# The Impact of Seatback Loading in Frontal Collisions

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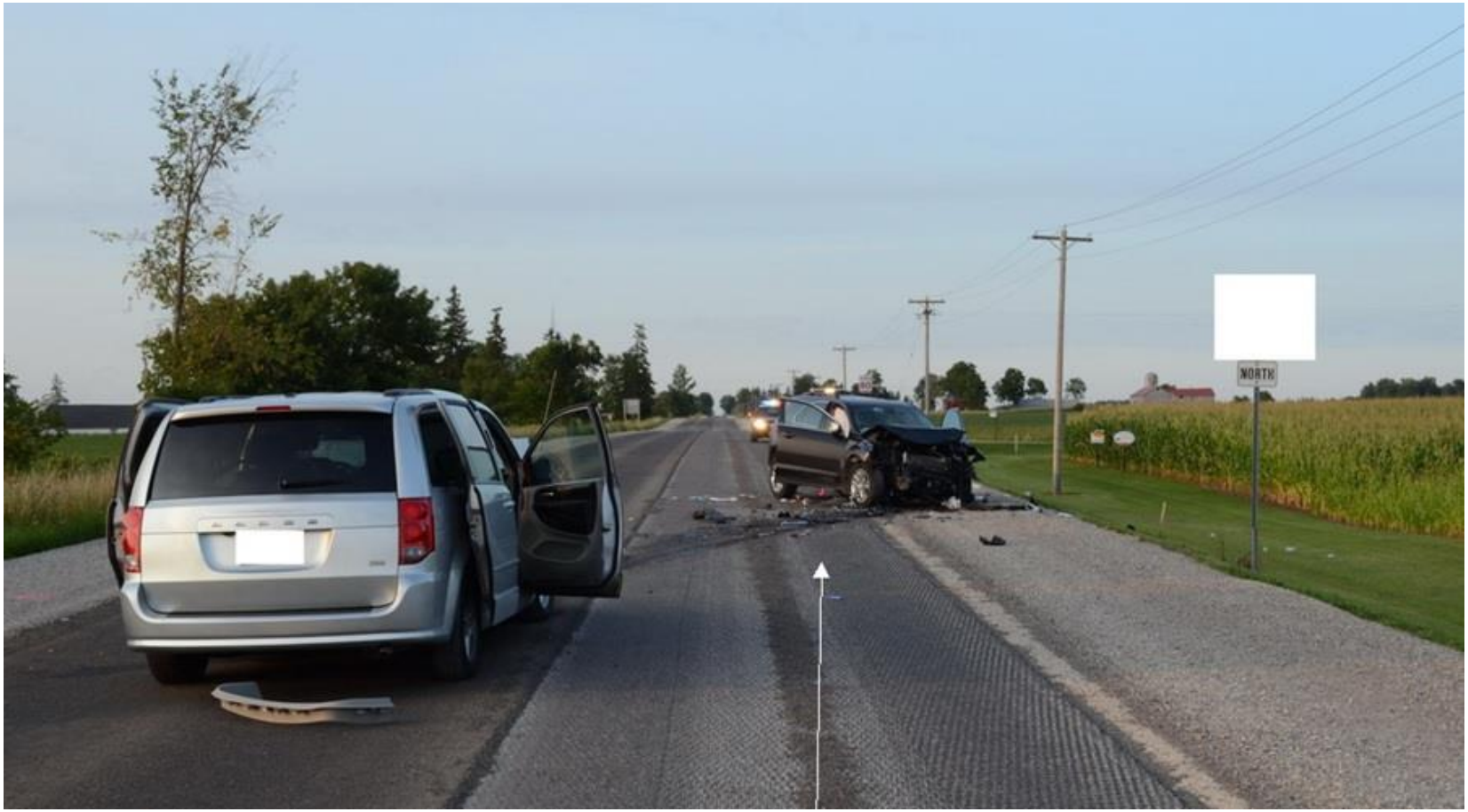
# Disclosure

- ✓ Research Ethics Board approval for data collection by **MOVES (Motor Vehicle Safety) research team** at **Western University** for **Transport Canada**
- ✓ Collision investigations performed by **Southwestern Collision Analysis**
- ✓ No conflict of interest, no financial relationships from parties with commercial interest

# Background



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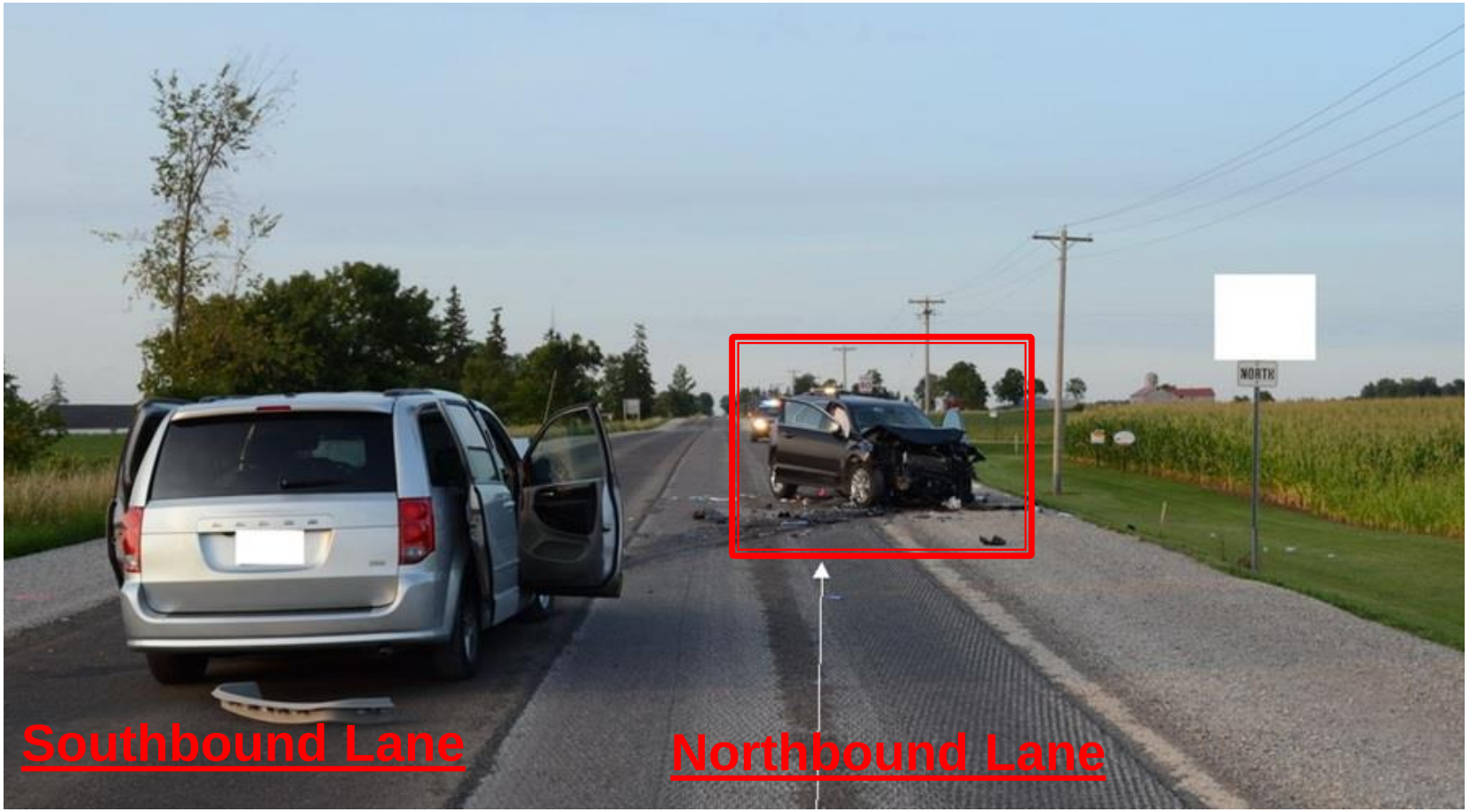

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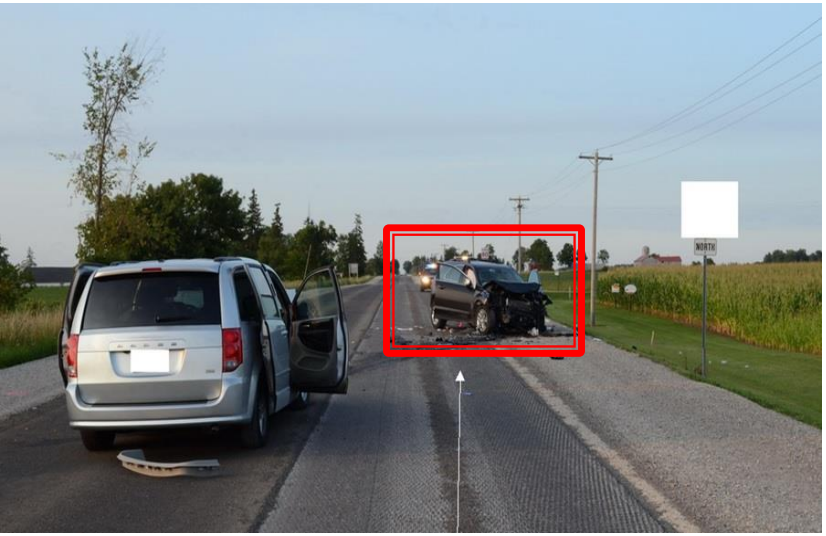


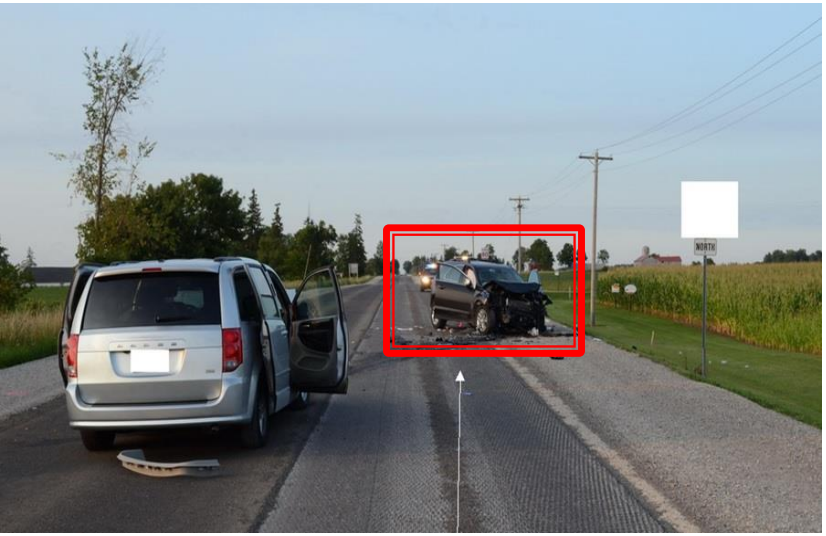
## Driving Environment

**Road Type:**
→ 2-way / 2-lane paved rural highway
→ Resurfacing in progress
→ No lane markings
→ Gravel shoulders

**Posted Speed:**
→ 80 km/h

**Weather Conditions:**
→ Clear / warm
→ Road surface dry

# Background

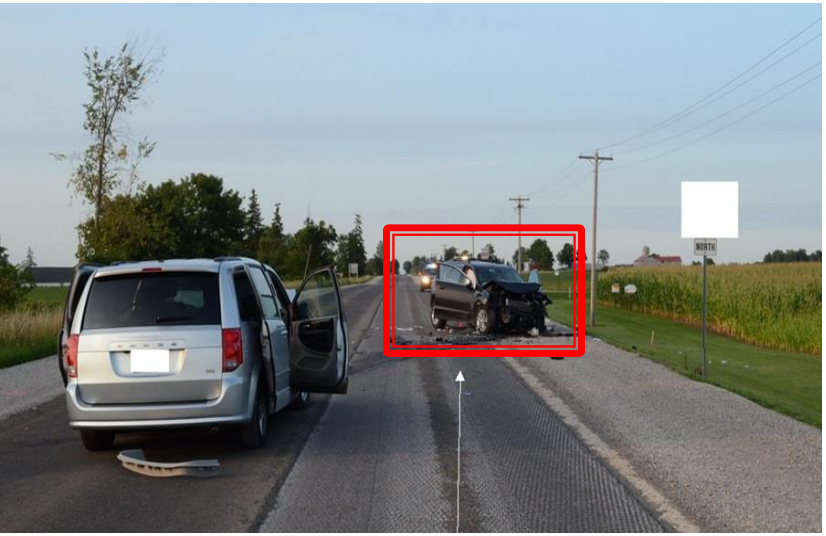


## Driver Behaviour

**Travel Speed:**
→ 76 km/h
→ Gradually accelerating
→ Travelling southbound

**Vehicle Maneuvering:**
→ Veered into oncoming (southbound) lane

# Background



## Collision Event

→Frontal collision
(Head-On in northbound lane)

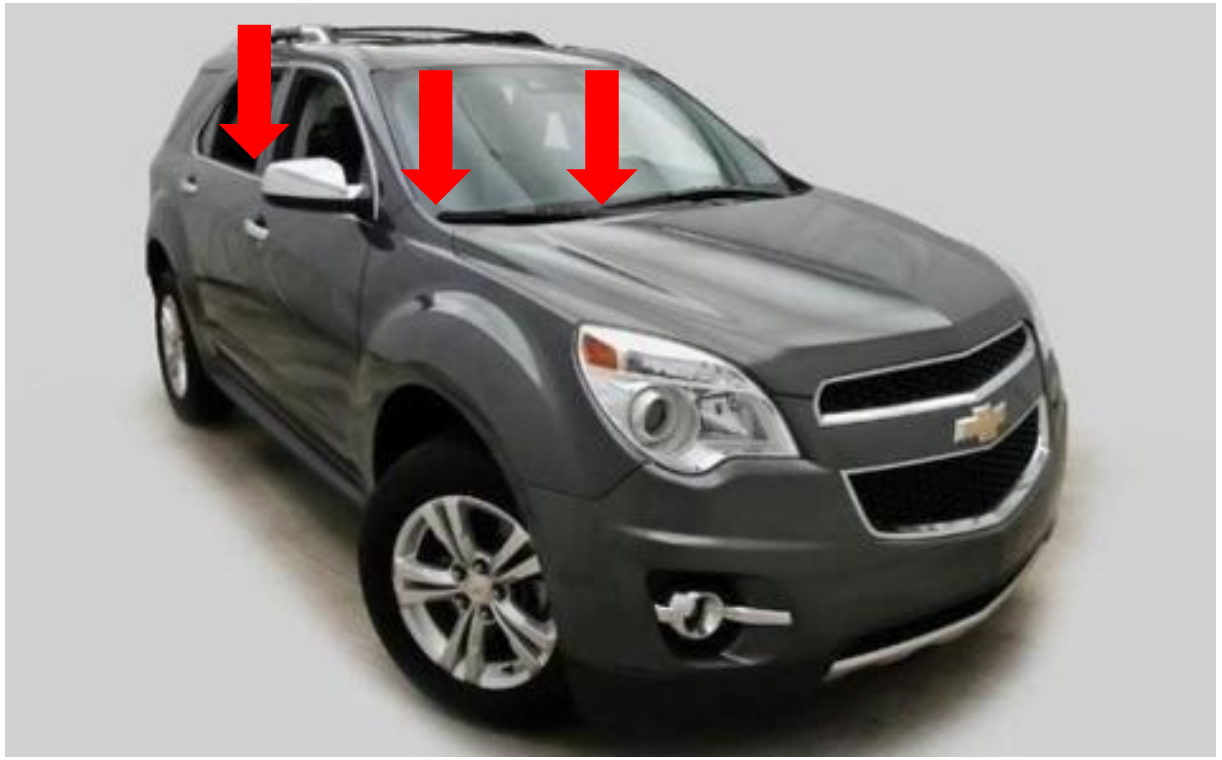
→Aversive reaction of non-case vehicle

→SUV (case vehicle) skidded 7m south
*(final position: east edge of northbound lane, facing southeast)*

→Non-case vehicle propelled rearwards
*(final position: southbound lane, facing north)*

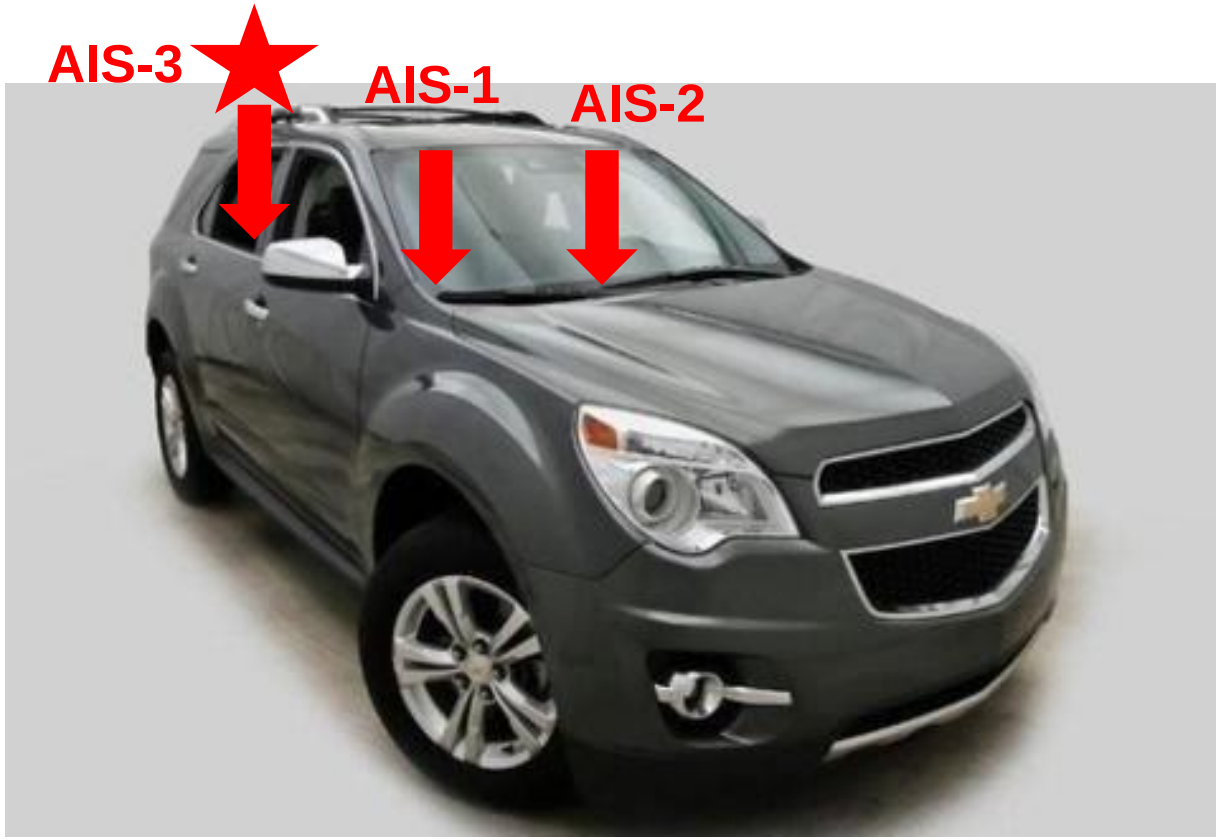
# Background

## Case Vehicle Occupants



# Background

## Case Vehicle Occupants



# Objective

***→To determine the factors and mechanisms responsible for the injuries to the occupants of the case vehicle.***

# Methodology

**MOVES Research Team**

→*Who is involved in the MOVES Research Team?*

→***funded by Transport Canada*** *(mandate under federal Motor Vehicle Safety Act)*

→*relationships with other agencies (eg. police, car salvage yards) established by* ***Southwestern Collision Analysis***

# Methodology

## MOVES Research Team: The Database

→***Southwestern Collision Analysis***
***(Mr. Kevin McClafferty)***

- *Documentation* of **physical evidence**
- *Documentation of* ***exterior/interior damage*** to vehicle
- ***Photography*** *of vehicle/scene*

→***Dr. Michael Shkrum***

- *Medical information*

# Methodology

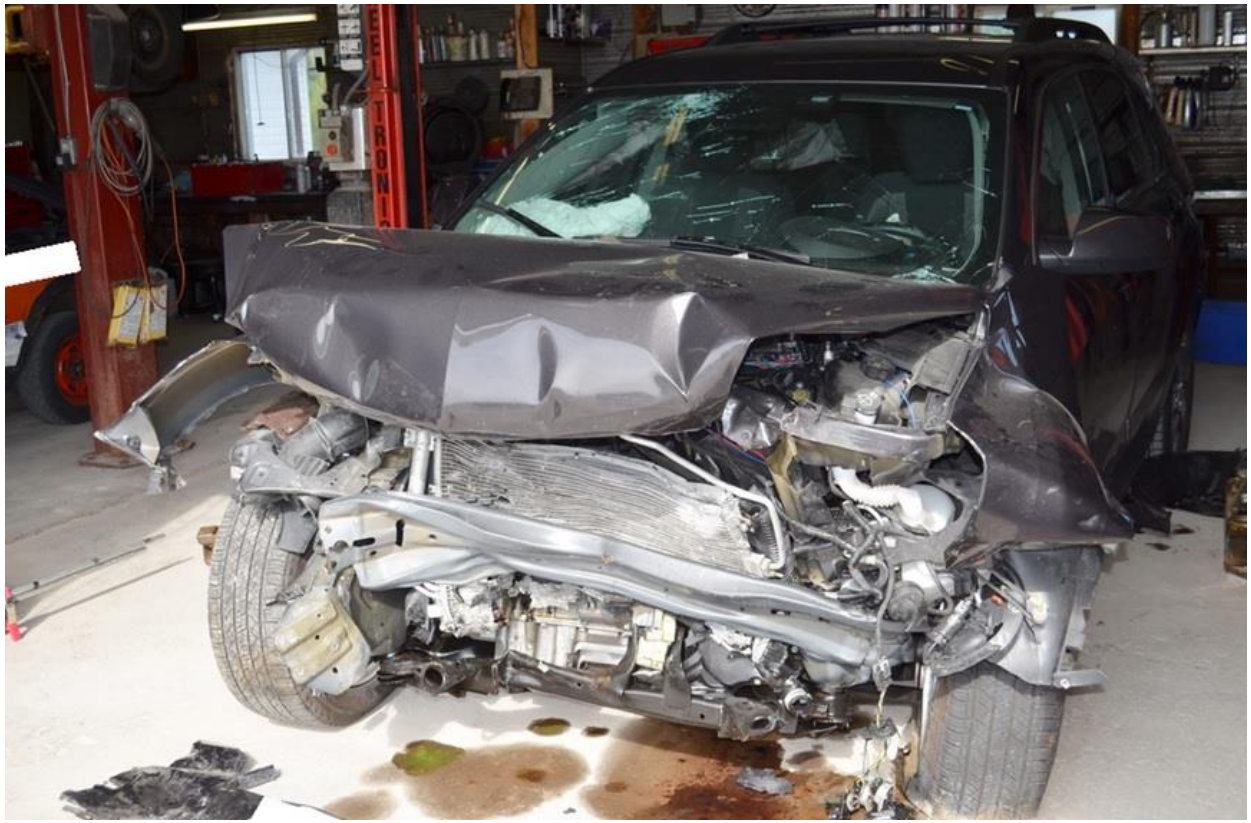
## MOVES Research Team: The Database

→*What types of data is included in the database?*

- ***Case narratives***
- ***Case vehicle photos***
- ***Scene photos***
- ***Collision diagrams***
- ***Physical data (EDR; damage analysis, etc.)***

# Results

## Exterior Vehicle Damage



→Maximum frontal crush = **64cm** (left corner of bumper) tapering to **36cm** (right corner of bumper)

→Hood buckled

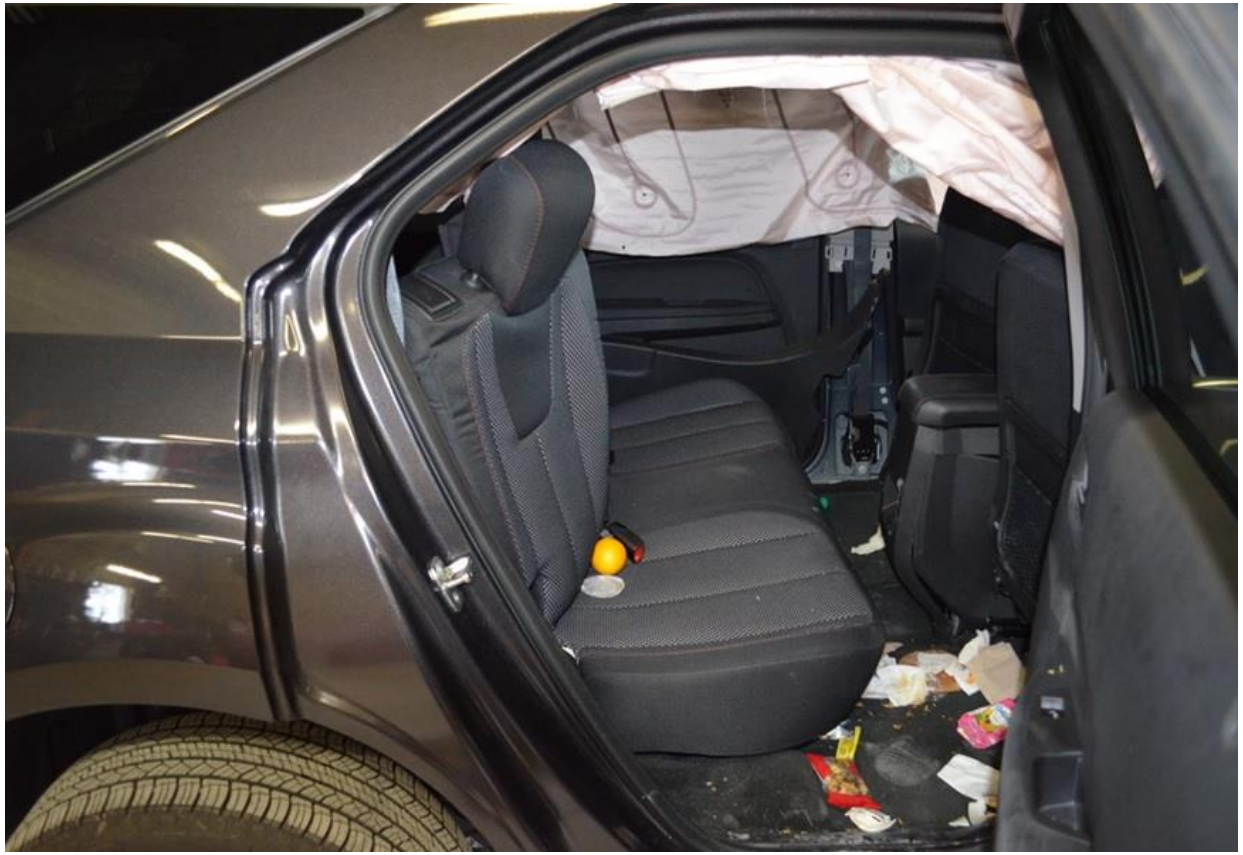
→Bumper fascia, grille, headlights separated from vehicle

→Windshield fractured

→Left front wheel jammed into wheel well

# Results

## Interior Vehicle Damage



→Intrusion at driver's floor (15 cm)

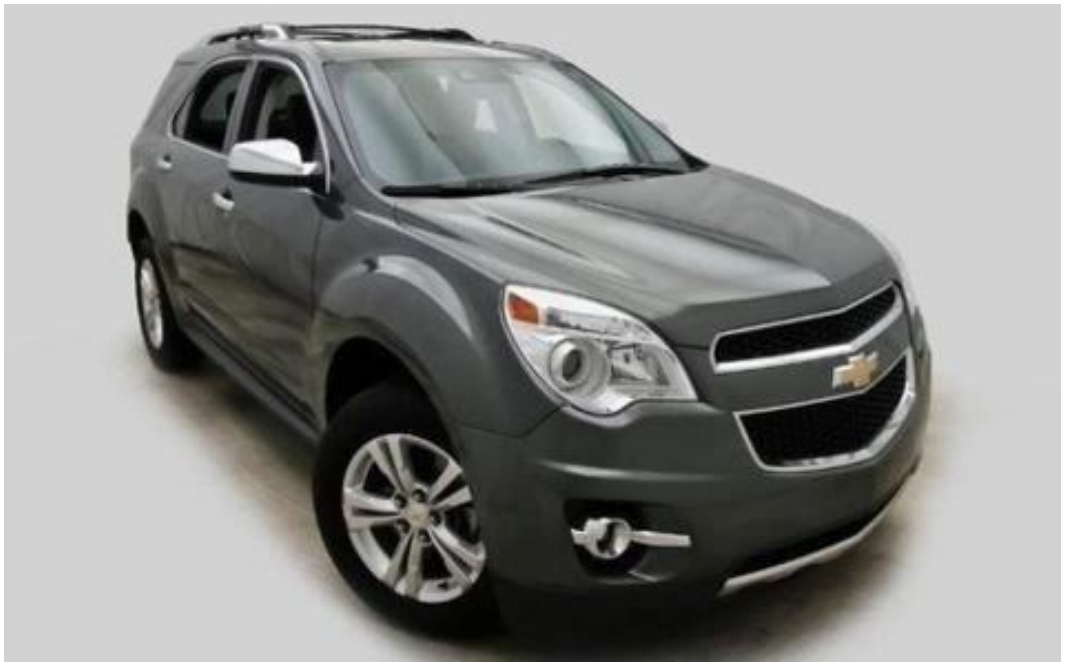
→Front and side curtain airbags deployed

→Deformation of driver's seatback

→Substantial deformation of right rear occupant's seatback

# Results

## Event Data Recorder



→Maximum longitudinal delta-V = **63 km/h @ 122ms**

→Maximum lateral delta-V = **4 km/h @ 44ms**

→Vehicle speed increased gradually from **76 km/h @ 5.0s** to **80 km/h @ 0.5s**

→Brake switch status = OFF (all intervals)

→Driver's seatbelt **pretensioners** commanded @ **3ms**;
→1st stage **front airbag** commanded @ **10ms**

# Results

## Driver Injuries

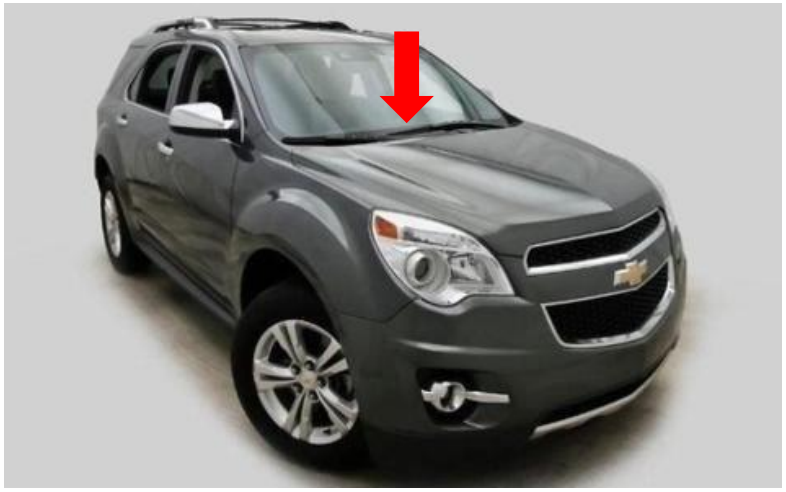
→Displaced fracture mid-shaft left clavicle **(AIS-2)**

→Abrasions and contusions on lower spine **(AIS-1)**

→Abrasions and contusions on left elbow **(AIS-1)**

→Abrasions and contusions on left shoulder **(AIS-1)**

→Abrasions and contusions on the left iliac crest **(AIS-1)**



# Results

## Right Rear Occupant Injuries

→Right pulmonary contusions **(AIS-3)**

→Concussion **(AIS-2)**

→3x small bowel perforations **(AIS-2)**

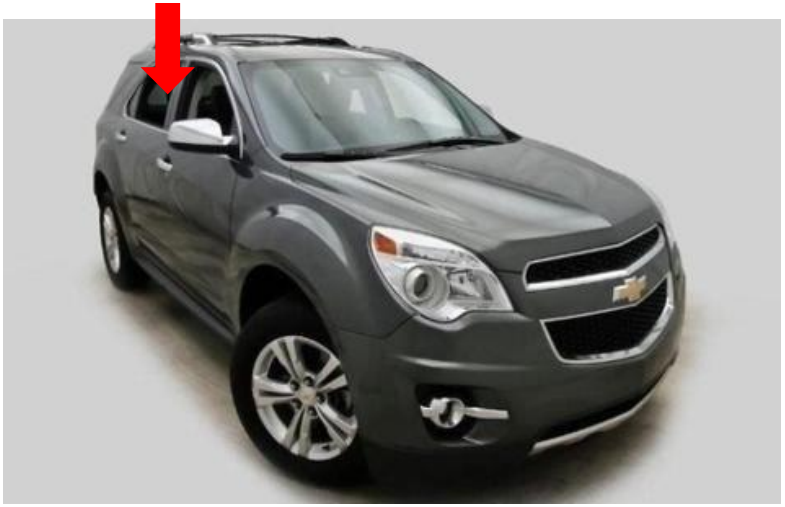
→Three colonic serosal tears **(AIS-2)**

→One colonic full thickness perforation **(AIS-2)**

→Right rectus hematoma **(AIS-2)**

→Nose bridge laceration **(AIS-1)**

→Right nose laceration **(AIS-1)**



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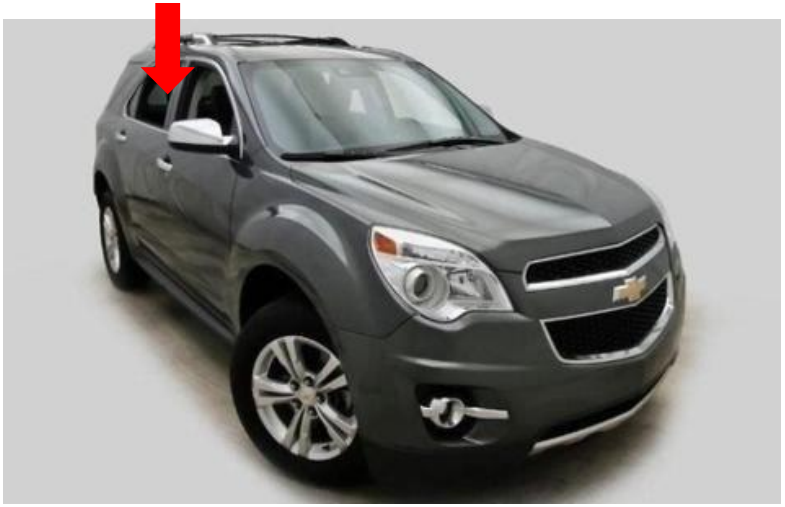
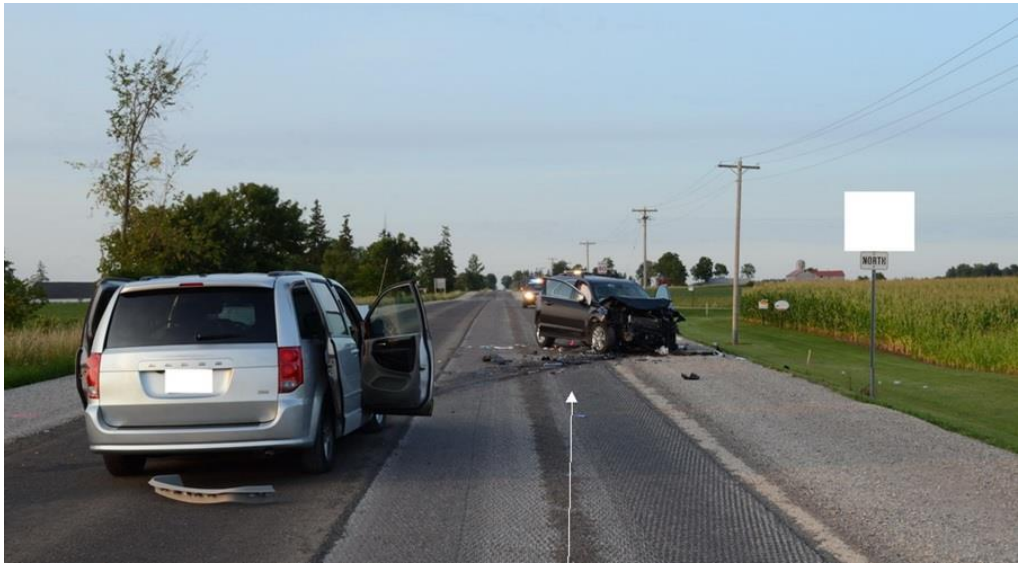
*Injuries more severe than driver*



# Discussion

## Physical Collision Analysis




→Vehicles closing at **114 km/h** at collision
(delta-V at maximum engagement = **57 km/h** for both vehicles)

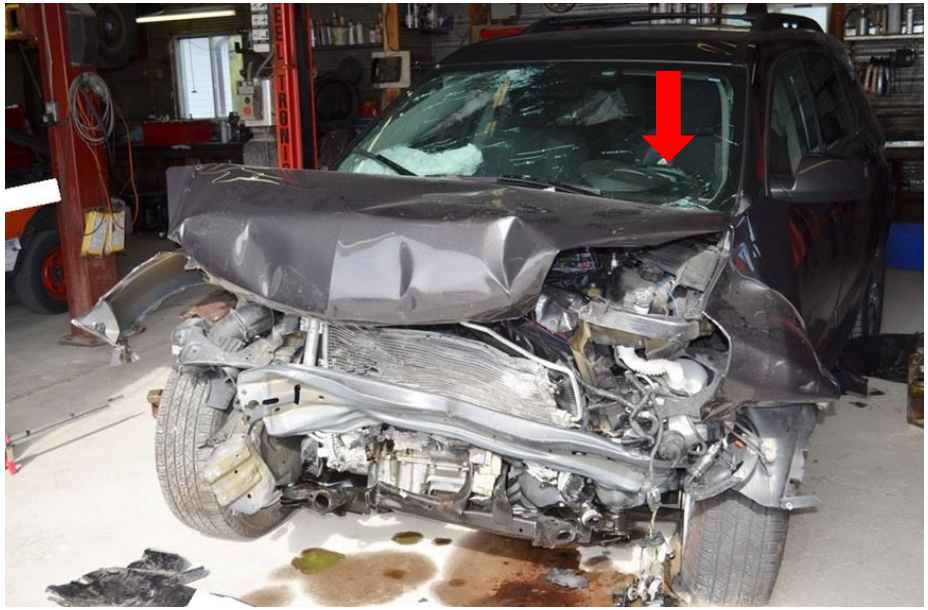
→Overall delta-V = **63 km/h**
(assuming 10% rebound)

→Damage analysis (using front stiffness values) confirms EDR delta-V (57 km/h prior to rebound)

→Severity of impact similar to frontal barrier crash test
@ 55 km/h

# Discussion

## Injury Analysis - Driver



**→TORSO BELT**

- Displaced fracture mid-shaft left clavicle **(AIS-2)**
- Abrasions and contusions on left shoulder **(AIS-1)**

**→LAP BELT**

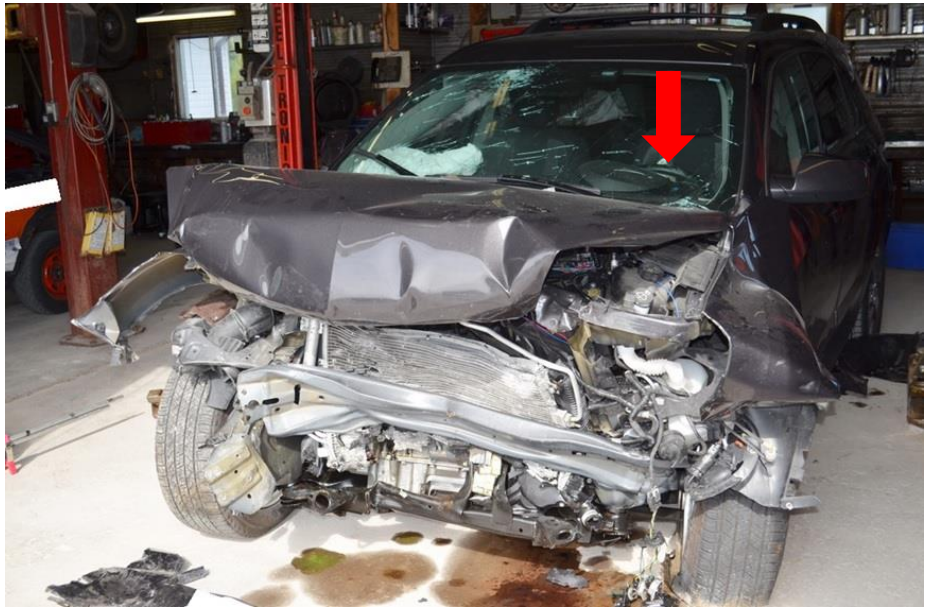
**-** Abrasions and contusions on the left iliac crest **(AIS-1)**

**→AIRBAG**

- Abrasions and contusions on left elbow **(AIS-1)**

# Discussion

## Injury Analysis - Driver

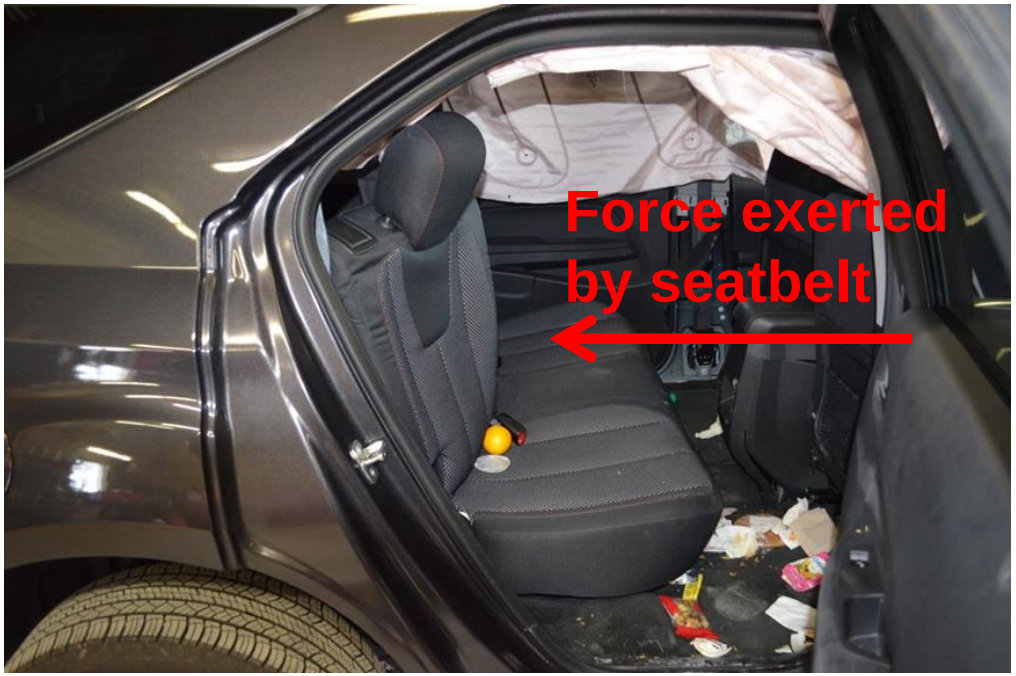


**→SEATBACK**

**-** Abrasions and contusions on lower spine **(AIS-1)**

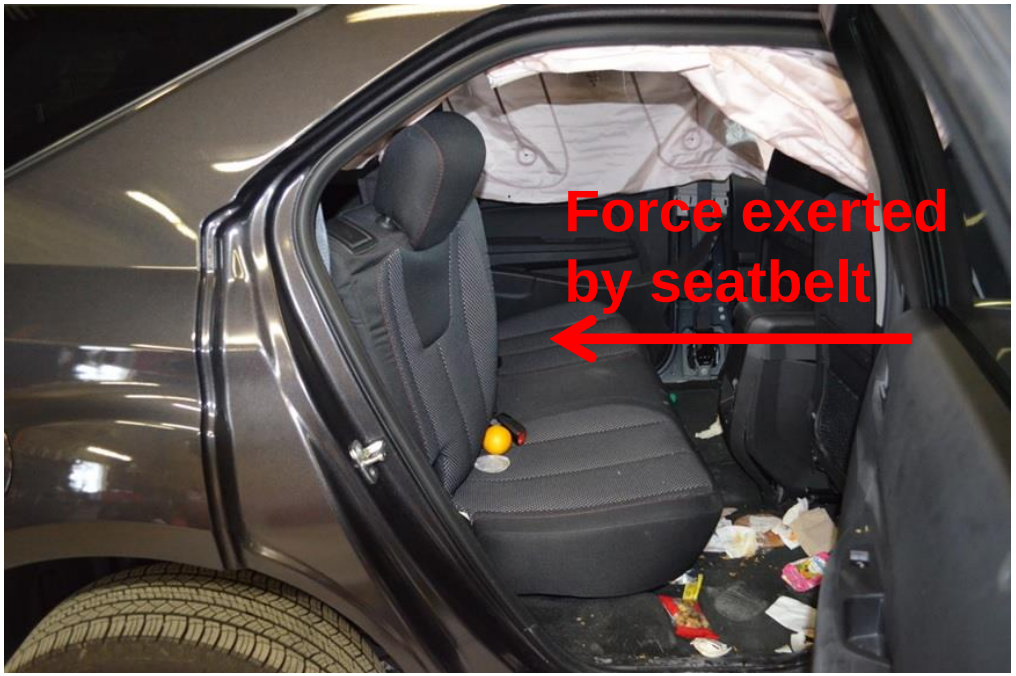
# Discussion

## Injury Analysis - Rear Occupant



# Discussion

## Injury Analysis - Rear Occupant




**→TORSO BELT**

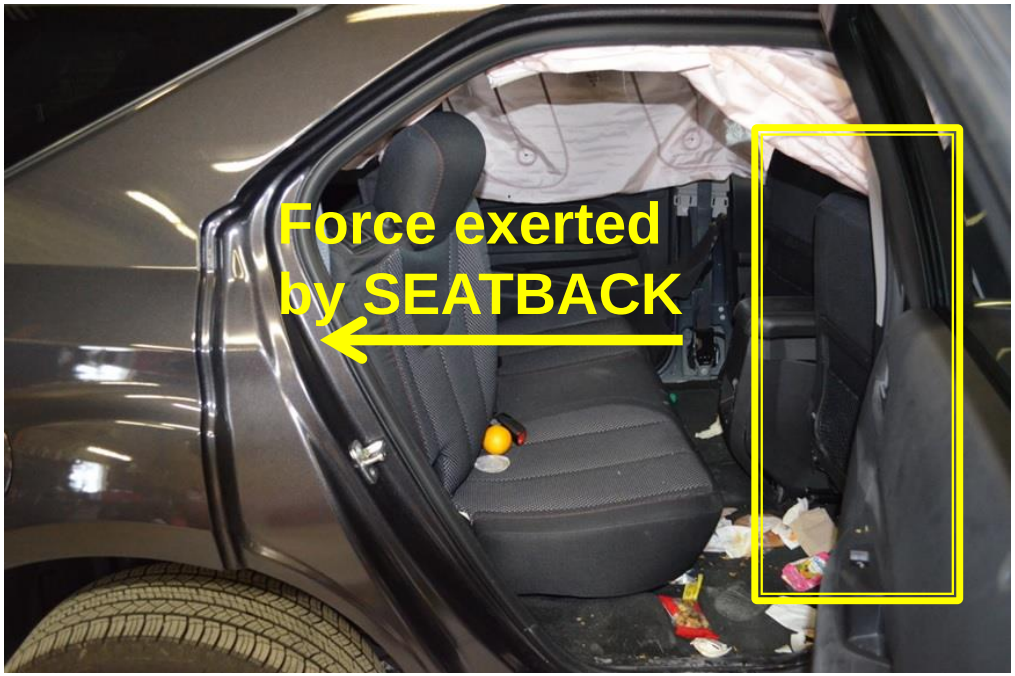
- Right pulmonary contusions **(AIS-3)**

**→LAP BELT**

- 3x small bowel perforations **(AIS-2)**
- 3x colonic serosal tears **(AIS-2)**
- Colonic full thickness perforation **(AIS-2)**
- Right rectus hematoma **(AIS-2)**

# Discussion

## Injury Analysis - Rear Occupant

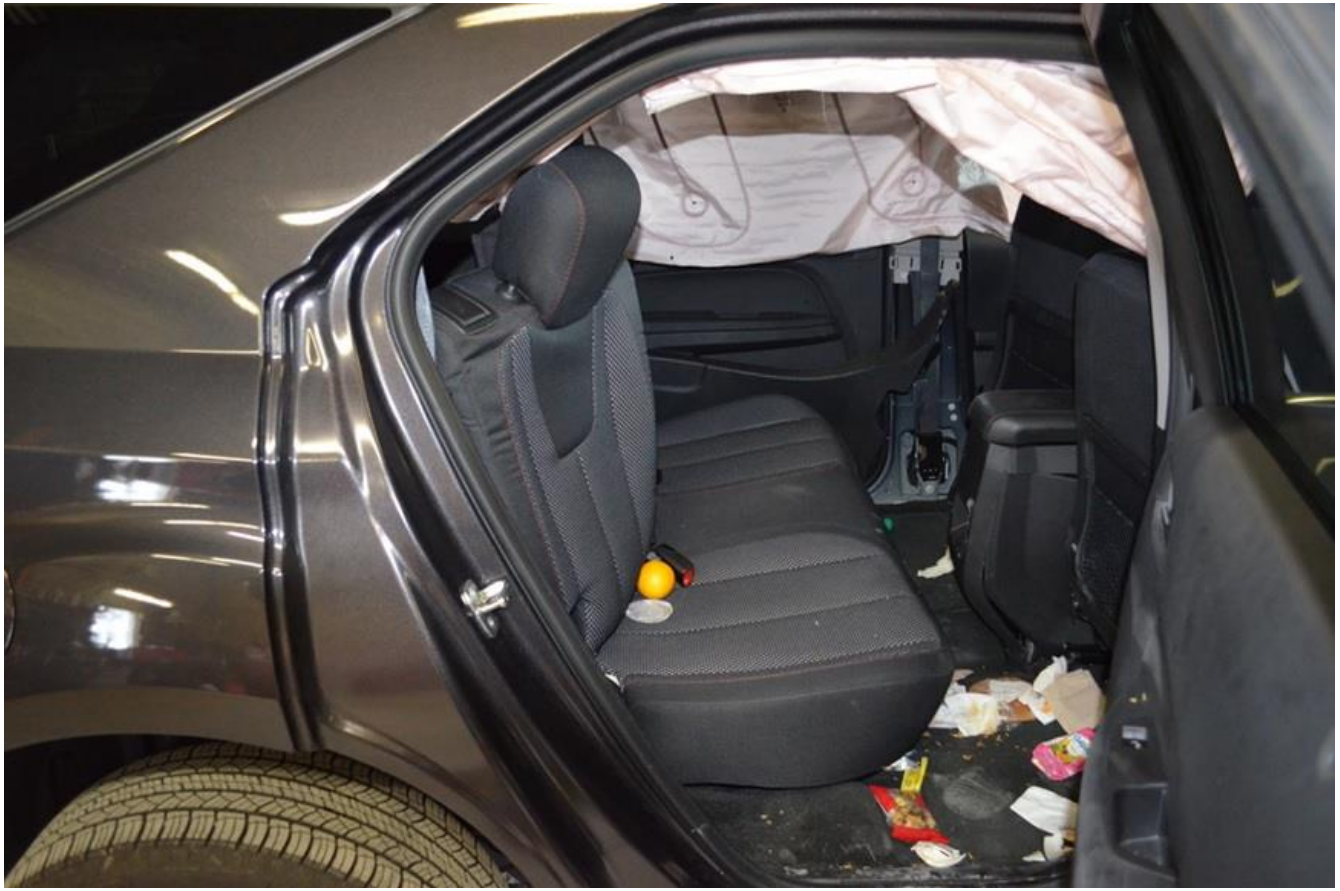



**→SEATBACK**

- Concussion **(AIS-2)**
- Nose bridge laceration **(AIS-1)**
- Right nose laceration **(AIS-1)**

# Discussion

***A closer look at the rear compartment…***



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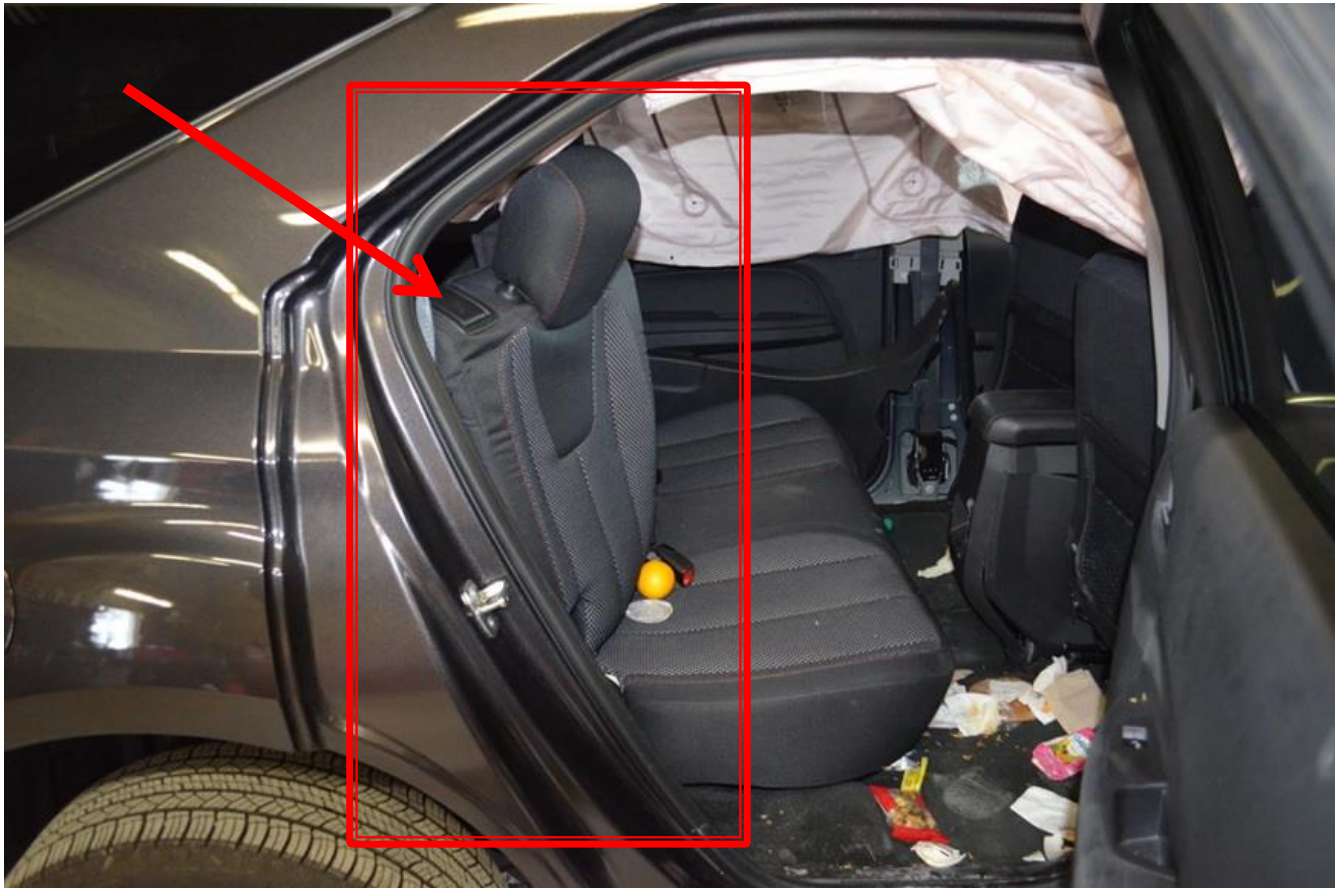
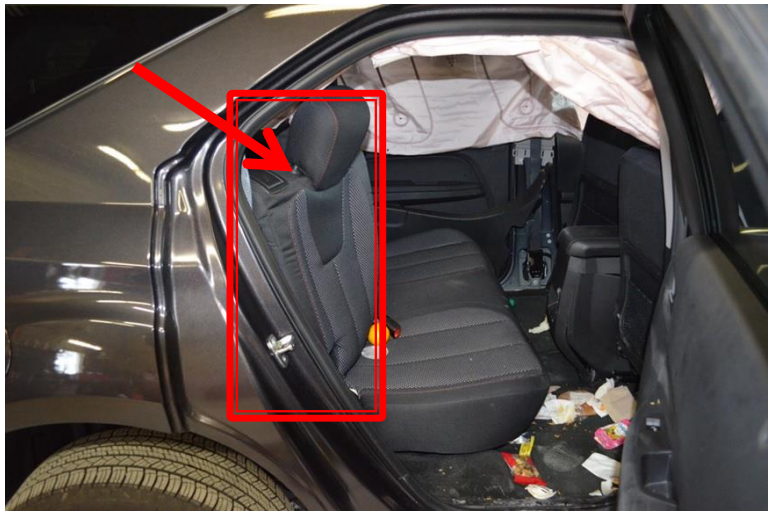


# Discussion

## ***A closer look at the rear compartment…***

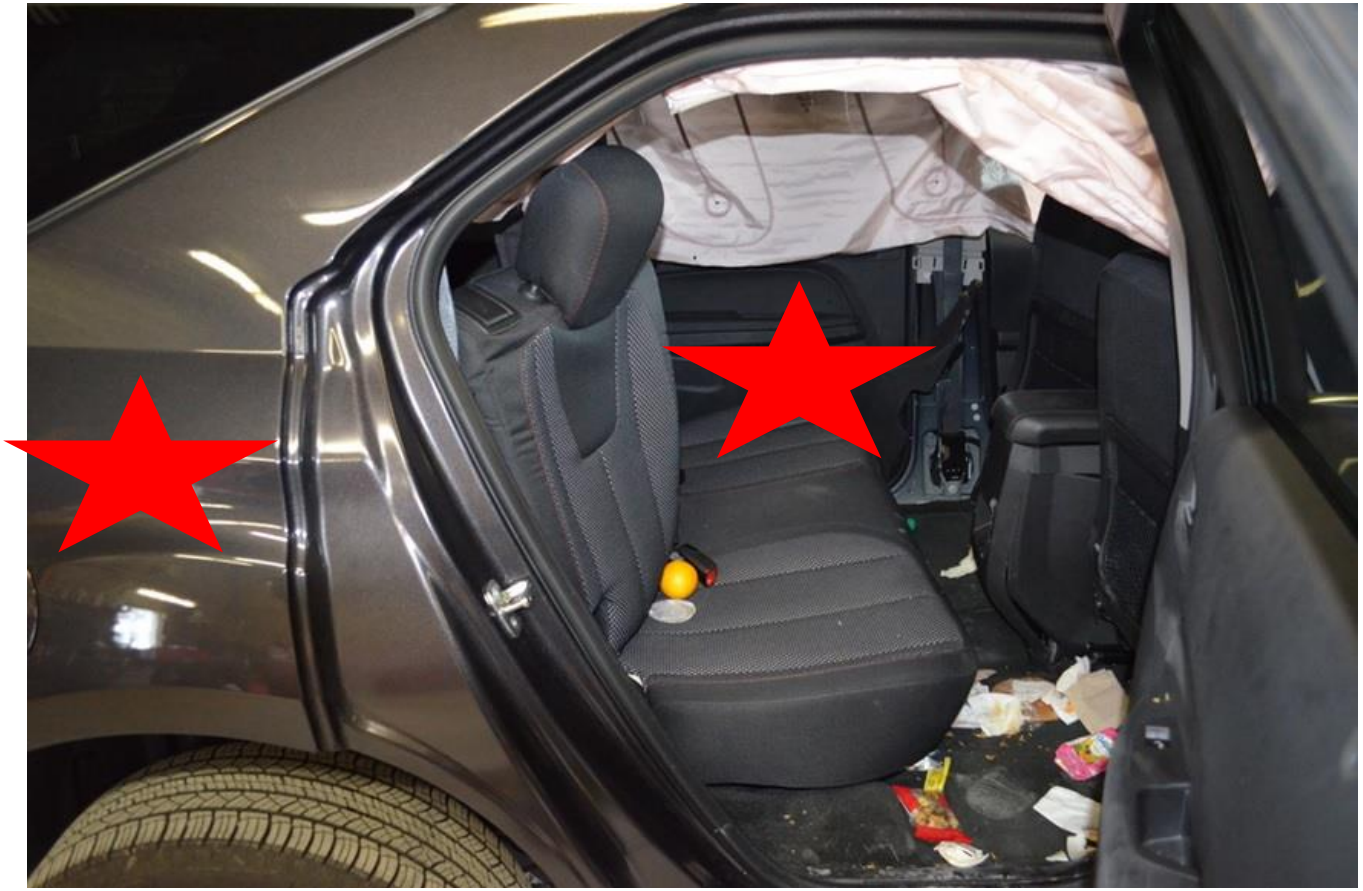


From Case Narrative:

"*Police indicated that there were a* ***large number of heavy duffle bags in the vehicle*** *at the time of the collision. These bags were removed prior to inspection. It is believed that they were originally situated in the rear cargo area and behind the driver on the left rear seatback which was folded down.*"

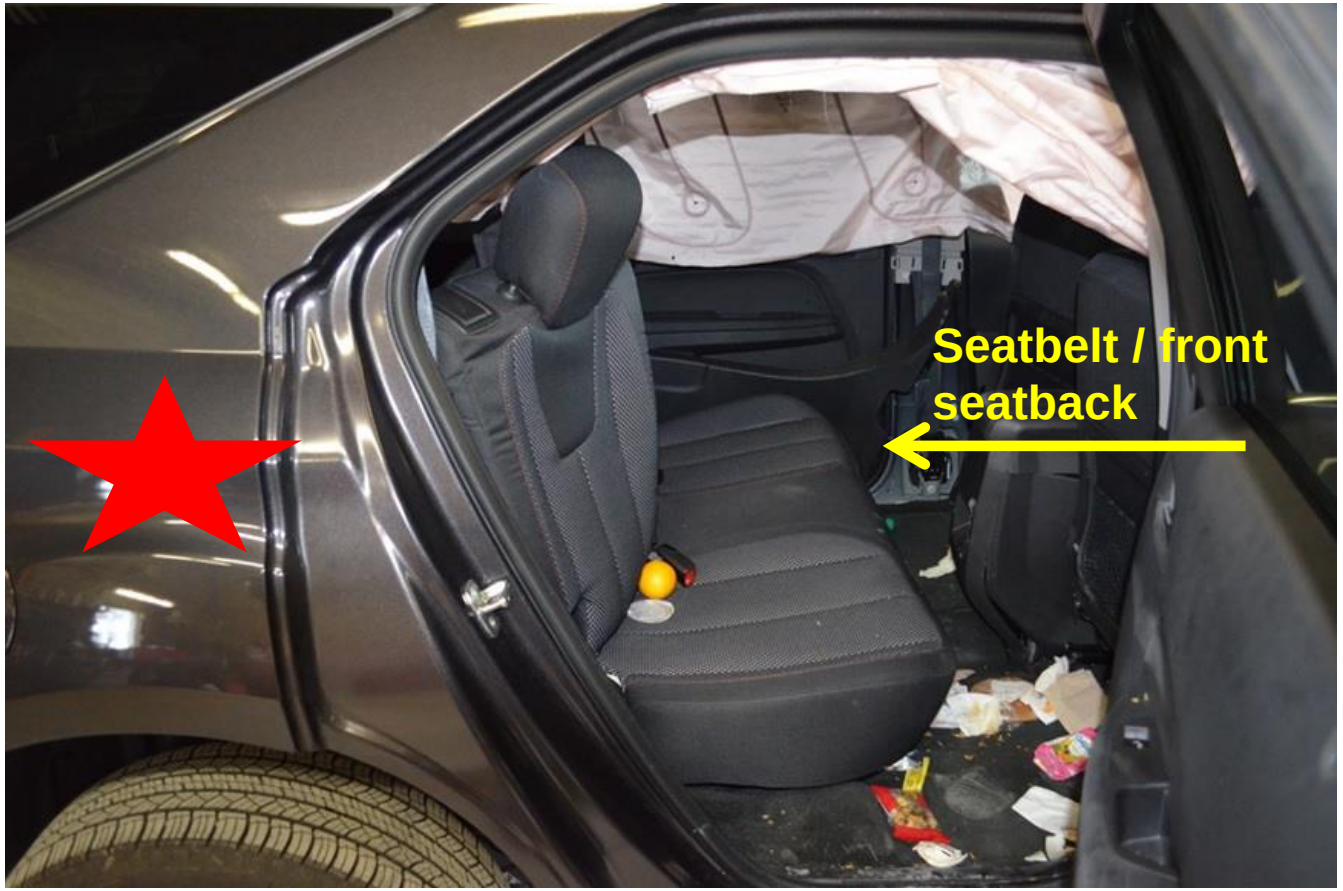
# Discussion

## Cargo contained within vehicle



# Discussion

## Cargo loading – another force to be considered



# Discussion

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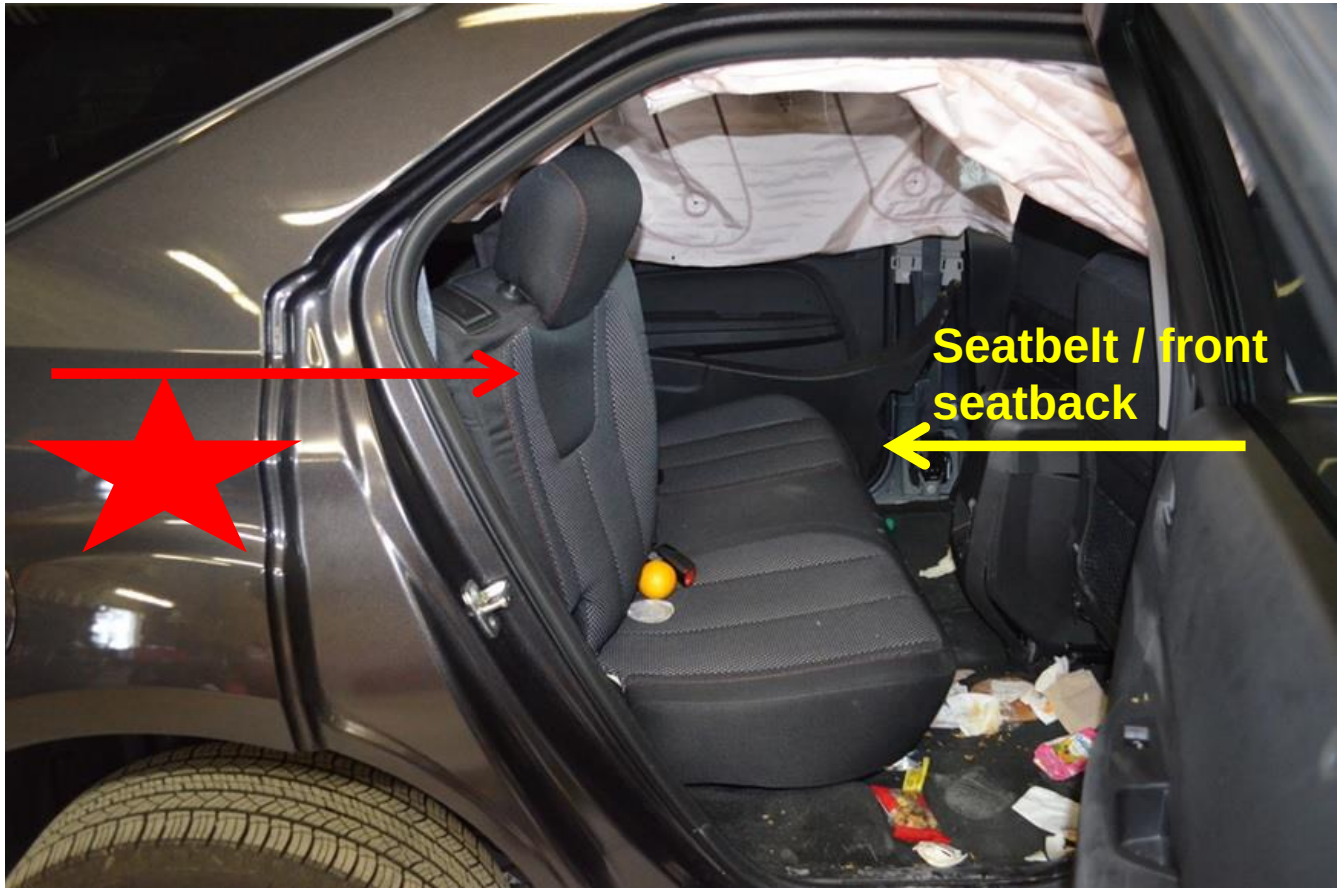
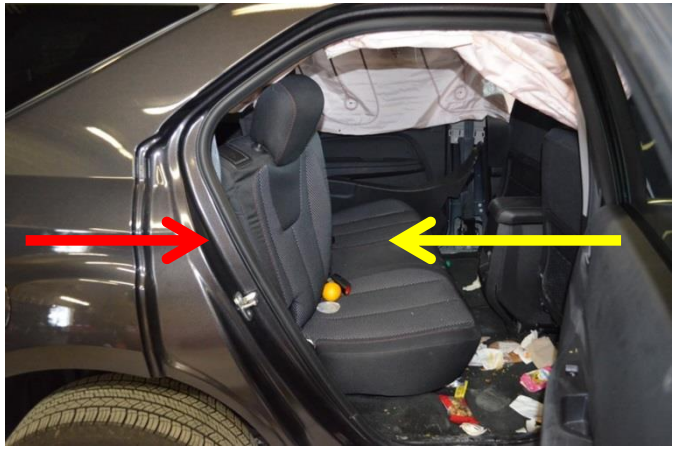


# Discussion

## Cargo loading – a contributor to occupant injuries



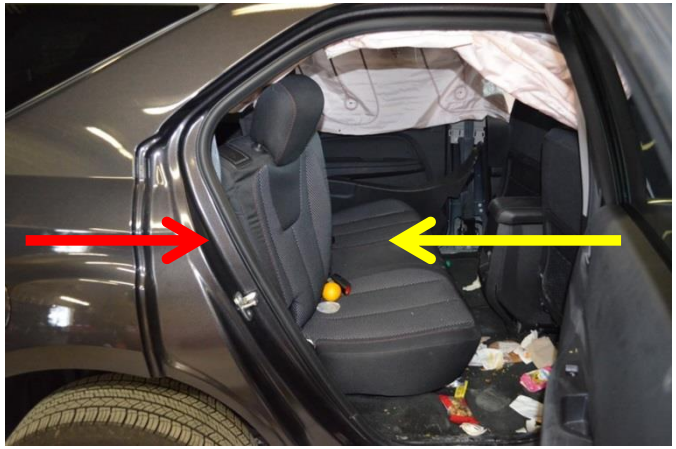
Seatbelt loading / front seatback contact

+

Cargo loading (rear seatback)

# Discussion

## Cargo loading – a contributor to occupant injuries



**Seatbelt loading**

+

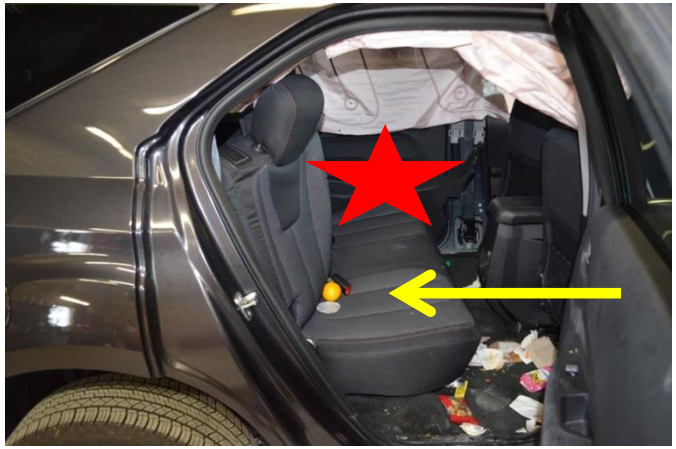
**Cargo loading (rear seatback)**

- Right rectus hematoma
**(AIS-2)**

- 3x small bowel perforations
**(AIS-2)**
- 3x colonic serosal tears
**(AIS-2)**
- Colonic full thickness perforation
**(AIS-2)**

# Discussion

## Cargo loading – a contributor to occupant injuries



**Front seatback contact**

+

**Cargo shifting (rear compartment)**

- Concussion
**(AIS-2)**
- Nose bridge laceration
**(AIS-1)**
- Right nose laceration
**(AIS-1)**

# Conclusions

→***Cargo shifting*** is a force to be considered in ***frontal collisions*** involving seatback loading

→Cargo shifting can increase severity of injuries to occupants from seatbelt/seatback

→**Rear occupant** sustained **injuries of increased severity** (vs. driver) despite **frontal collision** mechanism

# Conclusions

→***Cargo shifting*** is a force to be considered in ***frontal collisions*** involving seatback loading

→Cargo shifting can increase severity of injuries to occupants from seatbelt/seatback

→**Rear occupant** sustained **injuries of increased severity** (vs. driver) despite **frontal collision** mechanism

***Presence/location of cargo in vehicle should be considered in the investigation of frontal collisions involving seatback loading.***

# Questions?