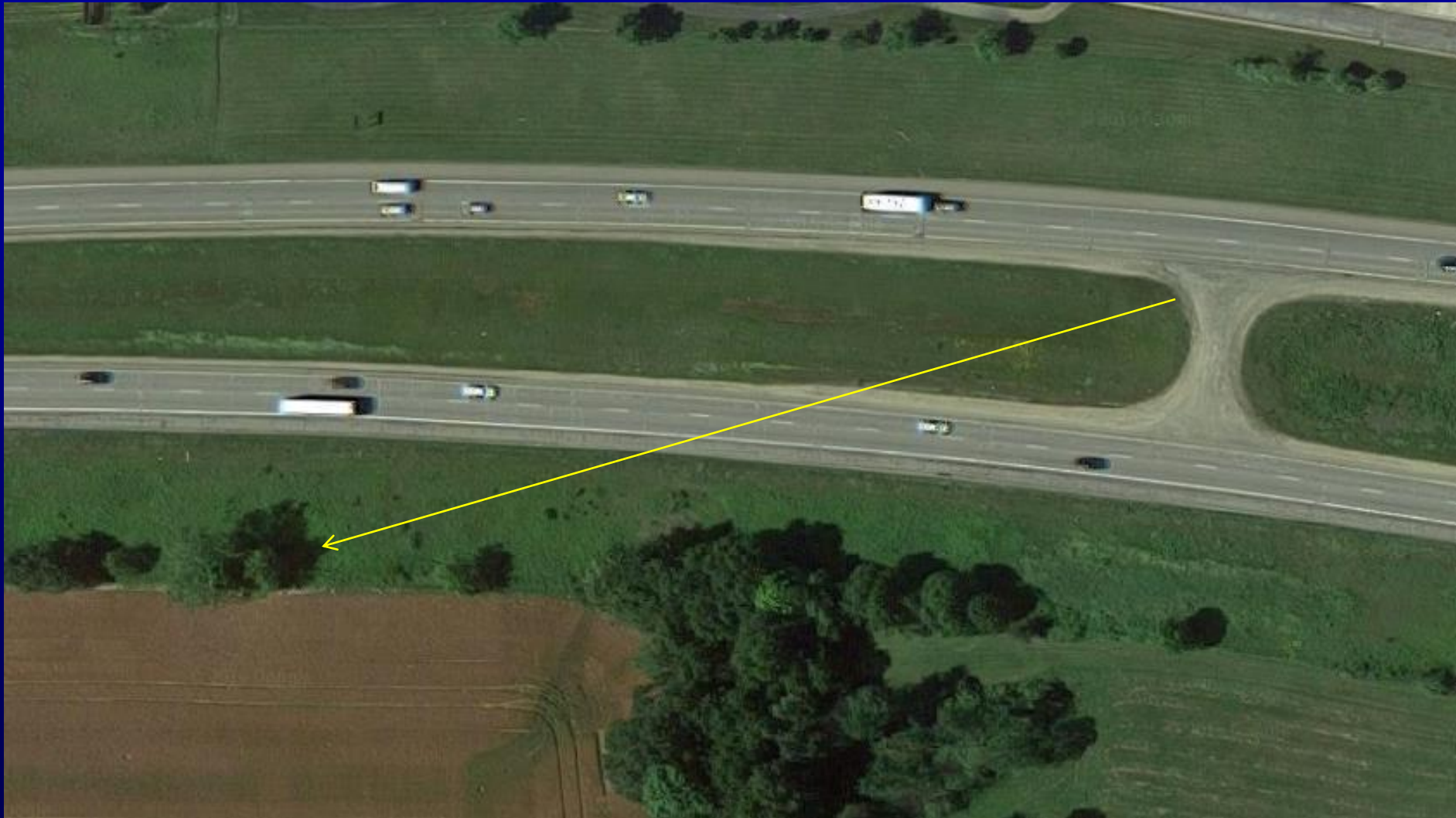
Crash Scenario



- **2015 Chevrolet Equinox vs. tree**
- **Dark, clear, dry asphalt roadway**
- **Driver of V1 reportedly fell asleep while driving**
- **V1 departs left side of road, crosses median & EB lanes & departs freeway**
- **V1 strikes a tree (30 cm diameter) with front end of V1**
- **DR & RF passenger are case occupants of V1**

Crash Scene

Bird's Eye View of Scene



Case Vehicle – 2015 Chevrolet Equinox



Exemplar vehicle

Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



CDC :	12-FYEN-5	Mass: 1706 kg
Direct damage length:	33 cm	
Max Crush:	98 cm	
PDOF:	0 degrees	
Severity:	50 ΔV mph	EDR: -60 ΔV mph
	- 50 longitudinal	
	0 lateral	

Case Vehicle – 2015 Chevrolet Equinox

System Status at Event (Event Record 1)

	Deployment
Event Record Type	
OnStar Deployment Status Data Sent	Yes
Complete file recorded (Event Recording Complete)	Yes
Crash Record Locked	Yes
OnStar SDM Recorded Vehicle Velocity Change Data Sent	No
Deployment Event Counter	1
Multi-Event, Number of Events (Event Counter)	1
OnStar Notification Event Counter	1
Time From Event 1 to 2 (Time Between Events) (seconds)	Data Not Available
Ignition Cycle, Crash (Ignition Cycles at Event)	1432
Algorithm Active: Frontal	Yes
Algorithm Active: Side	Yes
Algorithm Active: Rollover	Yes
Algorithm Active: Rear	No
Concurrent Event Flag Set	No
Event Severity Status: Frontal Pretensioner	Yes
Event Severity Status: Frontal Stage 1	Yes
Event Severity Status: Frontal Stage 2	Yes
Event Severity Status: Left Side	No
Event Severity Status: Right Side	No
Event Severity Status: Rear	No
Event Severity Status: Rollover	No
Safety Belt Status, Driver (Driver Belt Switch Circuit Status)	Not Buckled
Safety Belt Status, Right Front Passenger (Passenger Belt Switch Circuit Status)	Not Buckled
Center Front Row Belt Switch Circuit Status (If Equipped)	Data Not Available

Case Vehicle – 2015 Chevrolet Equinox

Center Front Row Belt Switch Circuit Status (If Equipped)	Data Not Available
Left Row 3 Belt Switch Circuit Status (If Equipped)	Data Not Available
Center Row 3 Belt Switch Circuit Status (If Equipped)	Data Not Available
Right Row 3 Belt Switch Circuit Status (If Equipped)	Data Not Available
Passenger Seat Occupancy Status	Occupied
Occupant Size Right Front Passenger Child (Passenger Classification Status)	No (Small Adult)
Passenger Air Bag ON Indicator Status	On
Passenger Air Bag OFF Indicator Status	Off
Low Tire Pressure Warning Lamp Status 0.5 Seconds Prior to Time Zero	Off
Frontal Air Bag Warning Lamp (SIR Warning Lamp Status 0.5 Seconds Prior to Time Zero)	Off
SIR Warning Lamp ON/OFF Time Continuously (seconds)	655330
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	1421
Ignition Cycles Since DTCs Were Last Cleared 0.5 Seconds Prior to Time Zero	253
Maximum Delta-V, Longitudinal (Maximum Longitudinal SDM Recorded Vehicle Velocity Change for FSR Event) MPH [km/h]	-60 [-96]
Time, Maximum Delta-V (Time From FSR Time Zero to Maximum Longitudinal SDM Recorded Vehicle Velocity Change)(msec)	156
Maximum Delta-V, Lateral (Maximum Lateral SDM Recorded Vehicle Velocity Change for FSR Event) MPH [km/h]	9 [15]
Time Maximum Delta-V, Lateral (Time From FSR Time Zero to Maximum Lateral SDM Recorded Vehicle Velocity Change)(msec)	292

Case Vehicle – 2015 Chevrolet Equinox

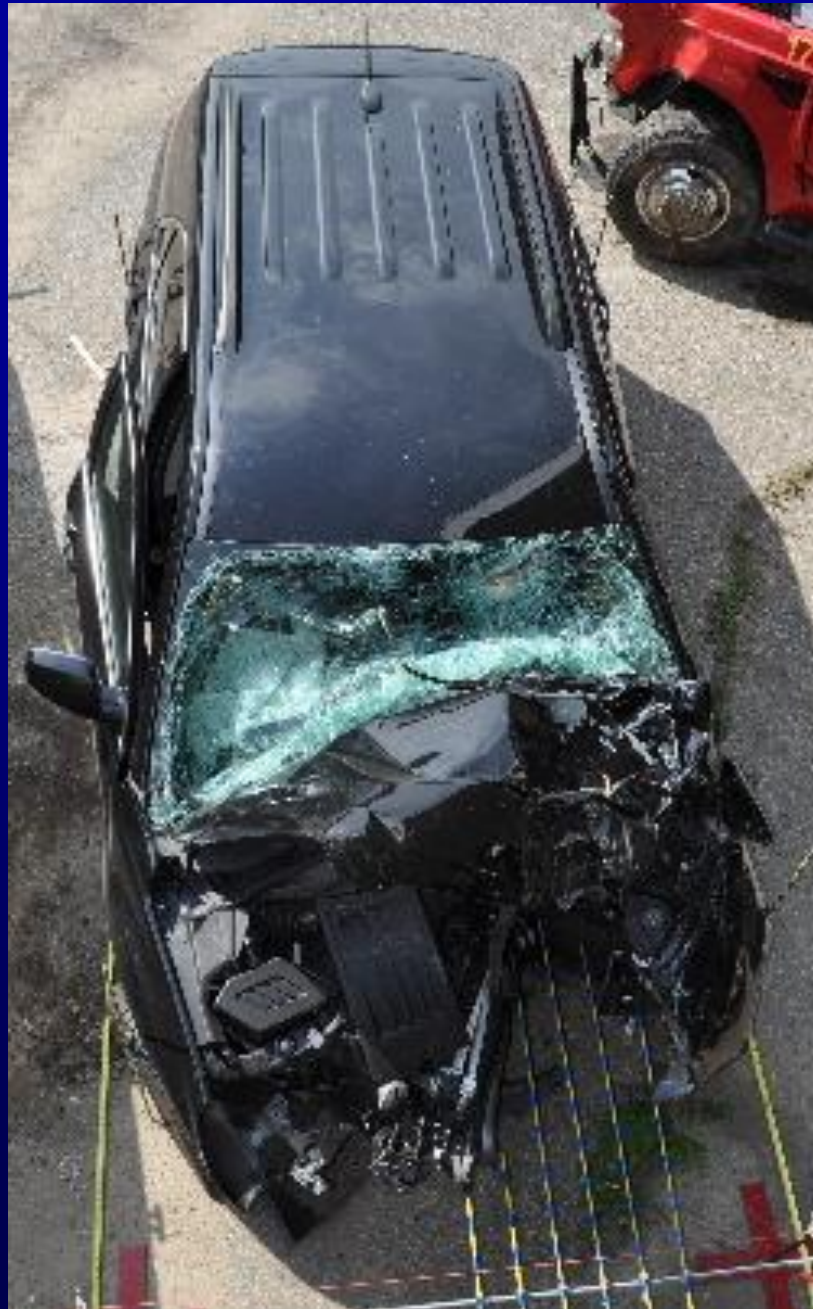
Pre-Crash Data -5.0 to -0.5 sec (Event Record 1)

Times (sec)	Accelerator Pedal, % Full (Accelerator Pedal Position)	Service Brake (Brake Switch Circuit State)	Engine RPM (Engine Speed)	Engine Throttle, % Full (Throttle Position)	Speed, Vehicle Indicated (Vehicle Speed) (MPH [km/h])
-5.0	57	Off	2496	61	73 [118]
-4.5	84	Off	3968	99	70 [112]
-4.0	73	Off	4352	38	76 [122]
-3.5	86	Off	5440	87	67 [108]
-3.0	85	Off	5824	37	77 [124]
-2.5	99	Off	5248	97	66 [107]
-2.0	94	Off	5248	99	66 [107]
-1.5	99	Off	6336	47	86 [138]
-1.0	51	Off	5120	20	73 [118]
-0.5	97	Off	4288	20	59 [95]

Pre-Crash Data -2.0 to -0.5 sec (Event Record 1)

Times (sec)	Cruise Control Active	Cruise Control Resume Switch Active	Cruise Control Set Switch Active	Engine Torque (lb-ft [N-m])	Reduced Engine Power Mode Indicator
-2.0	No	No	No	139 [188]	Off
-1.5	No	No	No	84 [114]	Off
-1.0	No	No	No	-1 [-1]	Off
-0.5	No	No	No	-18 [-24]	Off

Case Vehicle – 2015 Chevrolet Equinox



Case Occupant

- driver
- 21-year-old male
- 5 ft 7 in (170 cm)
- 158 lb (72 kg)
- 3-point manual belt not used
- SW & curtain airbags deployed
- ISS – 27
- LOS – 18 days

Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Driver – Catalog of Injuries

Mandible fracture

Right PTX

Left pulmonary contusion

Liver laceration

Left and right acetabulum fractures

Right iliac wing fracture

Left sacral ala fracture

Right inferior pubic ramus fracture

Left femoral neck fracture

Left intertrochanteric femur fracture

Right fibular fracture

Case Occupant

- right-front passenger
- 20-year-old female
- 5 ft 1 in (155 cm)
- 130 lb (59 kg)
- 3-point manual belt not used
- dash-mounted & curtain airbags deployed
- ISS – 22
- LOS – 8 days

Case Vehicle – 2015 Chevrolet Equinox



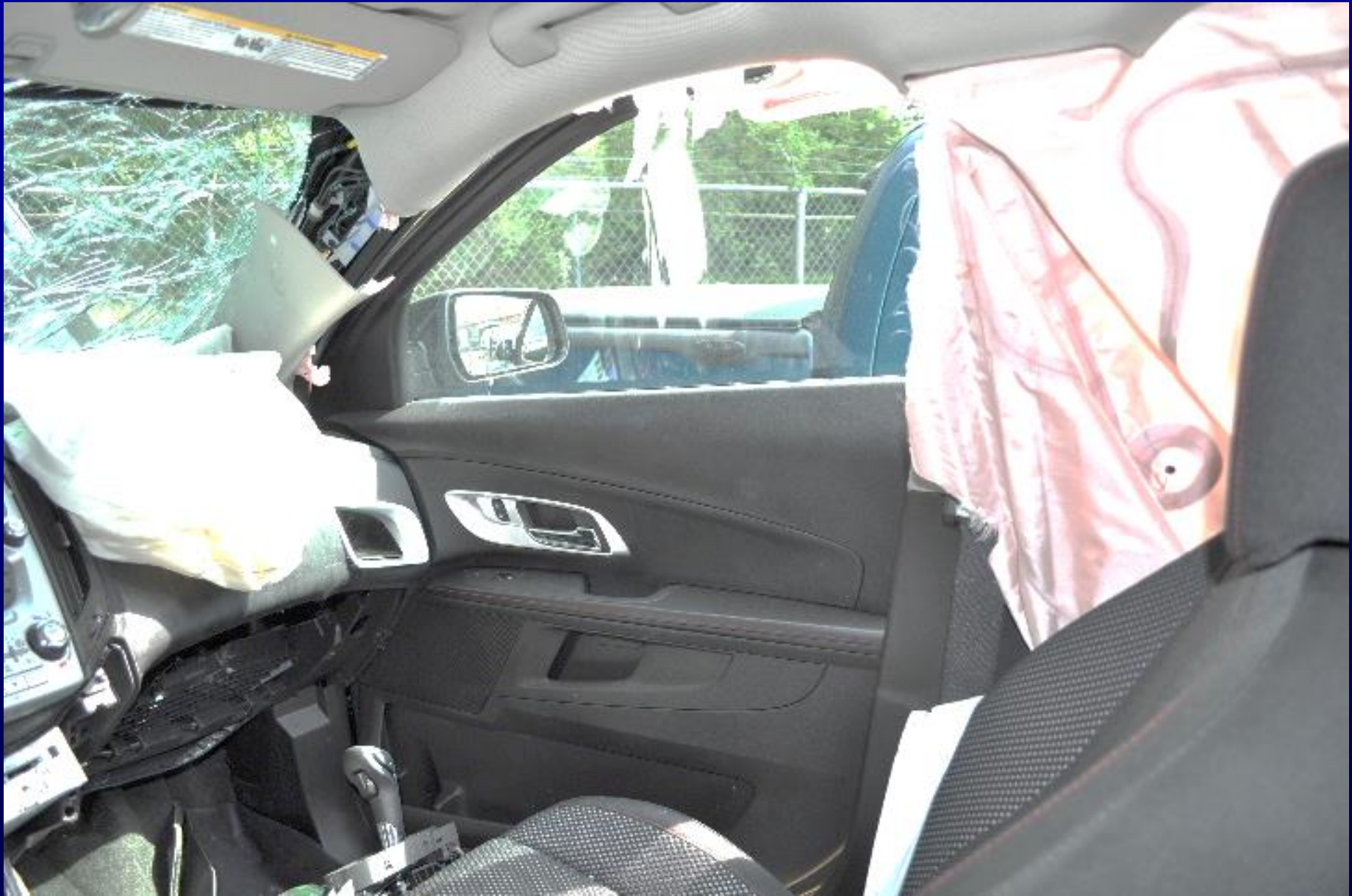
Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



Case Vehicle – 2015 Chevrolet Equinox



RF passenger – Catalog of Injuries

12 rib fractures

T9 transverse process fracture

Right proximal clavicle fracture

Right radius fracture

Left metacarpal fractures x4

Right pubic symphysis fracture

Left ilium fracture

Sacrum fracture

Right intertrochanteric femur fracture

Left bimalleolar fracture

Left calcaneus fracture

Thank-you for your attention!



Any Questions?

