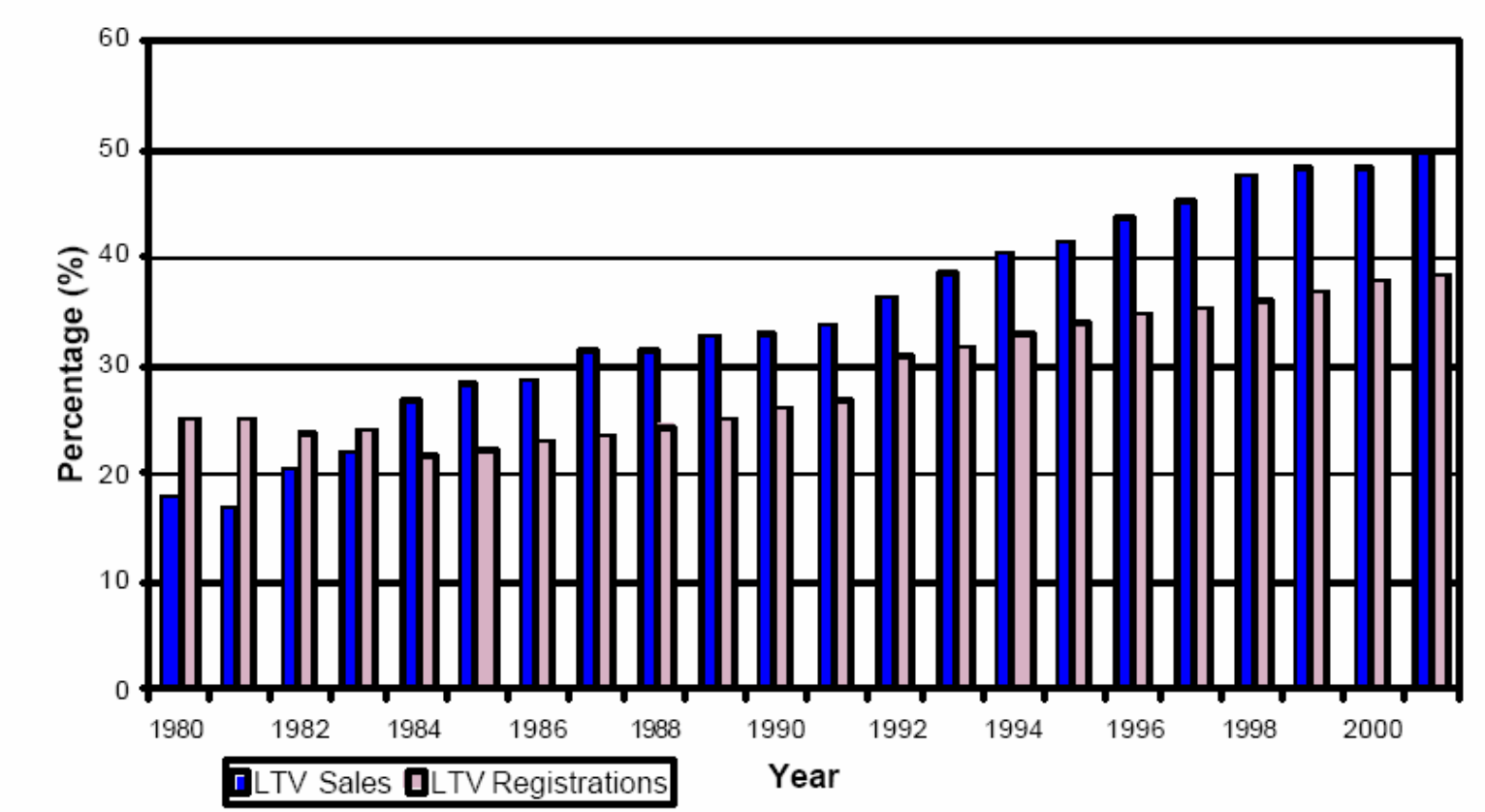
Evaluating Incompatibility in Side Impacts

Seattle CIREN Team – Mock, Kaufman

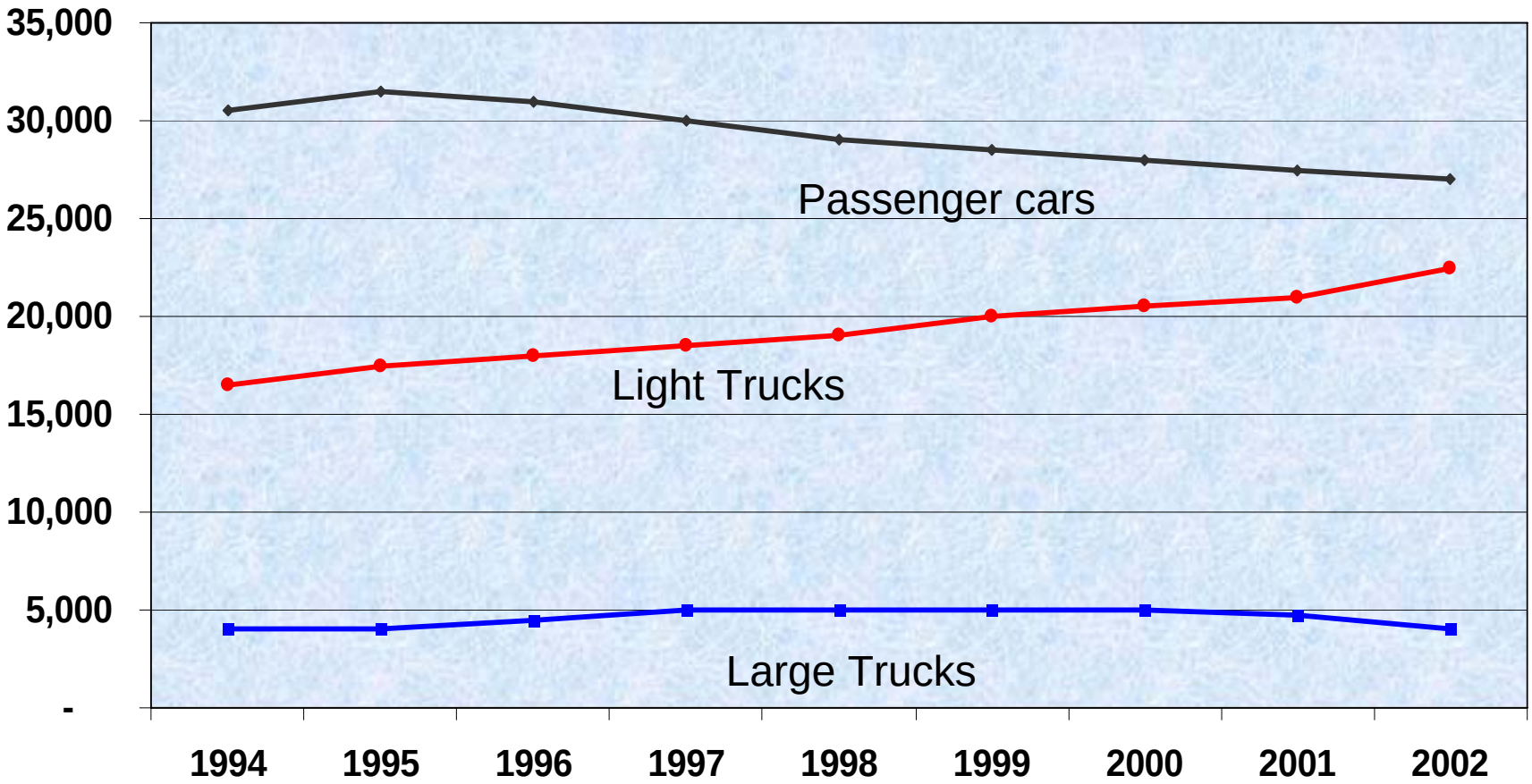
University of Washington

HARBORVIEW
INJURY PREVENTION
& RESEARCH CENTER

Increasing LTV Sales/Registrations



NHTSA's Research Program For Vehicle Aggressivity and Fleet Compatibility - Hollowell, Summers, Prasad.

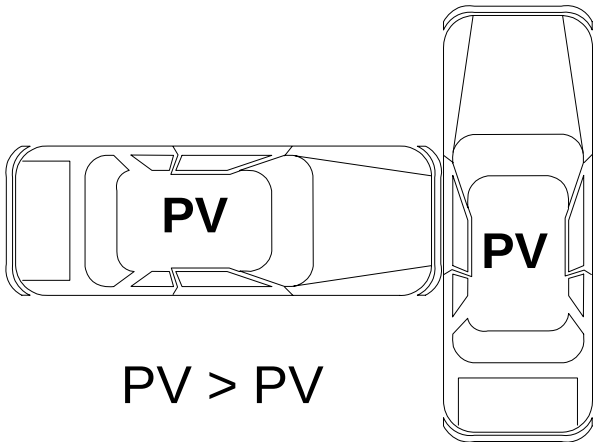


Number and type of vehicles involved in all motor vehicle traffic deaths

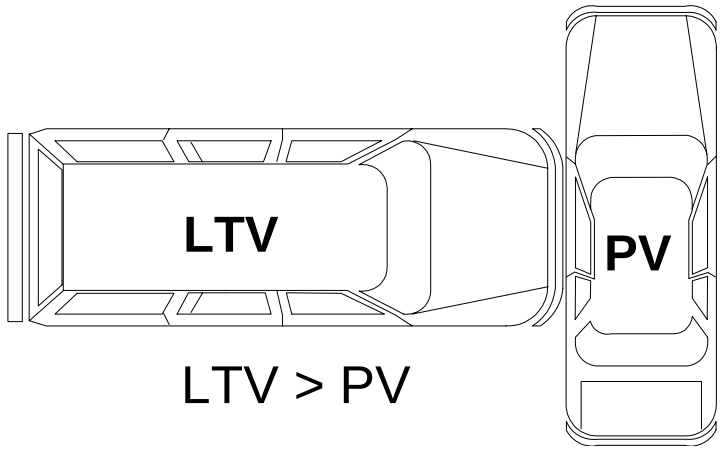
Traffic Safety Facts

Side Impact Groups

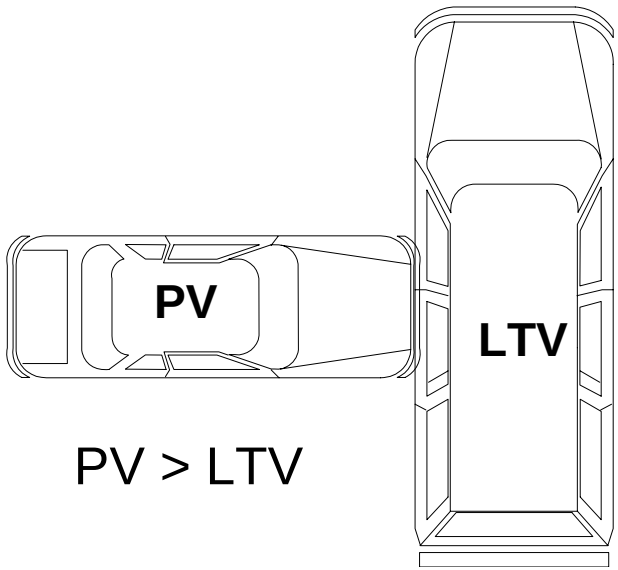
Passenger Vehicle - PV
Light Truck Vehicle - LTV



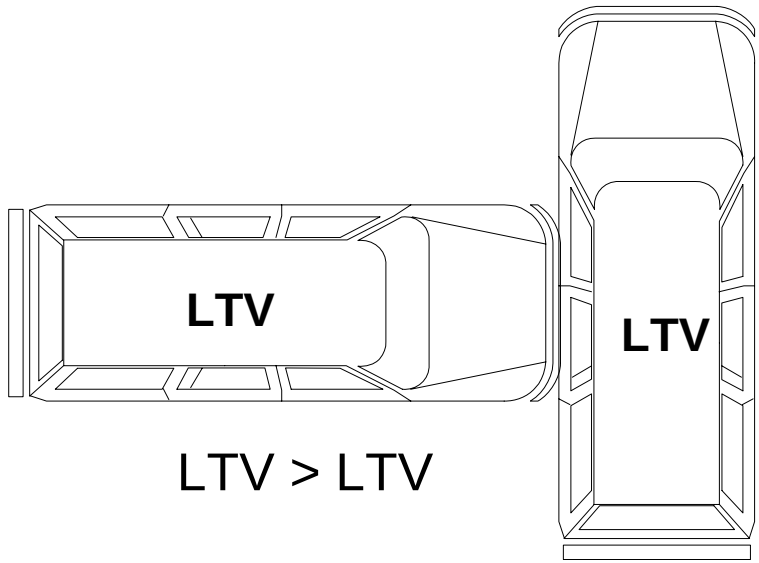
PV > PV



LTV > PV



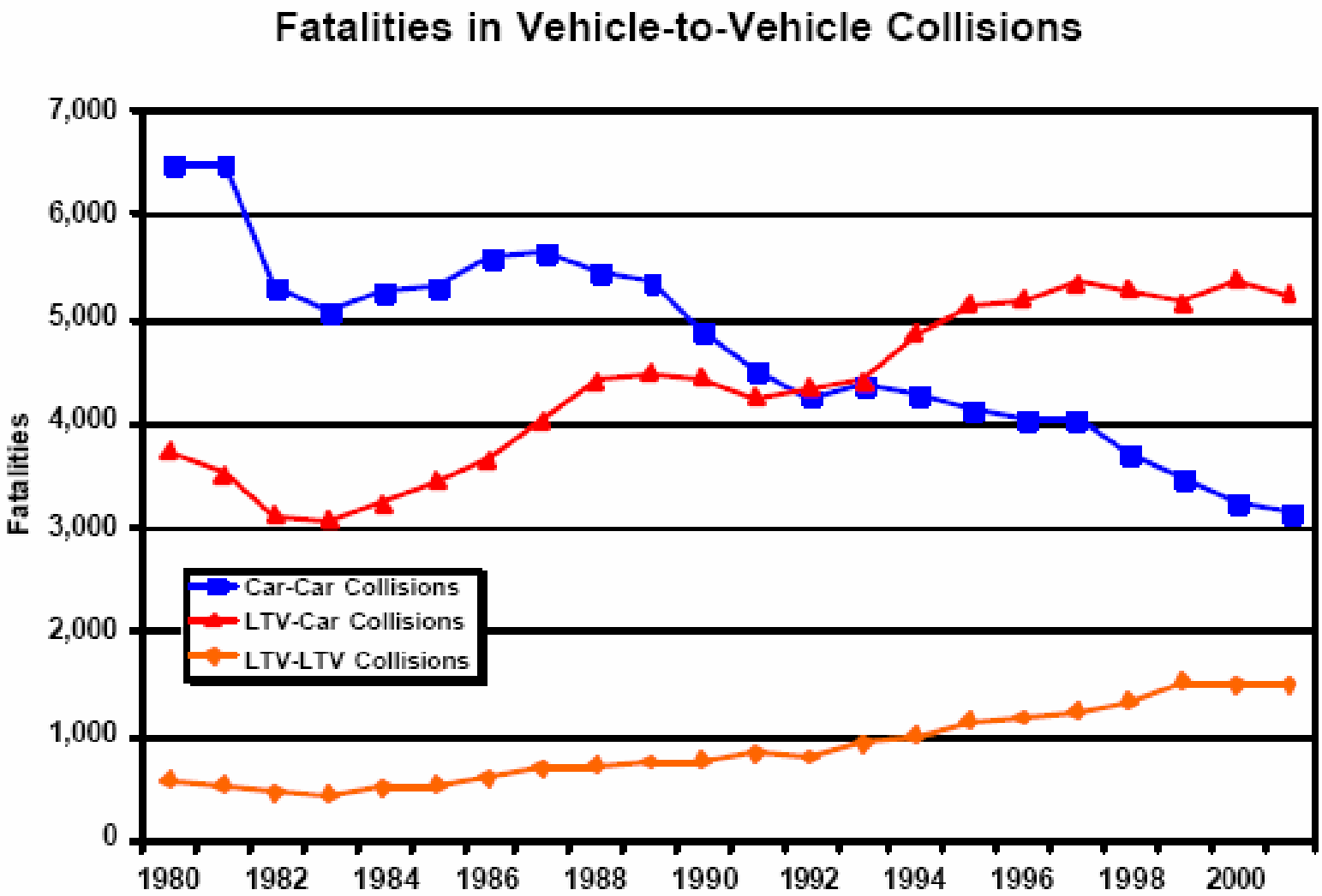
PV > LTV



LTV > LTV

Increasing LTV-PV Fatalities

NHTSA research paper#307-Summers, Hollowell, Prasad

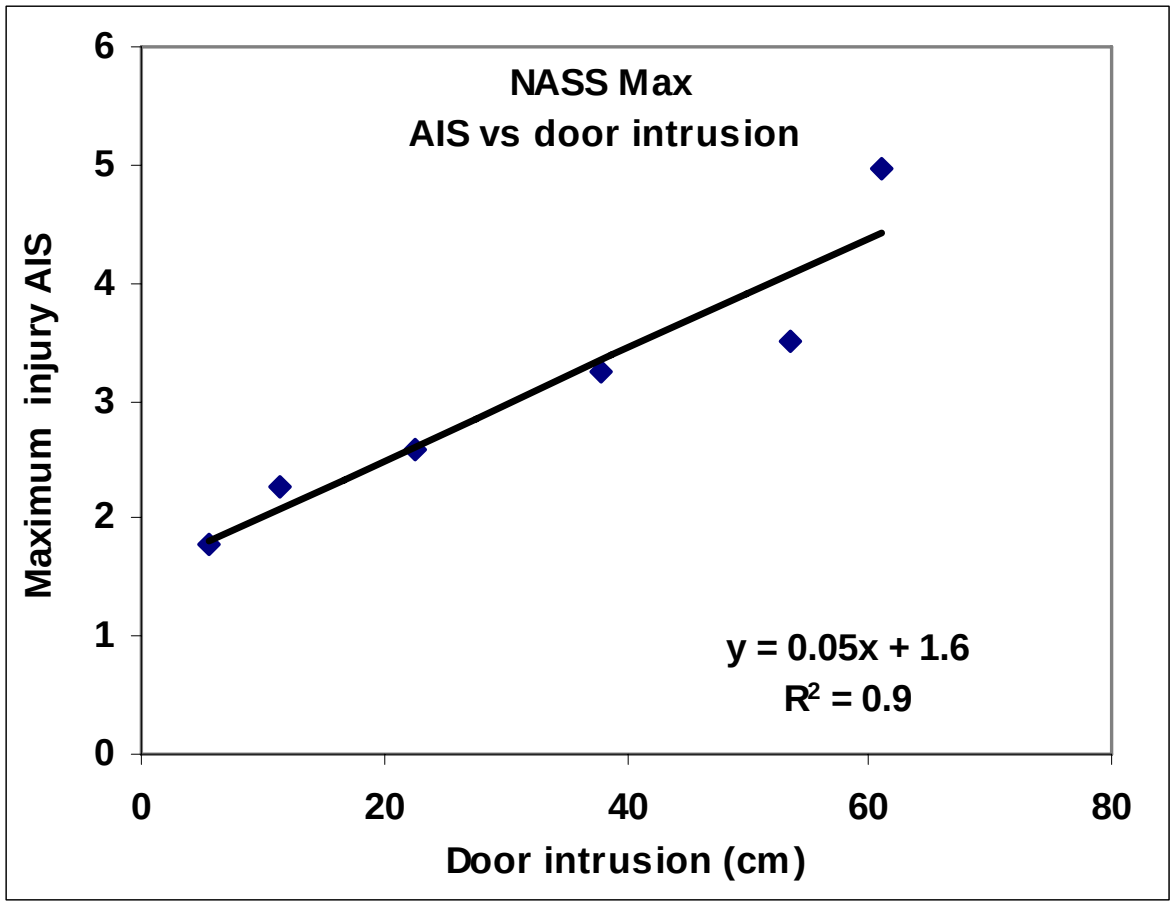


Mismatch/Front to Side Impact Estimated National Estimates (all rows)

	Weighted Frequency	%
PV > PV	1,165,783	62.8
LTV > PV	401,539	21.3
PV > LTV	191,875	10.7
LTV> LTV	89,670	4.9
OTHER/UNK		0.13
TOTAL	1,853,268	100%

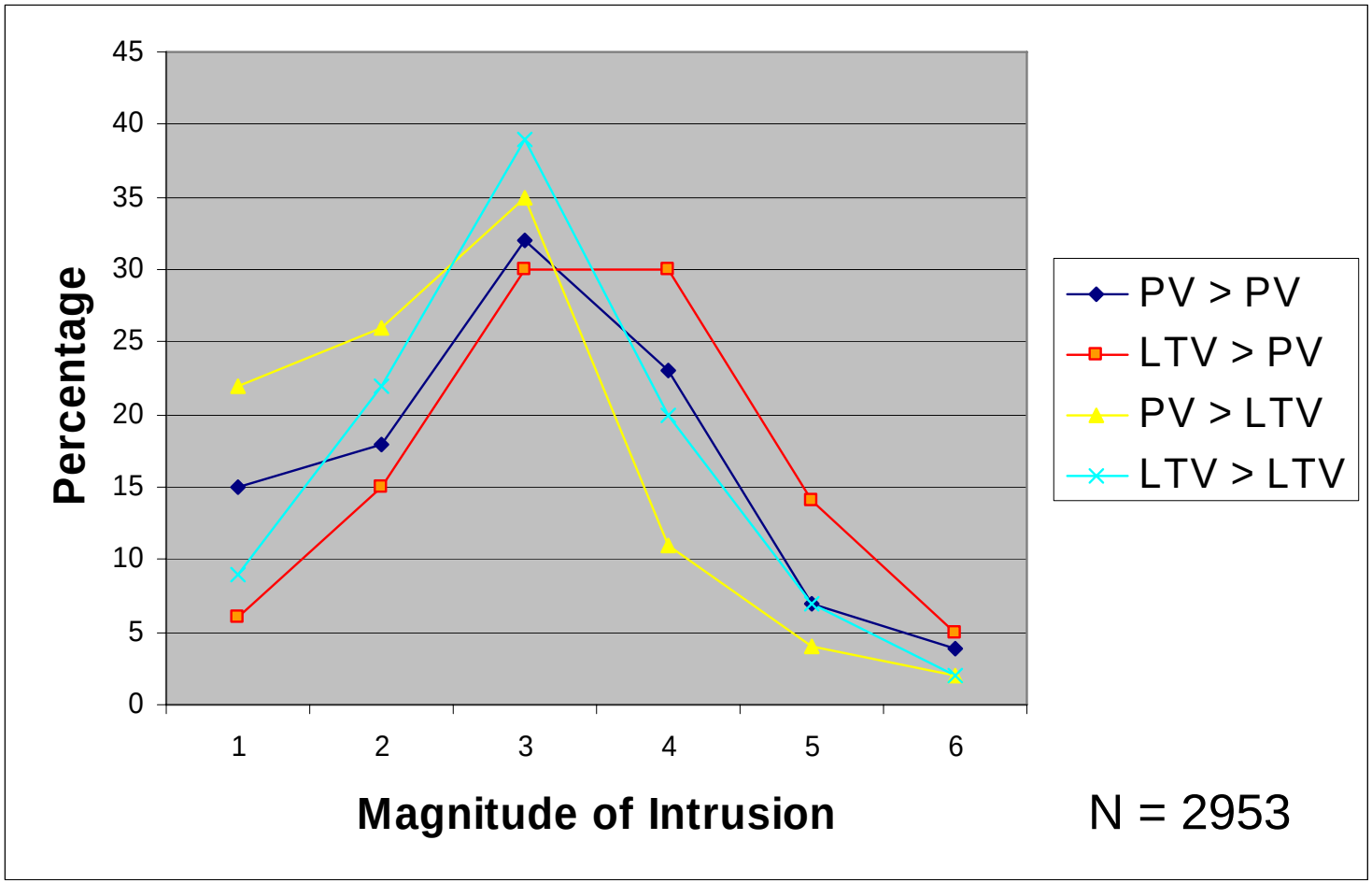
NASS/CDS 1993-2004 Freq.

NASS MAIS v Door Intrusion
All Crash Types



MAIS for Thorax, Abdomen, Pelvis

Side Impact Groups
Intrusion in front seat positions



Magnitude

1=3>8cm

2=8>15cm

3=15>30cm

4=30>45cm

5=46>60cm

6 > 61cm

Side Impact Group Injuries (Front Rows)

% of AIS 2 or greater injuries per group

Type crash	% Head AIS 2+	% Thorax AIS 2+	% Pelvis AIS 2+	%Abdomen AIS 2+
PV > PV	14	16	13	9
LTV > PV	**26**	**26**	**19**	**15**
PV > LTV	10	7	4	3
LTV > LTV	23	13	10	9
Other/Unk.	26	11		16

N = 4958

Side Impact Groups - Mean Max AIS

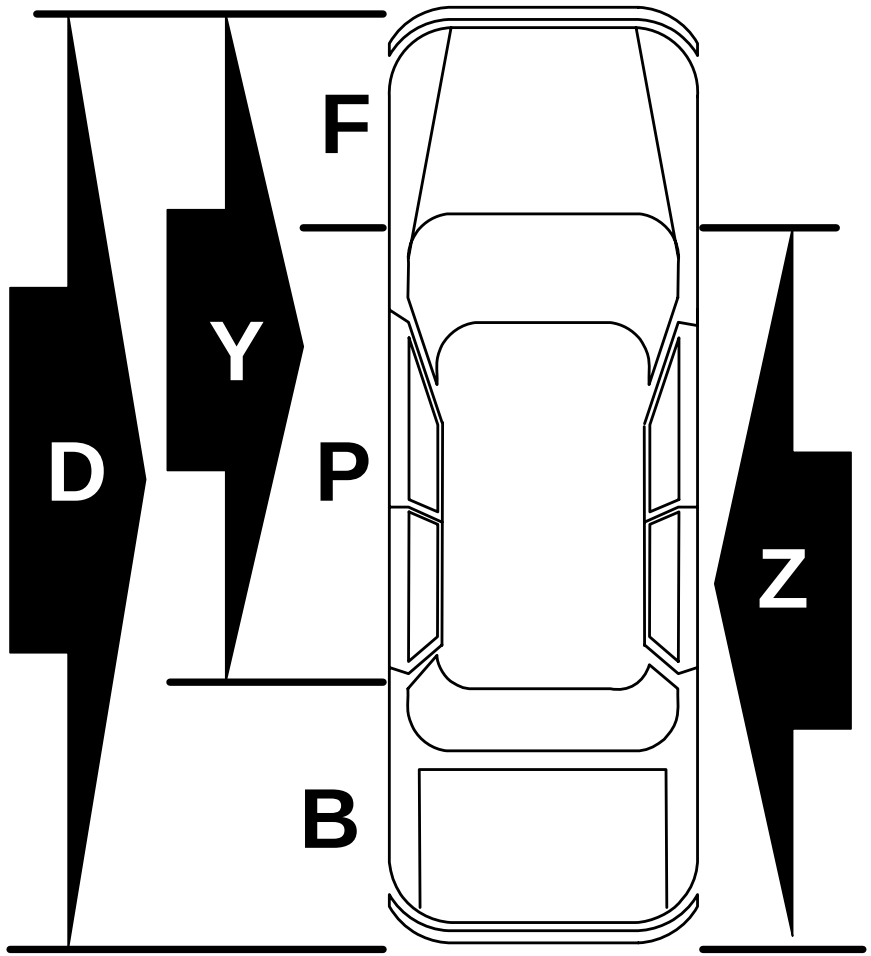
	Max Mean AIS
PV > PV	1.52
LTV > PV	**2.16**
PV > LTV	1.14
LTV > LTV	1.54
Unknown/other	1.58

N = 4958

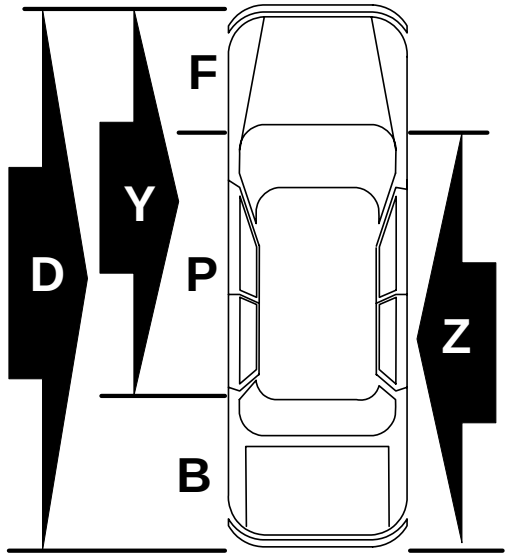
Side Impact Collision Deformation Classification (CDC)

Longitudinal Locations

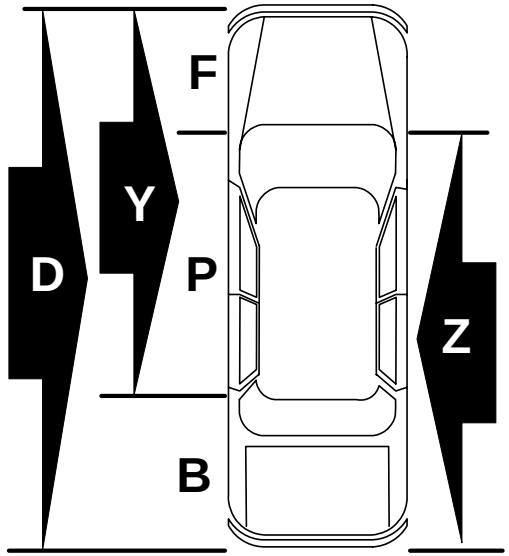
For both Left or Right side



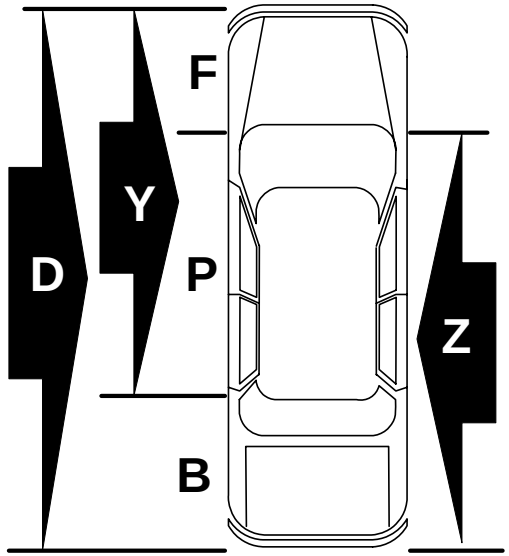
P - ZONE



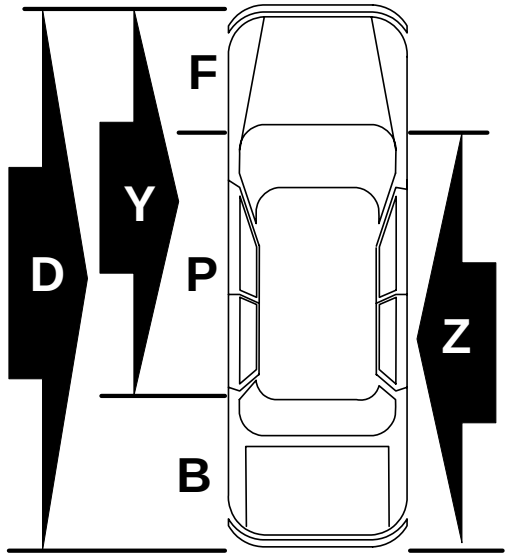
P - ZONE



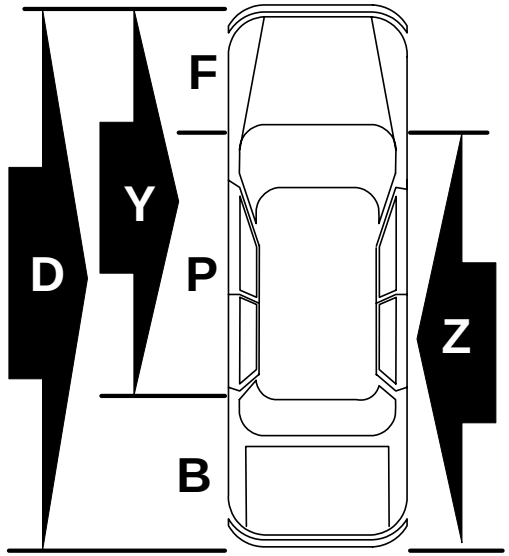
Y - ZONE



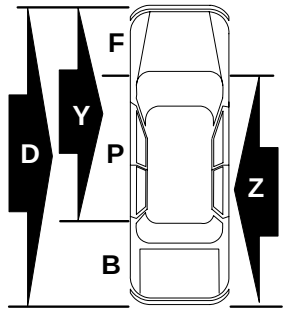
D - ZONE



Z - ZONE



Weighted Freq. by Impact zone

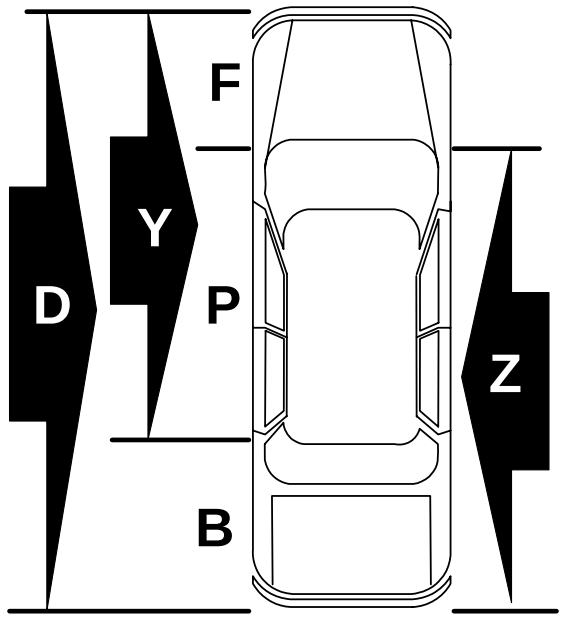


	PV->PV	LTV->PV	PV->LTV	LTV->LTV
B	7%	2%	10%	7%
D	3%	4%	4%	11%
F	35%	24%	19%	18%
P	10%	13%	11%	4%
Y	**29%**	**37%**	**35%**	**47%**
Z	15%	20%	21%	13%
Total Weighted	1053326	351450	176874	82132

NASS/CDS 1993-2004

Side Impact Groups –Front Row
% AIS 2+ Head injury per location

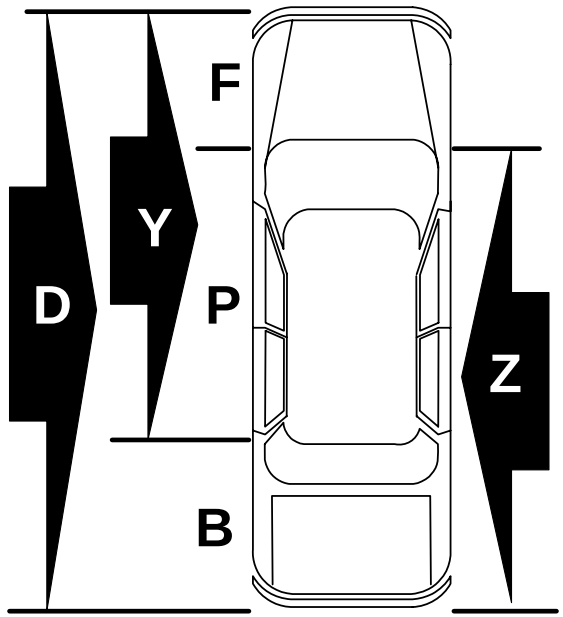
	B	**D**	**F**	**P**	**Y**	**Z**
PV > PV	6	22	6	9	18	17
LTV > PV	6	**40**	9	**22**	**28**	**27**
PV > LTV	0	20	8	9	11	11
LTV > LTV	8	35	7	19	**27**	16



NASS/CDS 1993-2004

Side Impact Groups – Front Row
% AIS 2+ Thorax injury per location

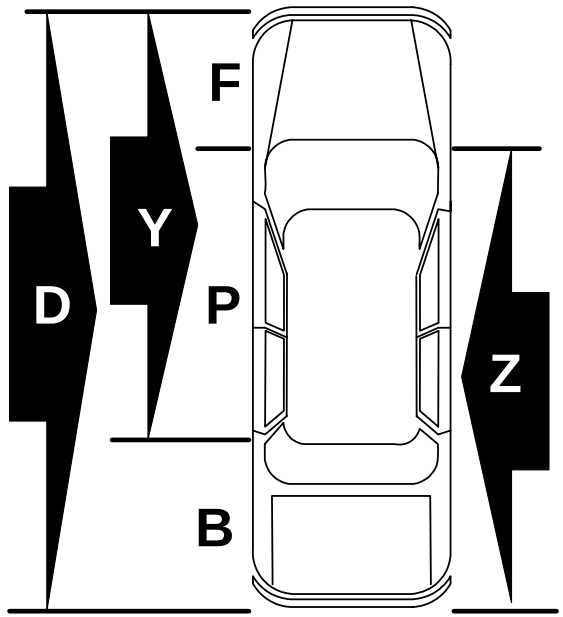
	B	**D**	**F**	**P**	**Y**	**Z**
PV > PV	2	**34**	2	17	18	17
LTV > PV	12	**37**	3	**37**	**29**	**25**
PV > LTV	3	9	7	1	11	6
LTV > LTV	7	**28**	0	13	13	7



NASS/CDS 1993-2004

Side Impact Groups – Front Row
% AIS 2+ Pelvis injury per location

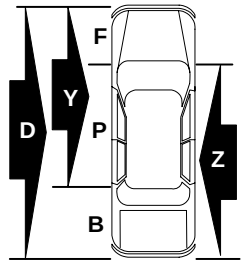
	B	**D**	**F**	**P**	**Y**	**Z**
PV > PV	0	**28**	1	13	19	9
LTV > PV	0	**32**	1	**29**	**23**	**11**
PV > LTV	0	14	0	0	8	2
LTV > LTV	0	**21**	0	0	14	7



NASS/CDS 1993-2004

Mean Max AIS by Impact zone

Front row seat positions



			PV->PV	LTV->PV	PV->LTV	LTV->LTV
B	**Max AIS**	**Mean**	0.75	0.69	0.61	1.17
D	**Max AIS**	**Mean**	2.40	**3.01**	1.67	2.23
F	**Max AIS**	**Mean**	0.85	1.10	0.86	0.76
P	**Max AIS**	**Mean**	1.65	**2.52**	1.02	1.44
Y	**Max AIS**	**Mean**	1.81	**2.43**	1.43	1.59
Z	**Max AIS**	**Mean**	1.68	**2.08**	1.25	1.32
Total			2488	1090	485	254

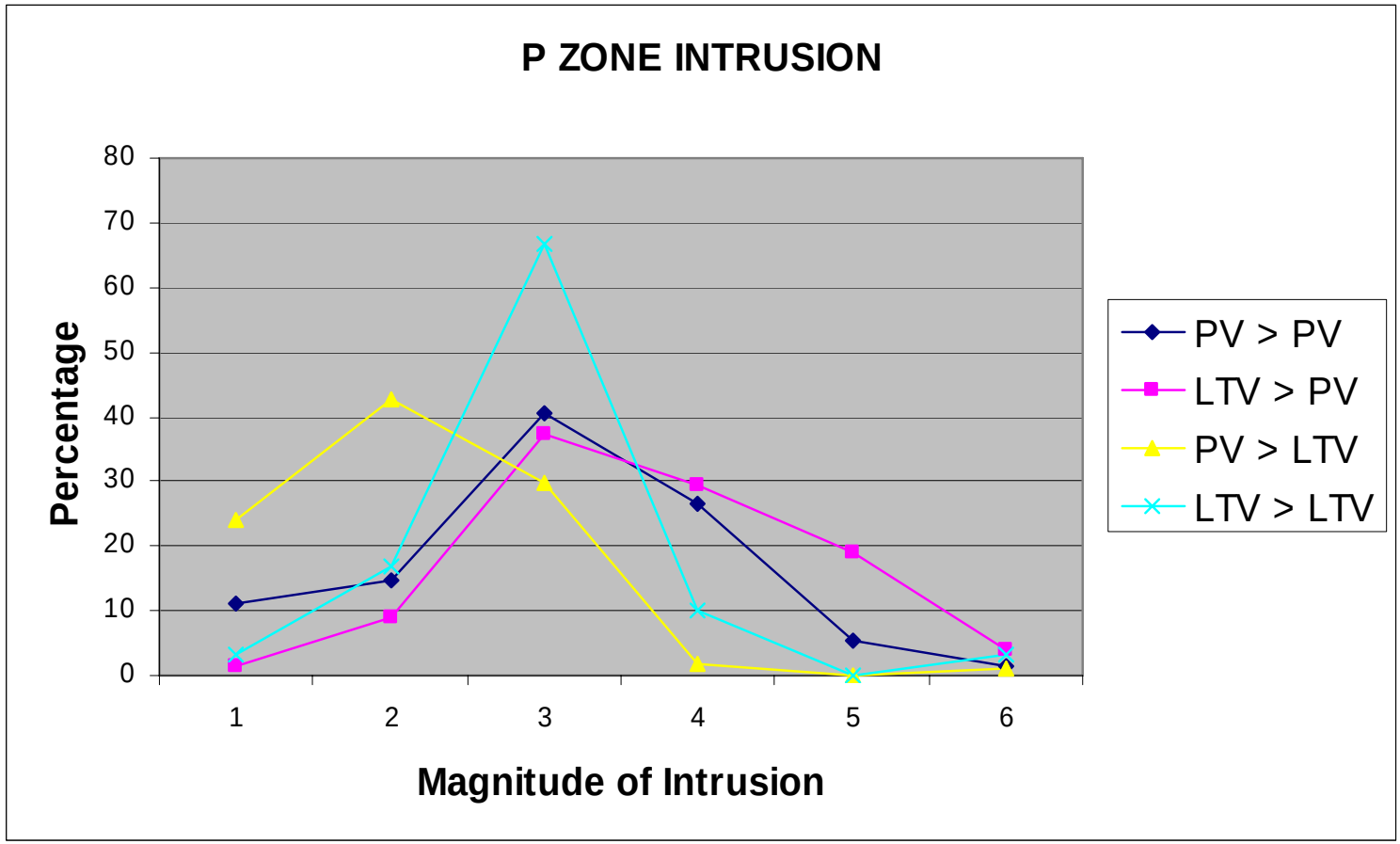
NASS/CDS 1993-2004

Occupant Role

	OCCUPANT'S ROLE	
	Driver	Passenger
	%	%
Vehicle-to-Vehicle Collision Type		
PV->PV	73.2	26.8
LTV->PV	73.0	27.0
PV->LTV	74.8	25.2
LTV->LTV	72.3	27.7
Other/Unknown	78.9	21.1

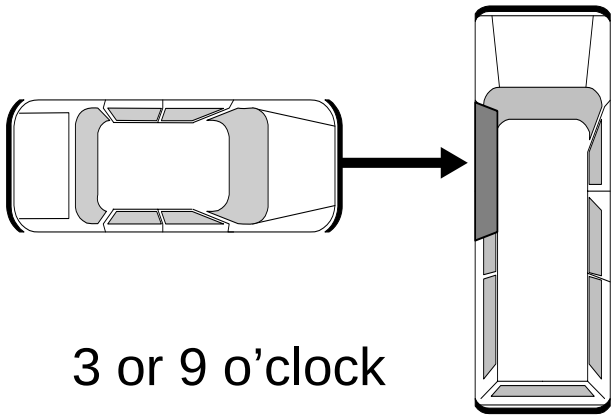
NASS/CDS 1993-2004

% Magnitude of Intrusion
P zone - side impact groups

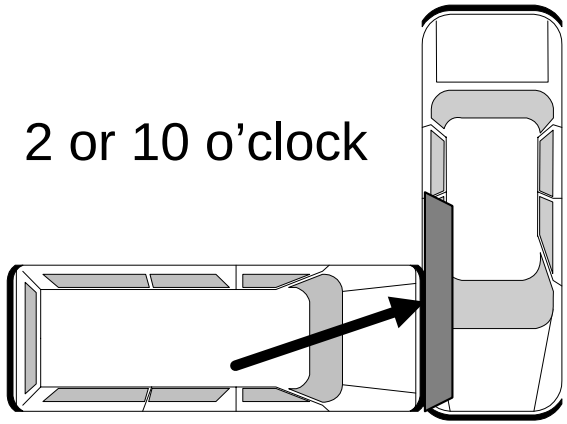


Exterior Damage Assessment

Side impact damage reflect the principal direction of force (PDOF)



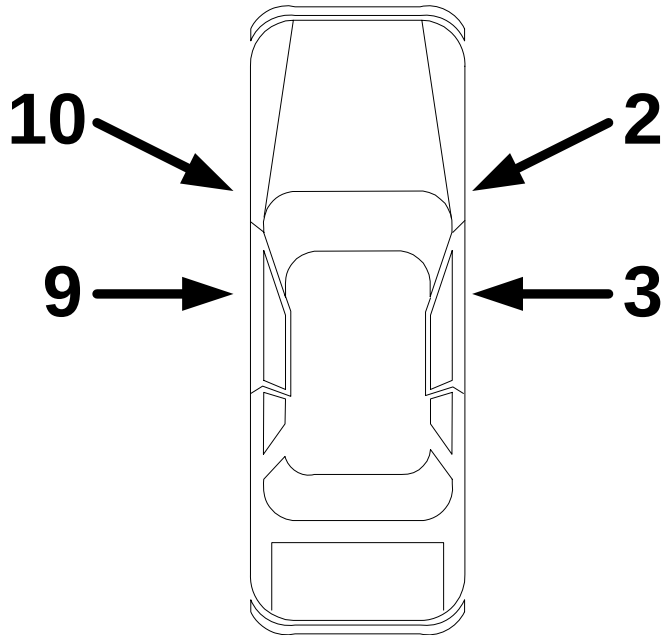
3 or 9 o’clock



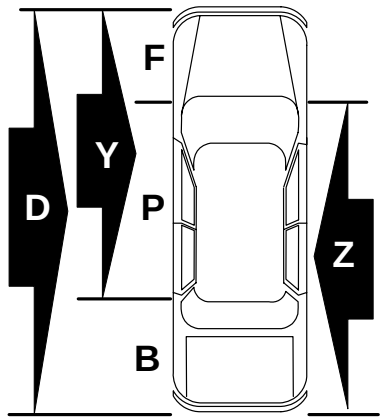
2 or 10 o’clock

Principal Direction of Force - PDOF

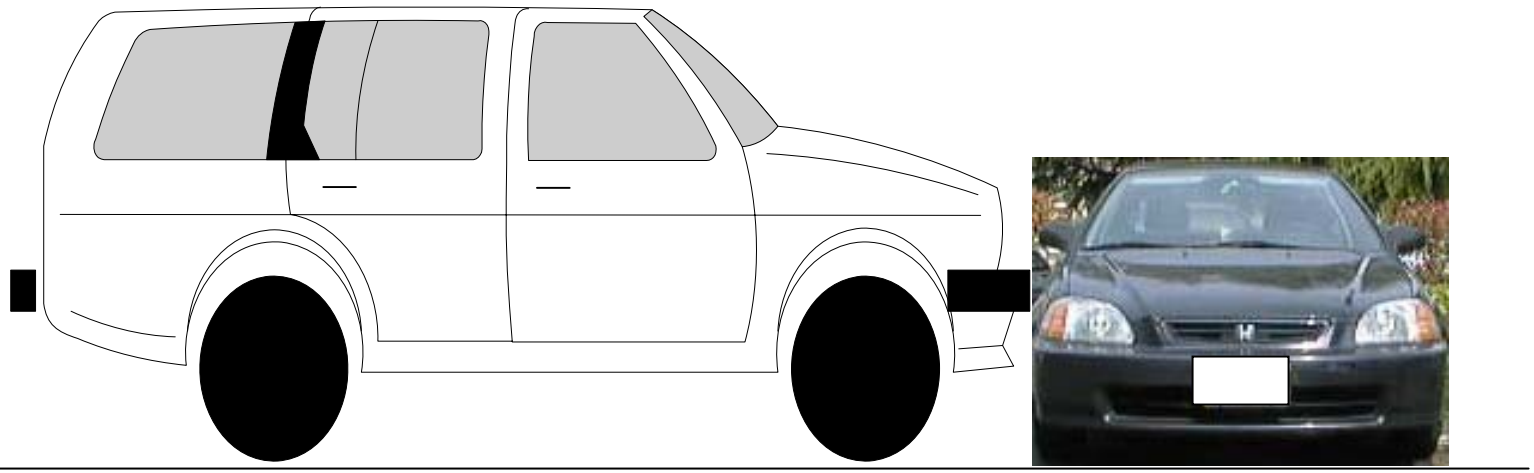
- In all the side impact groups 10 and 2 o’clock occurred twice that of 9 and 3 o’clock.
- The PDOF’s were evenly distributed among all the side impact zones in each side impact group.



PV > PV
LTV > PV
PV > LTV
LTV > LTV

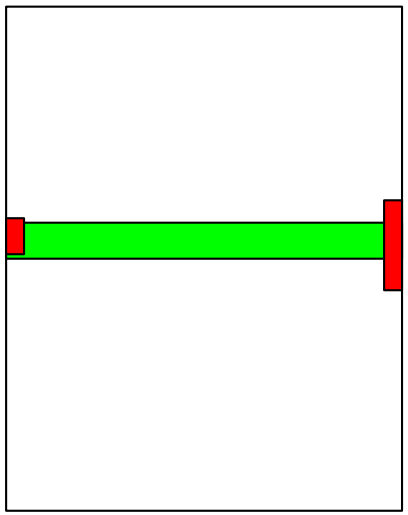


LTV > PV - Side Impacts

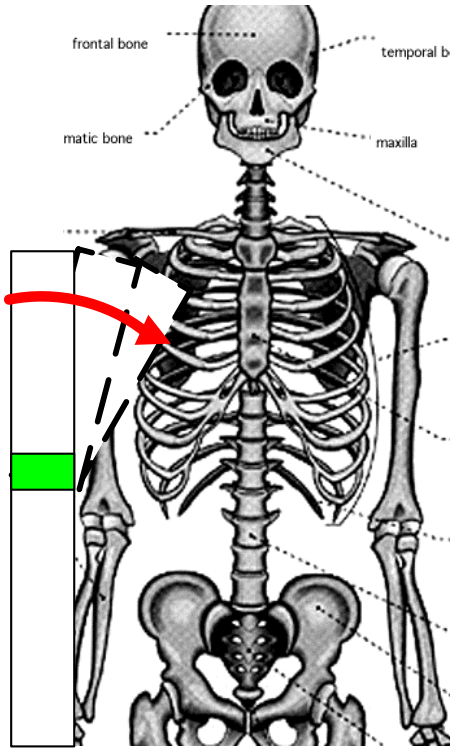


Some LTV bumper frame heights are overriding the lateral side impact support beams

Side impacts with LTV's impact above lateral door support beams



Side View



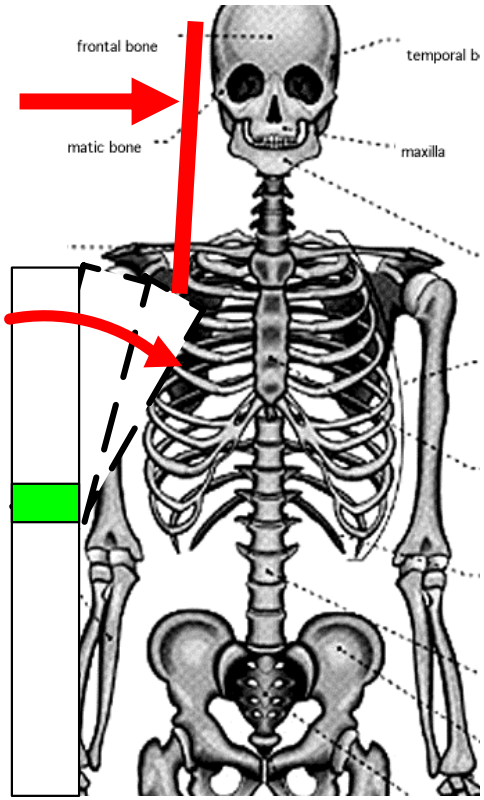
End View

Upper door panel intrusion

Side Impact – LTV > PV

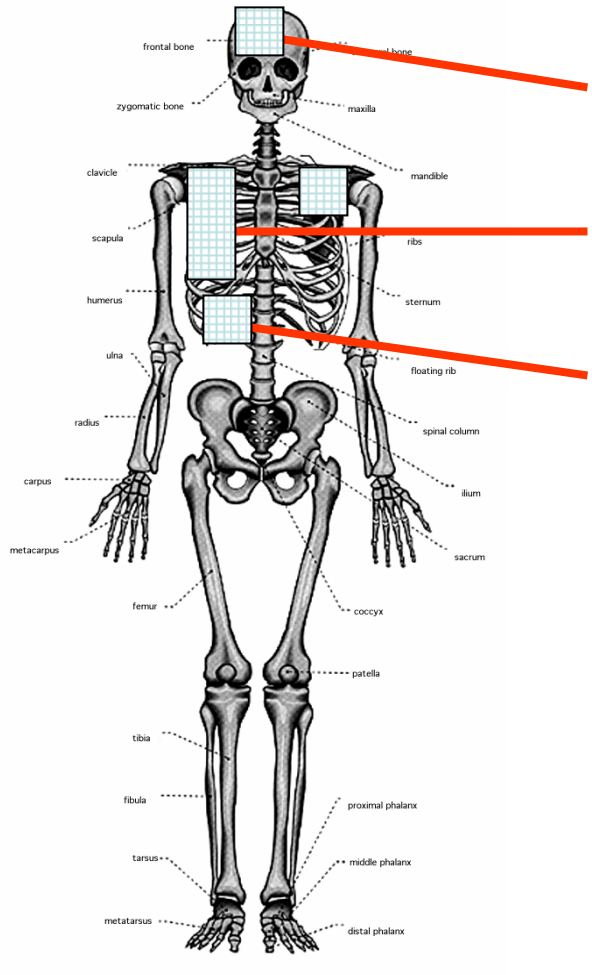
- Front Seat Passenger
- Elderly, Male
- Lap/Shoulder belt
- Compact sedan struck by a LTV (large pickup)

Upper door panel intrusion Case review



End View

Injuries

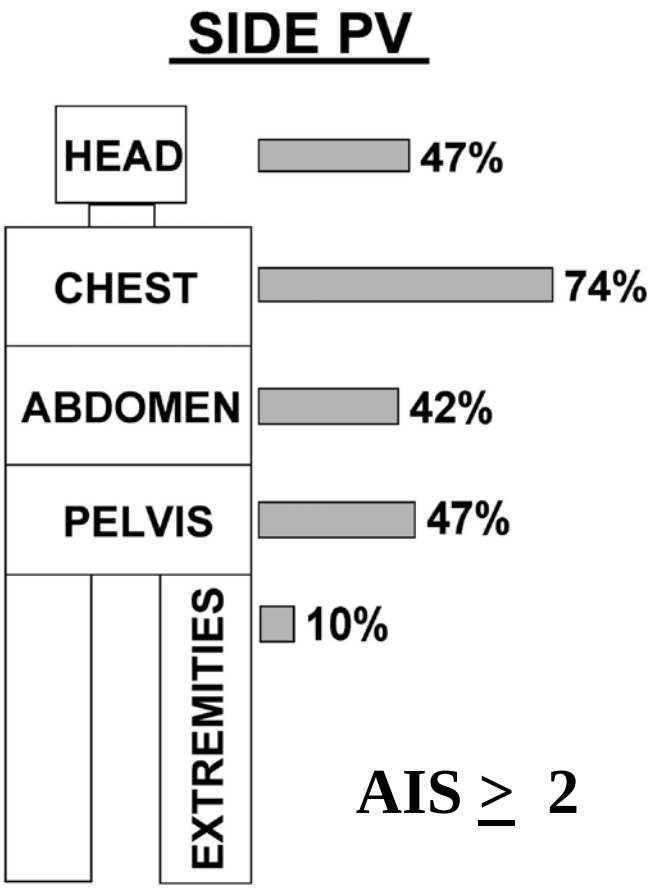


Head – Serious Injury

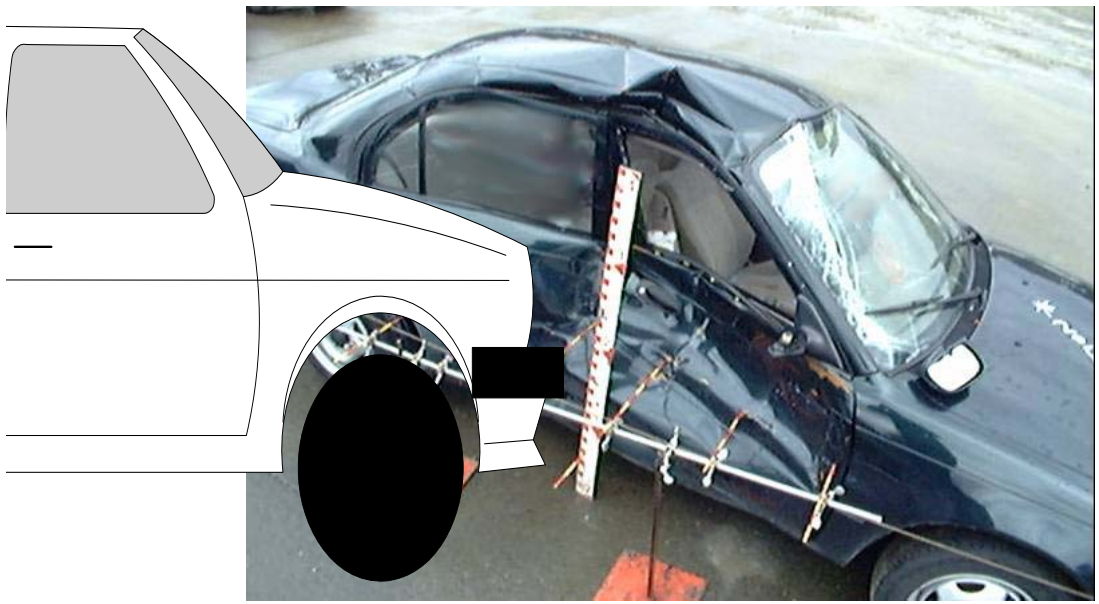
Chest – Severe Injury

Abdomen – Moderate Injury

CIREN Data Summary



LTV Front into Side Passenger Vehicle



Acierno S, Kaufman R, Mock C, Rivara F, Grossman D. Vehicle mismatch: Injury patterns and severity. Accident Analysis and Prevention 39 (2004) 761-772.

Side impact crash test
LTV > PV

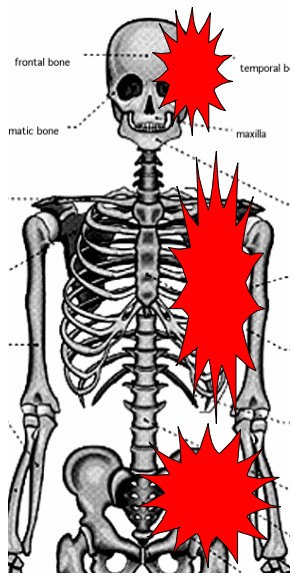
Front of LTV hood and grill into window area at time of impact creating potential direct contact with the occupant’s head

LTV > PV

Head = AIS 5 (critical)

Chest = AIS 4 (severe)

Pelvis = AIS 4 (severe)



Interior view

Chest contact

Pelvis contact

Raised center console

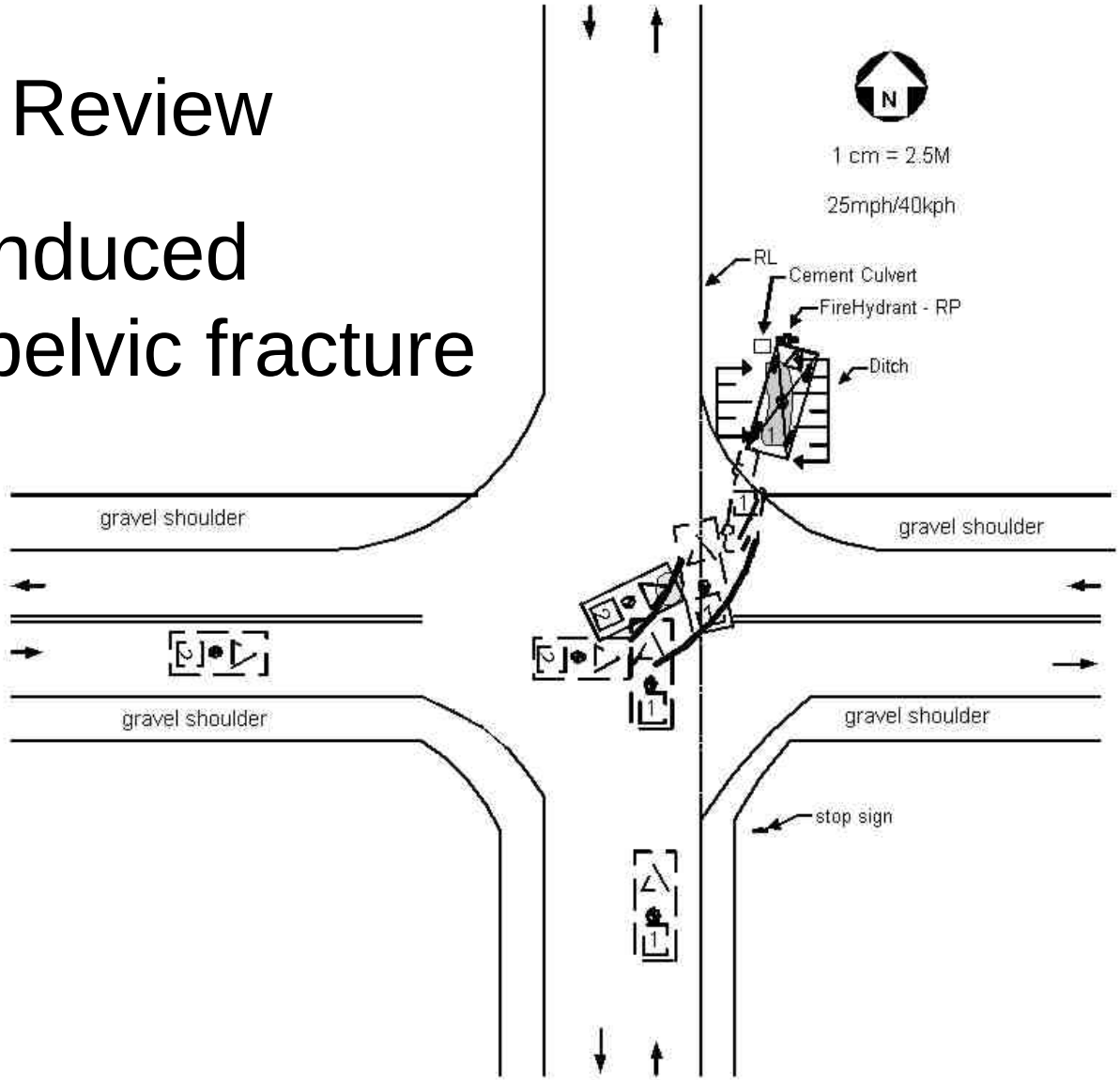
Lower lateral door intrusion associated with pelvic fractures

Moderate Pelvic Fracture

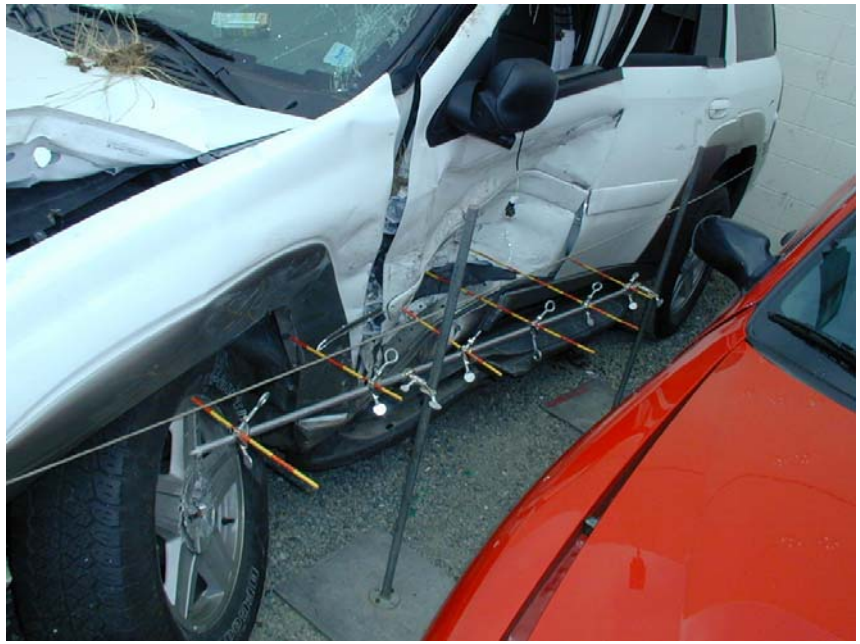
No center console

CIREN Case Review

Side impact induced rollover with pelvic fracture



Side Impact – 10 o’clock Y zone
Low door impact – induced rollover



Light Truck Vehicle

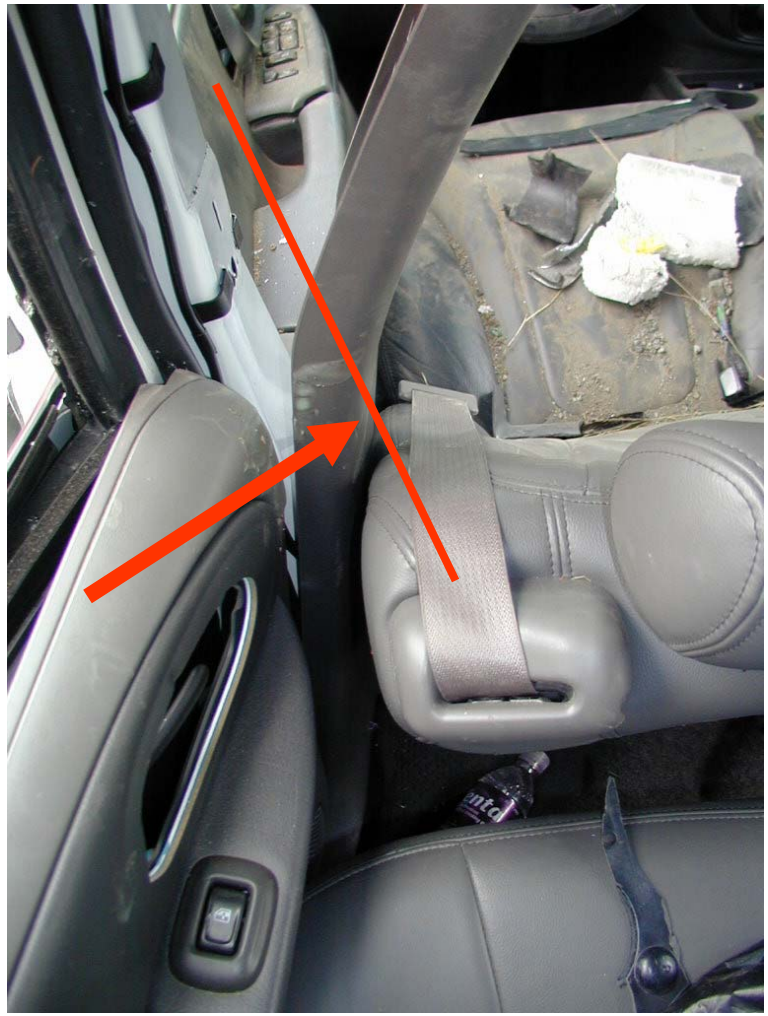
Moderate Side impact w/rollover

40’s yr. – Female – Lap/shoulder restrained, no air bag deployments

Struck by PV

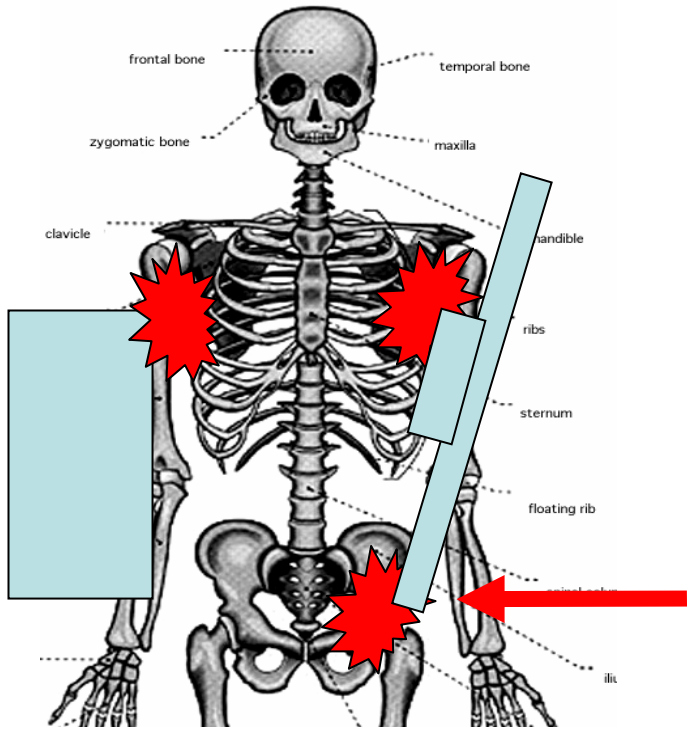
Lower lead angled door intrusion

Contact with door panels and raised center console



Contacts and Injury summary

AIS 3 - Serious Bilateral Chest Injuries



AIS 2 – Moderate Pelvic Fractures

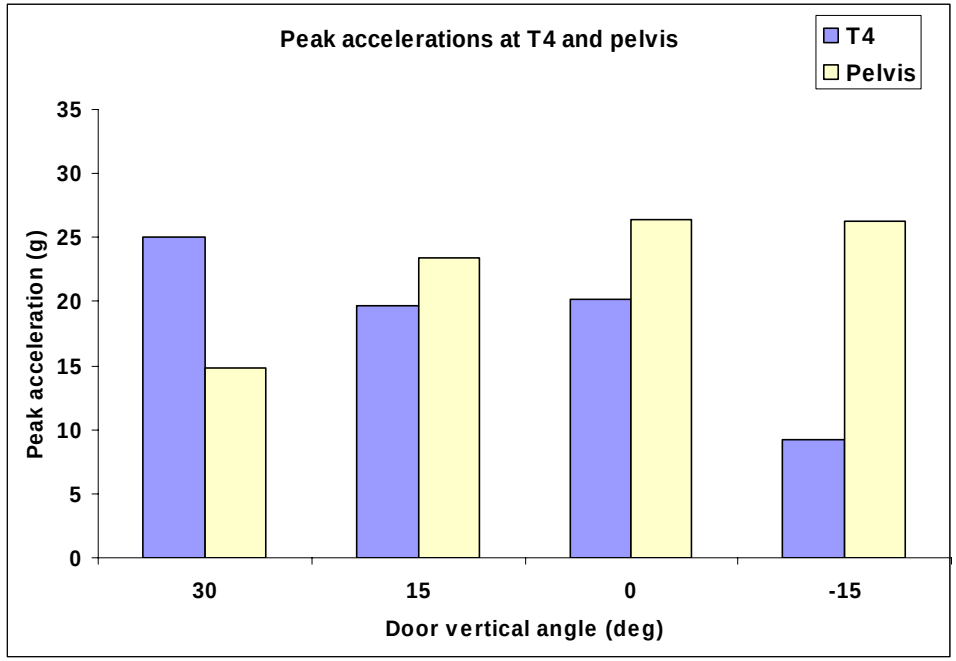
Front to Side Impact Induced Rollovers

Striker	Struck by then rolled over	N	% of total	Weighted Percentage	National Estimates	Yearly Estimates
PV	PV	154	25%	24%	41,300	3441
LTV	PV	34	5%	4%	7,000	700
PV	LTV	302	48%	52%	86,700	7200
LTV	LTV	101	16%	15%	25,500	2083
Other	Other		5%	5%	6700	600
Total		624	100%	100%	167,000	14,000

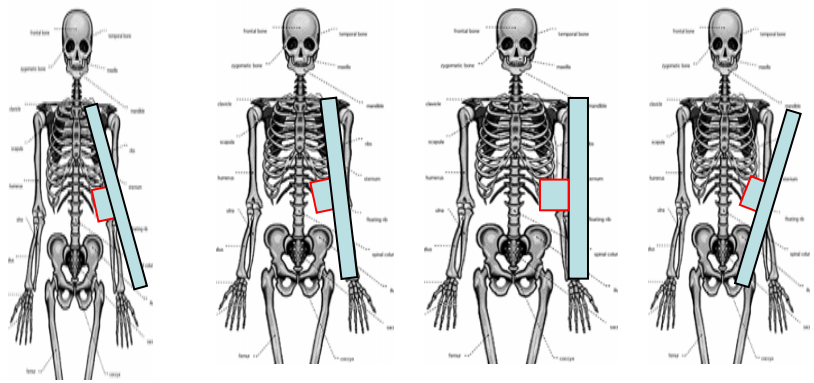
NASS/CDC 1993-2004

Seattle CIREN Door Angle Testing

Door Angle and Peak Acceleration Results (g)

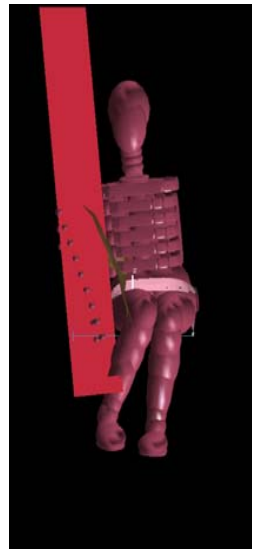


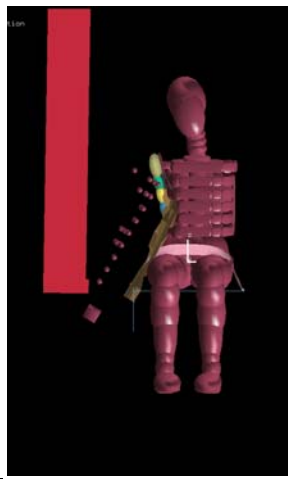
The Role of Door Orientation on Occupant Injury in a Nearside Impact. A CIREN, MADYMO modeling and experimental study. Traffic Injury Prevention, 6:372-378, 2005 – Seattle CIREN Team



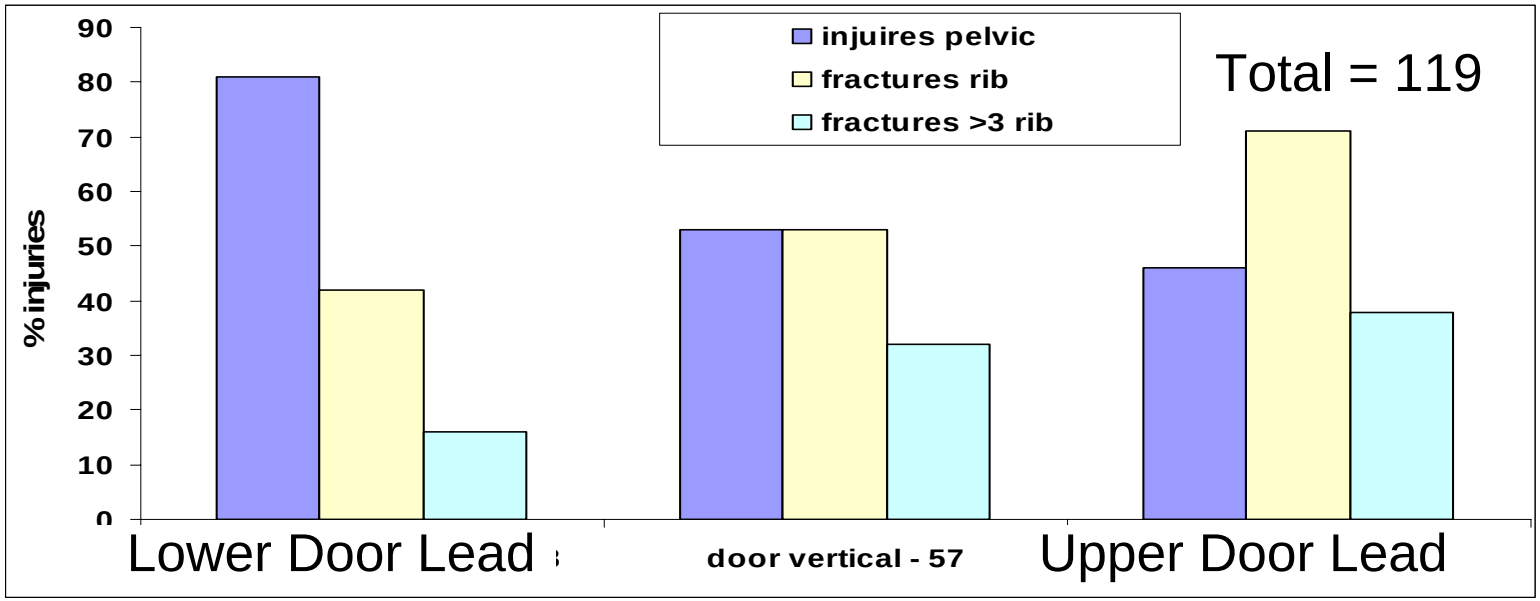
MADYMO Modeling Results

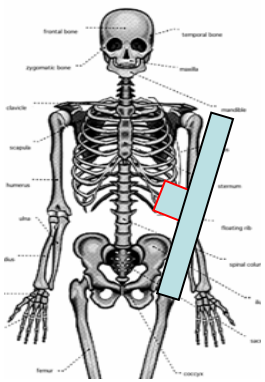
MEASURE	pelvis (g)	T4 (g)	T1 (g)
door angle +30 deg (upper border tilted inwards)			
USDOT	30.6	87.9	
SIDiiS	60.1	52.5	55.6
BIOSID	59.1		33.4
door angle -15 deg (lower border tilted inwards)			
USDOT	47.9	62.2	
SIDiiS	64.2	35.7	35.7
BIOSID	78.5		21.4
	Percent change door angle -15 deg. to 30 deg.		
USDOT	-56.5	29.2	
SIDiiS	-6.8	32.0	35.8
BIOSID	-32.8		35.9



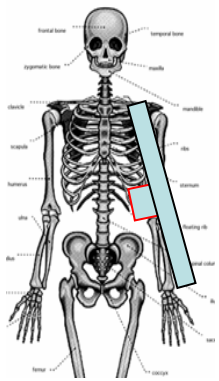


CIREN Data Reviews





18/38 from PV impacts
MAIS = 3
ISS = 18
Mean Intrusion =32 cm
Mean Delta V = 34 kph
21mph

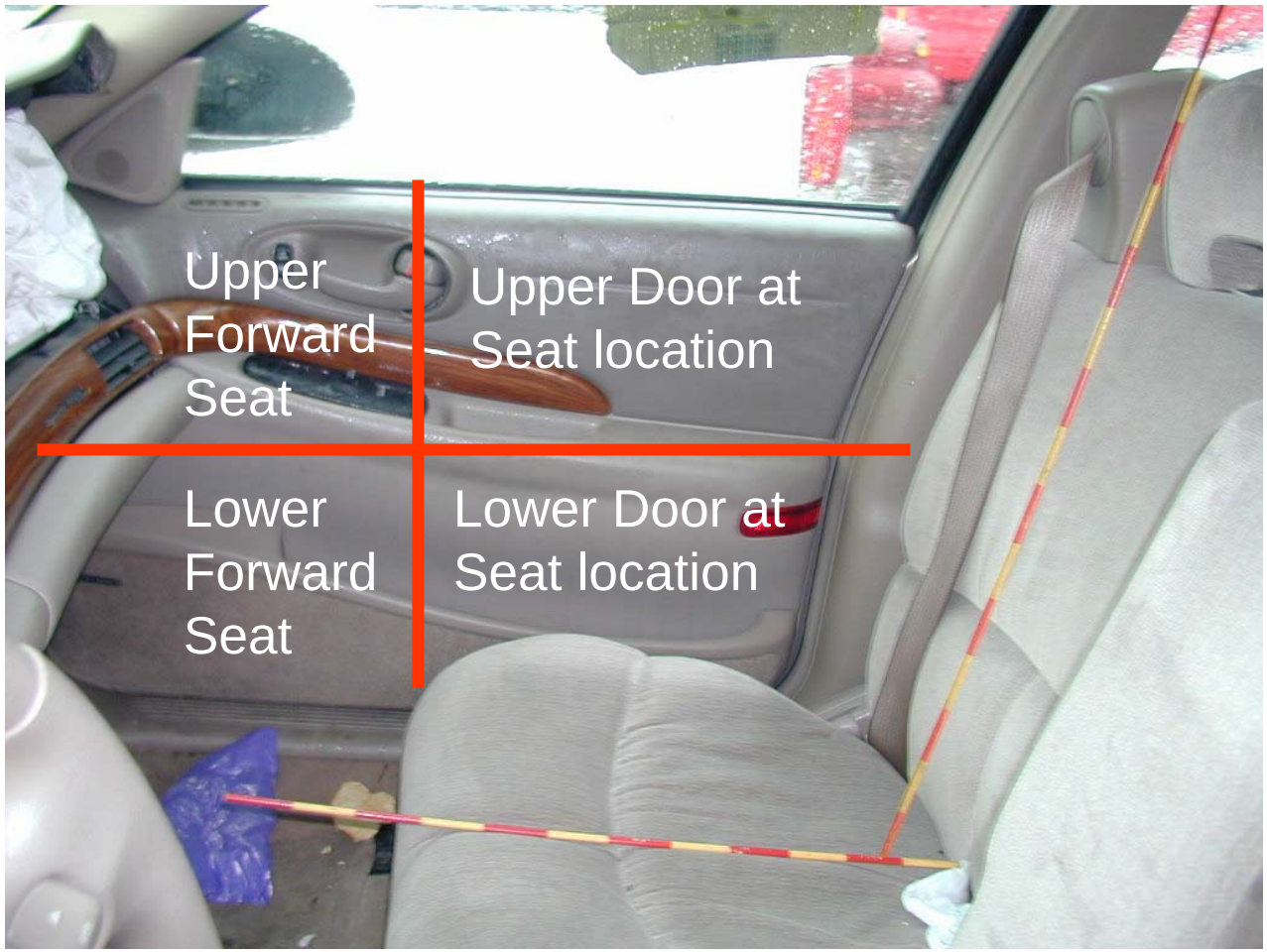


16/24 LTV impacts
MAIS = 4
ISS = 21
Mean Intrusion = 34 cm
Mean Delta V = 33 mph
21 kph

Door Panel Intrusion Documentation

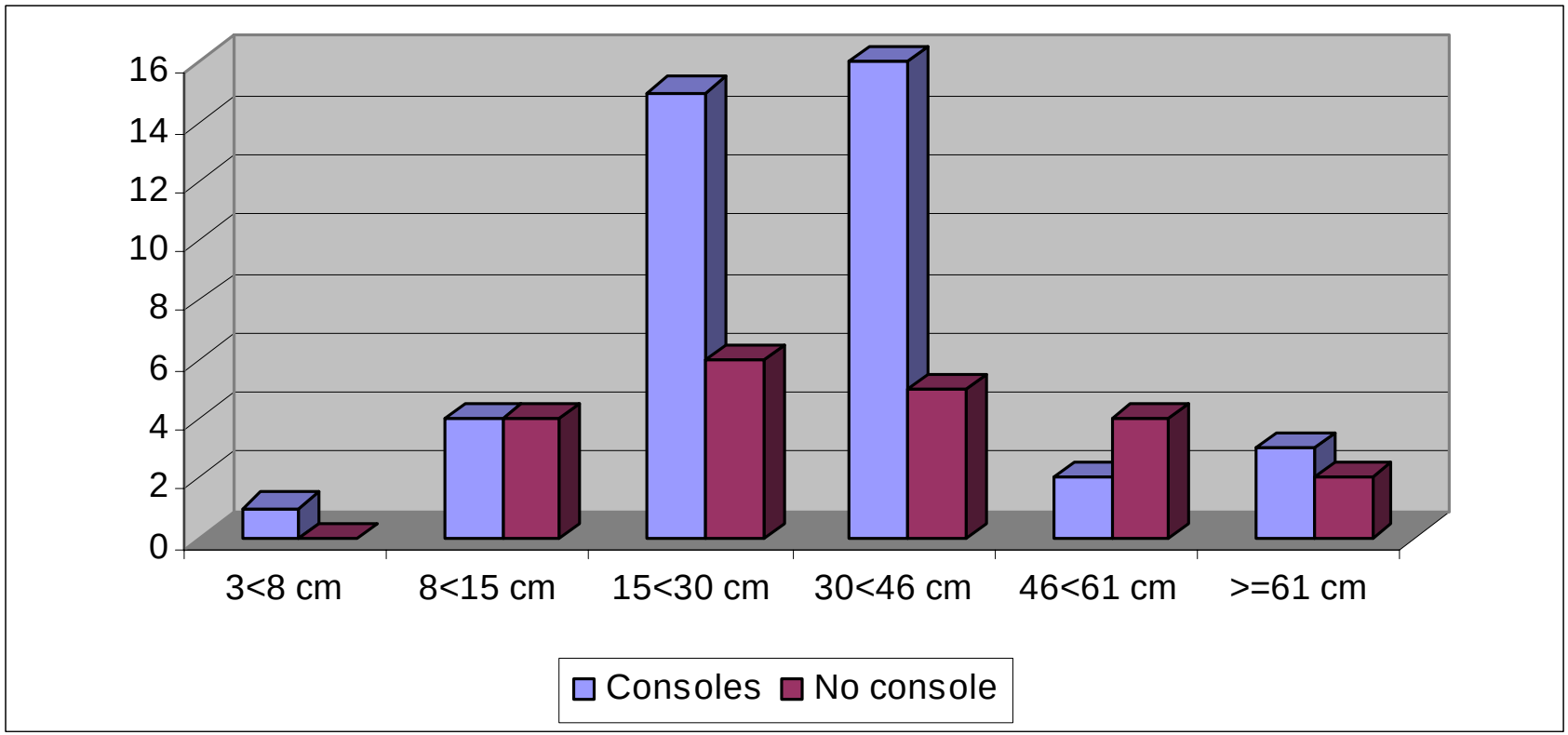
- Limitation of NASS data: all door panel intrusion measurements are taken at the max point on any location of the door panel
- CIREN data allowed evaluation of door intrusion height with linked images to each intrusion.
- Suggest creating a quadrant location method to document door panel intrusion in respect to seat locations

Quadrant locations on Door Panel



Divided by top of armrest and front of seat cushion at time of impact

Moderate and serious pelvic injury in nearside crashes by magnitude of intrusion



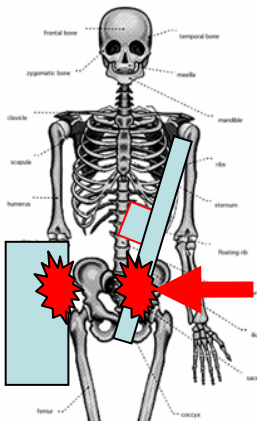
REDUCING PRIMARY AND SECONDARY IMPACT LOADS ON THE PELVIS DURING SIDE IMPACT -2005 ESV PAPER NUMBER 05-0036
Seattle CIREN Team and San Diego CIREN -Carol Conroy

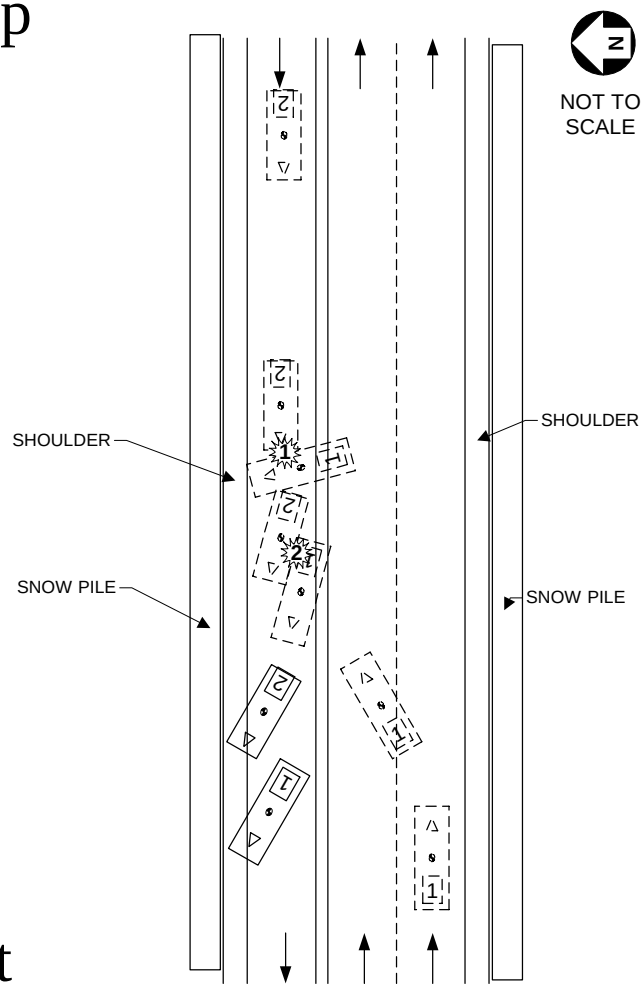
LTV > LTV Side impact

Case Vehicle – 2000's Compact Pickup

Struck by a 1990's LTV

Bilateral Pelvis

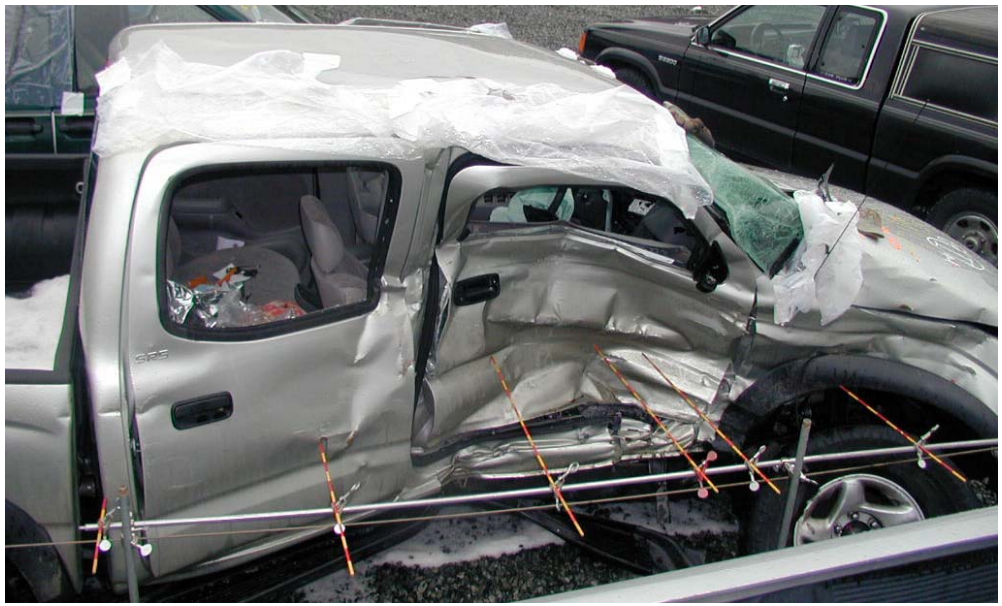




Case occupant – 20's yrs./ female

Front right passenger - Lap/shoulder belt

Y–zone impact



Moderate Delta V

Lateral Principle Direction of Force

Door panel intrusion = 45 cm/17.7inches

Contact evidence on door panel and center console

Serious bilateral pelvic fractures occurred

Bilateral vs. Unilateral Pelvic Fracture

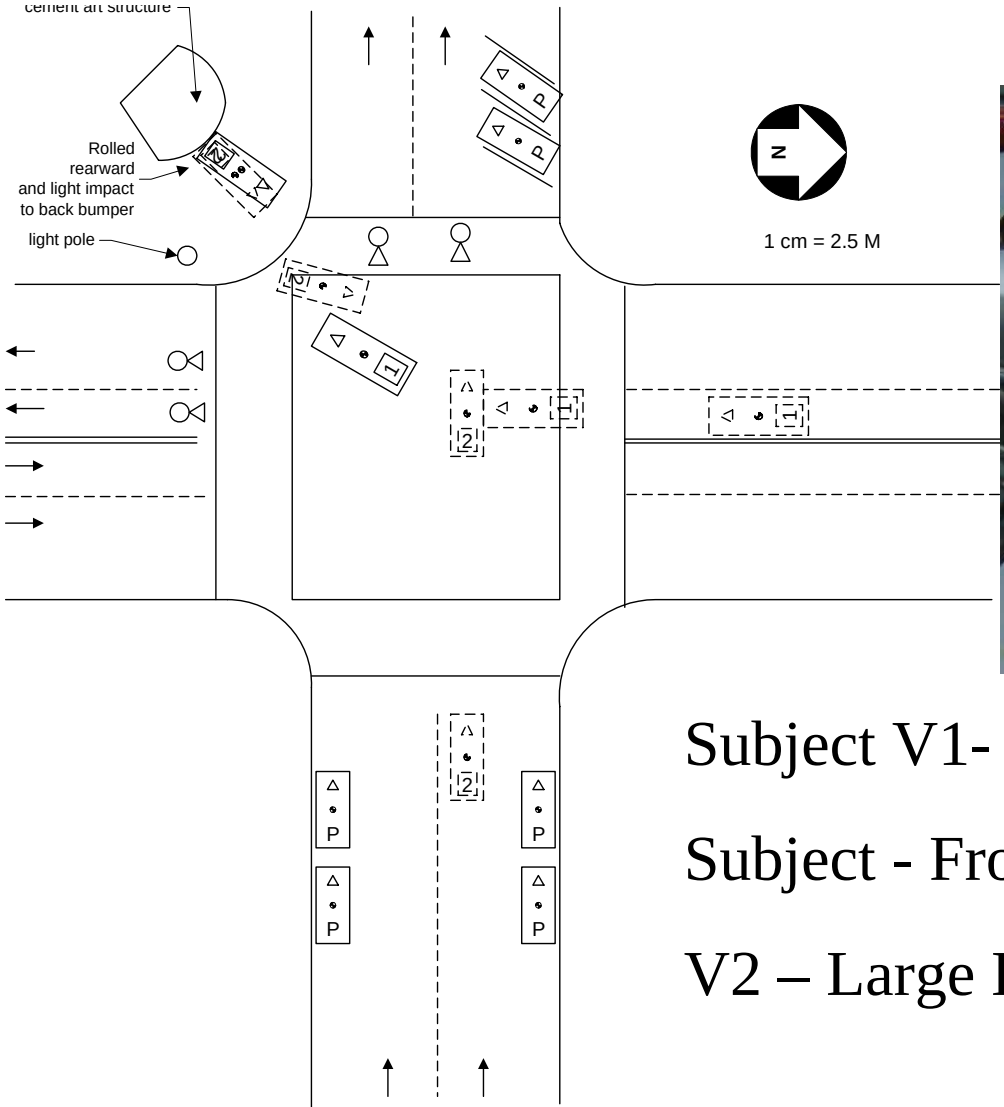
- Bilateral
  - Highly unstable
  - Significant hemorrhage
  - Surgical intervention
  - Internal organ injury
  - Immediate
    - Bladder/Urethra
  - Delayed
    - Sexual and urinary dysfunction (20%)
- Unilateral
  - Stable
  - Minimal hemorrhage
  - Treated non-surgically

Vehicle Incompatibility Preventive Measures

Side Air bags provide head and chest protection

LTV > PV

Side-impact air bag protection



Subject V1- 2000 Four door sedan

Subject - Front Right Passenger

V2 – Large LTV

LTV > PV
P-zone impact

Right side direct lateral impact

Delta V = 18 mph/29kmph

Extrication to door

Profile adjusted

Demographics/Contacts

30’s. Female

No Manual belts used

Side door mount air bag deployment

Lower door panel to lower chest/abdomen

Pelvis scuff to B pillar

Seatbelt locked in position by intrusion

Intrusions

Door Mount Side Air bag

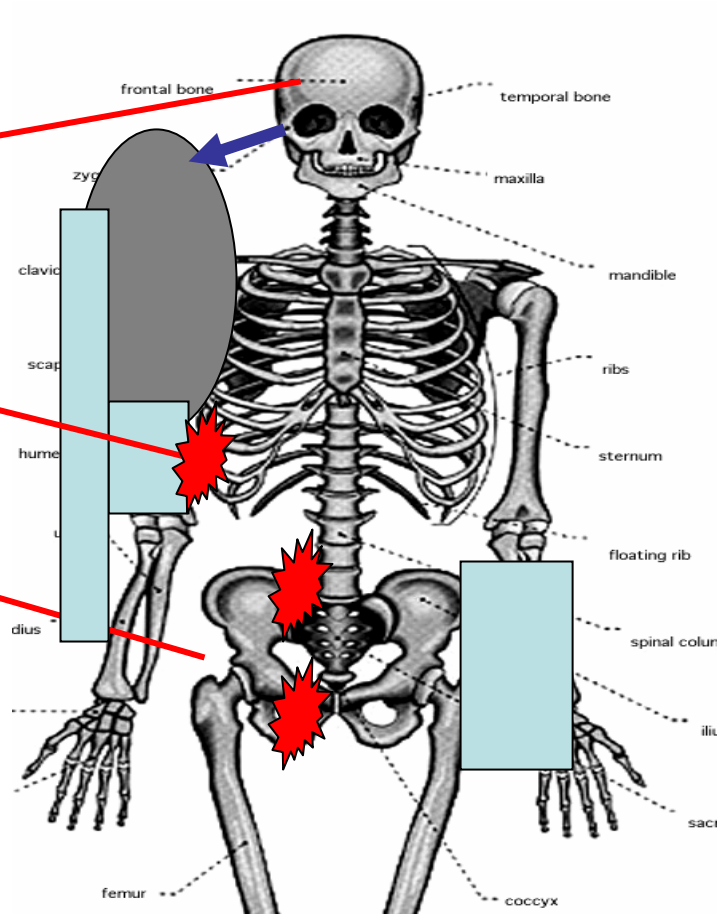
Main protection to upper thorax, but extends enough upward for some head protection

Injury Summary

Head – Minor Injury

Chest – Serious injury to lower chest

Pelvis – Serious pelvic fractures



Upper chest and head appear to be protected by door mount thorax air bag considering an SUV upper door impact.

Conclusions

- Height and magnitude of the door intrusion correlated with location of injury and severity
- LTV > PV had the greatest mean max AIS
- LTV > PV had a greater percentage of head, thoracic, abdominal, and pelvic injuries
- CIREN data allowed evaluation of door intrusion angles, and recommended door quadrant intrusion documentation
- PV > LTV accounted for half of all the rollovers induced by side impact collisions

Conclusions

- For all impact groups the Y-zone impact was the most common
- 10 and 2 o'clock PDOFs occurred twice that of 9 and 3 o'clock in all side impact zones and groups
- LTV > PV group had the greatest mean AIS for each body region involving the zones that included the passenger compartment
- In this LTV > PV group, the D-zone (less common) was the most severe with a mean AIS of 3, followed by the Y (most common), and P zones
- Case review showed that a side impact air bag was preventive in an LTV > PV side impact crash