The Benefits of Booster Seats – Sled Tests and CIREN Case Examples

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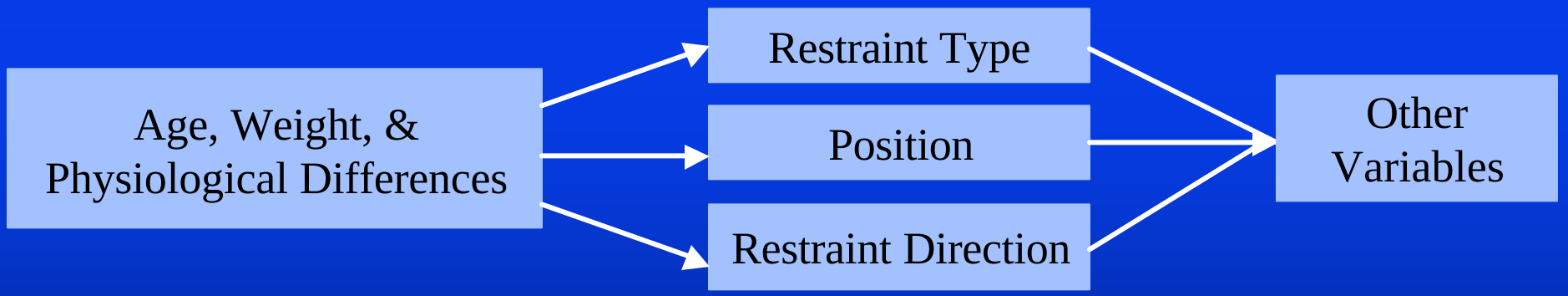
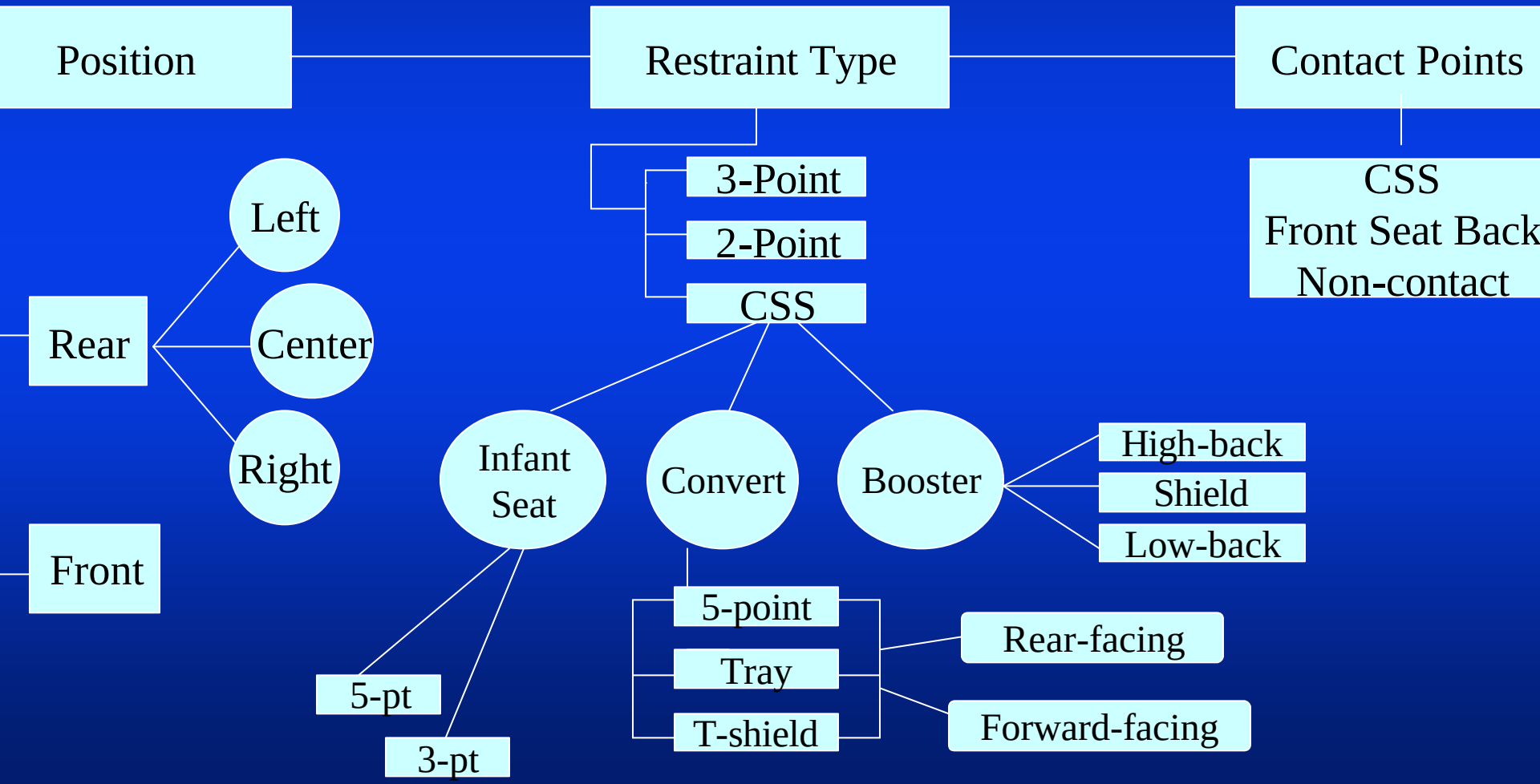
Objectives

- Increase knowledge benefits of booster seats in child passenger safety
- Understand injury risks associated with premature graduation from booster seats
- Use simulation models to further quantify injury patterns with different restraint systems

Kids are different!



Other Variables



Booster Seats

Height of 4’9” – appropriate for vehicle belt only
Booster seats recommended for children 4-10 years old
Stature (seated height) more important than age, weight

igh Back Booster

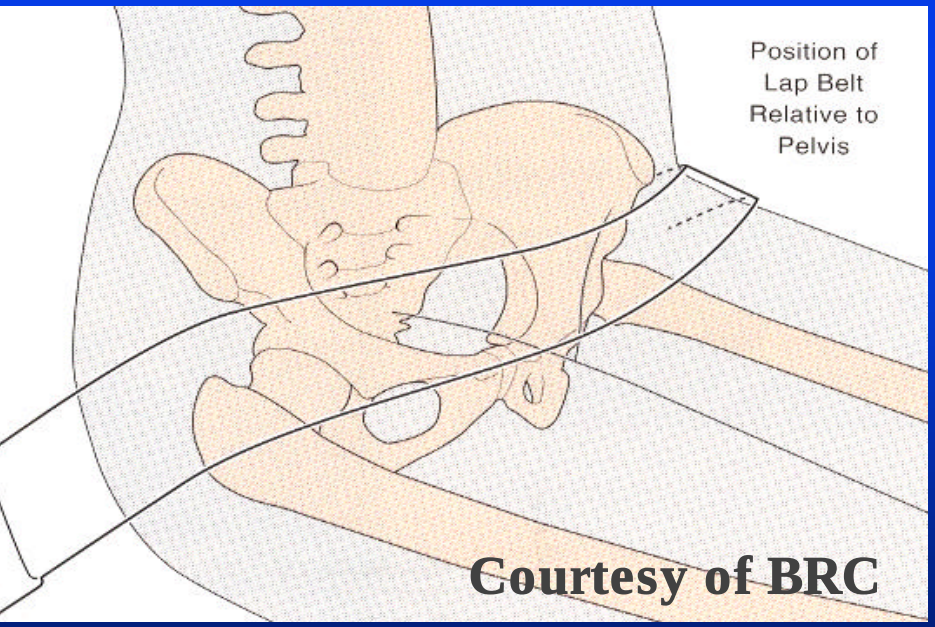
Low Back Booster

Shield Booster
Not recommended

Reasons for Booster Seats

Improve fit of vehicle belt

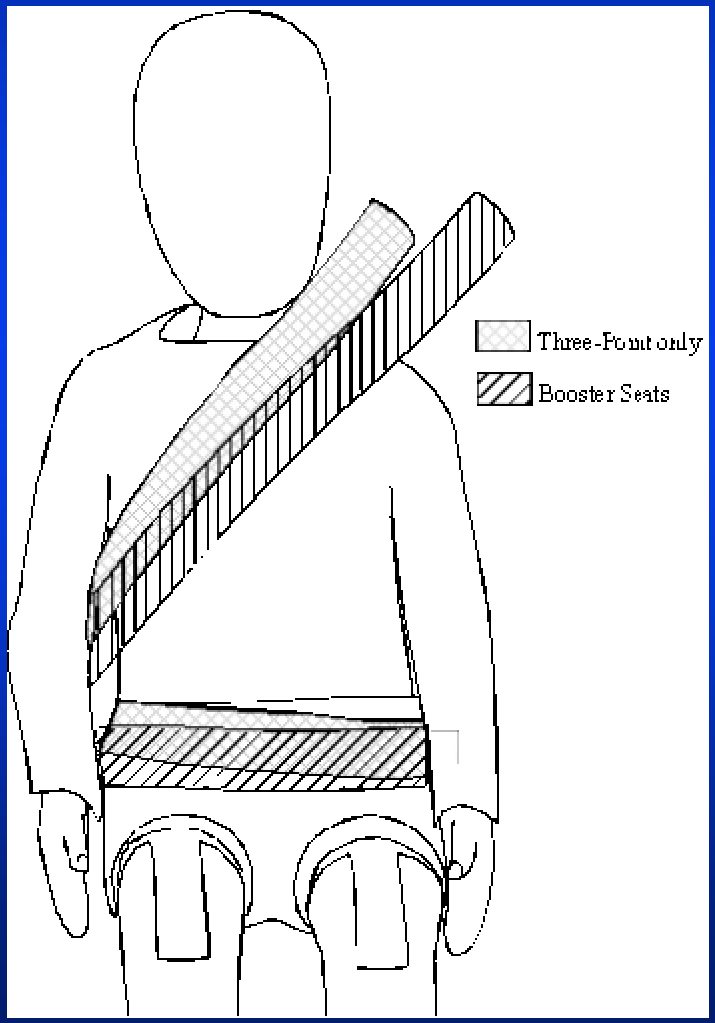
- Lap belt (prevent submarining)



Reasons for Booster Seats

mprove fit of vehicle belt

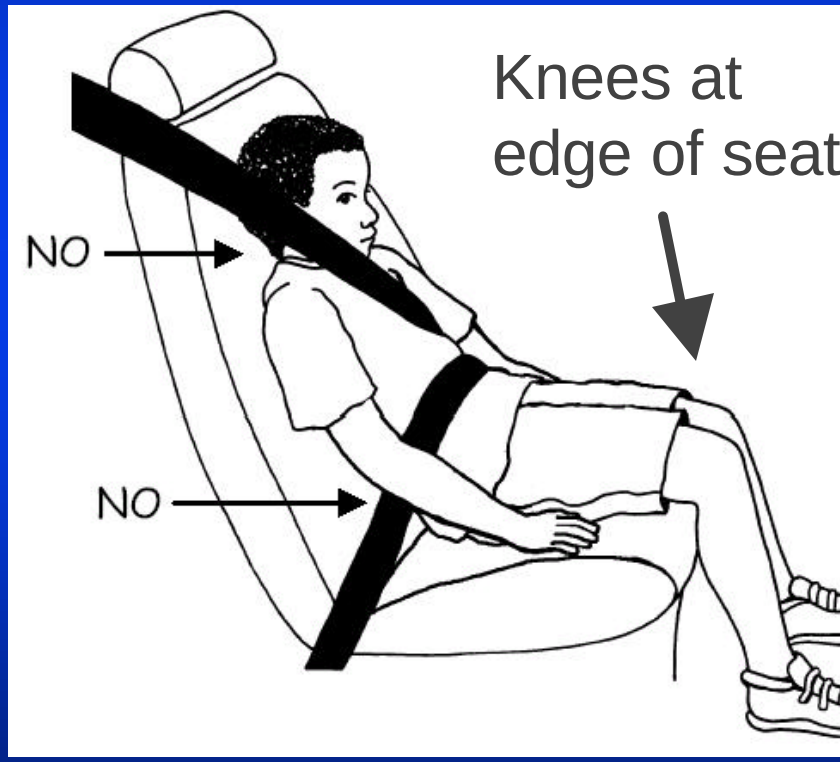
- Shoulder belt – across chest and shoulder



Reasons for Booster Seats

ractical concerns

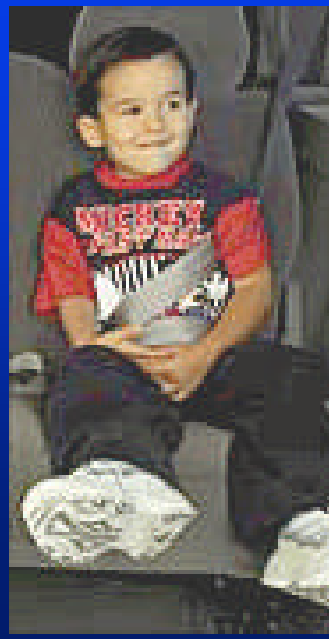
- Prevent slouching due to leg length
- Degrades fit for both lap and shoulder belt



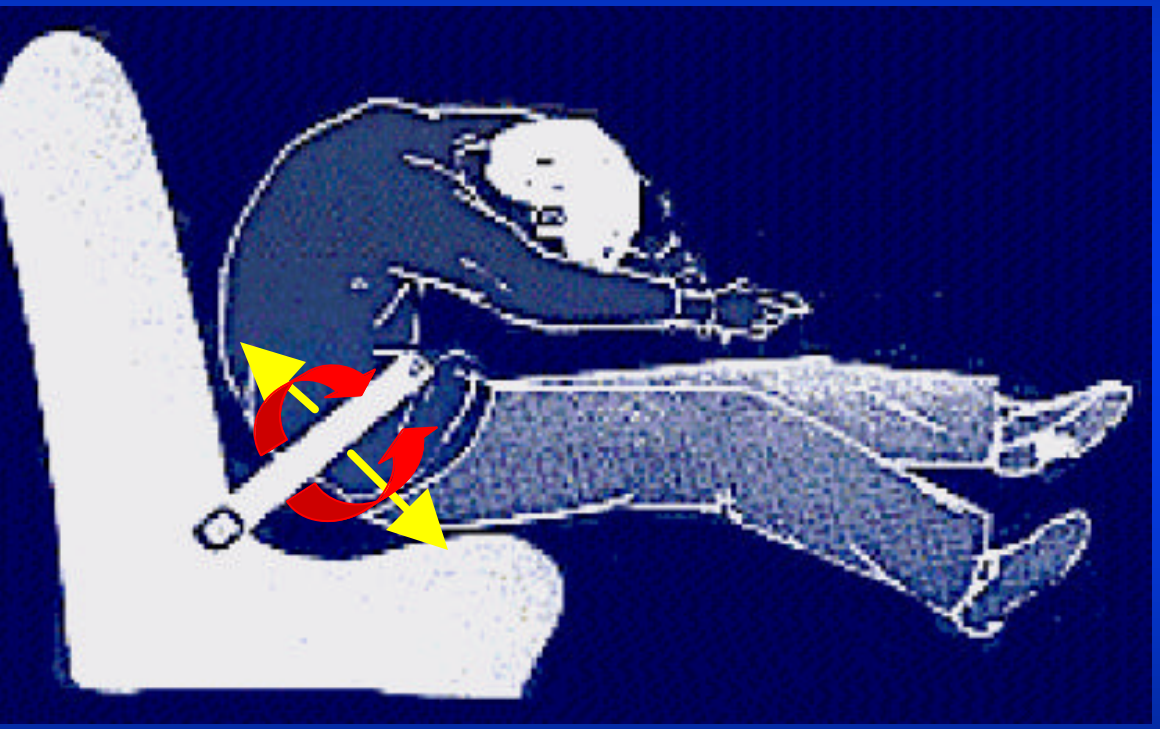
Reasons for Booster Seats

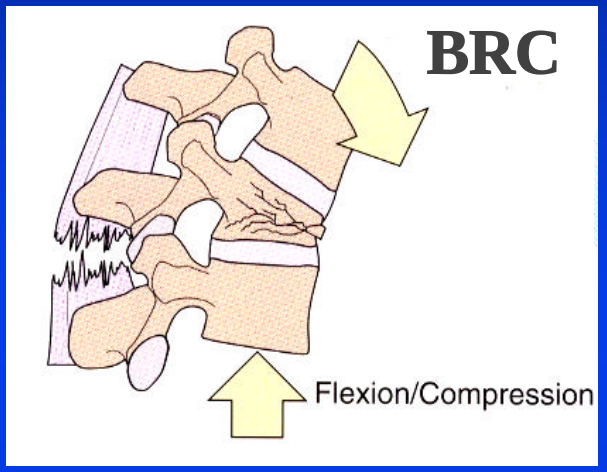
ractical concerns

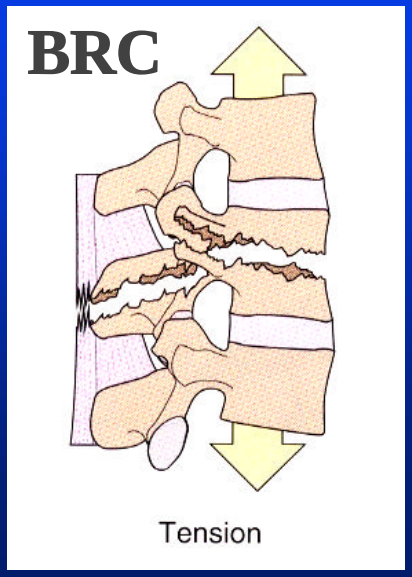
- Uncomfortable shoulder belt position
- Leads to misuse of shoulder belt
- Behind back, Under arm



Chance Fracture







Sled Tests

Quantifying the injury patterns

Sled Tests

Similar to FMVSS 213

- 48 km / h (30 mph) impact speed
- 3rd row bench seat, Windstar minivan
- Hybrid III 6 year old dummy

4 Sled Tests

- High Back Booster Seat
- Low Back Booster Seat
- Shoulder belt behind back
- Shoulder belt under arm

Sled Tests

High Back Booster Seat

Low Back Booster Seat

Sled Tests

Shoulder Belt Behind Back

Shoulder Belt Under Arm

Sled Test

- Measured forces during crash simulation
  - Head Excursion
  - Lap Belt Force
  - Shoulder Belt Force
  - Flexion of Lumbar Spine
  - Lumbar Tension

Sled Tests – Injury Measures

				
	HBB	**LBB**	**Shoulder Behind Back**	**Shoulder Under Arm**
Head Excursion (cm)	**64.3**	**58.5**	**91.6**	**73.1**

Sled Tests – Injury Measures

				
	HBB	**LBB**	**Shoulder Behind Back**	**Shoulder Under Arm**
Lap Belt Force (N)	**3180**	**3011**	**4078**	**2611**
Shoulder Belt Force (N)	**5080**	**5340**	**-**	**4000**

Sled Tests – Injury Measures

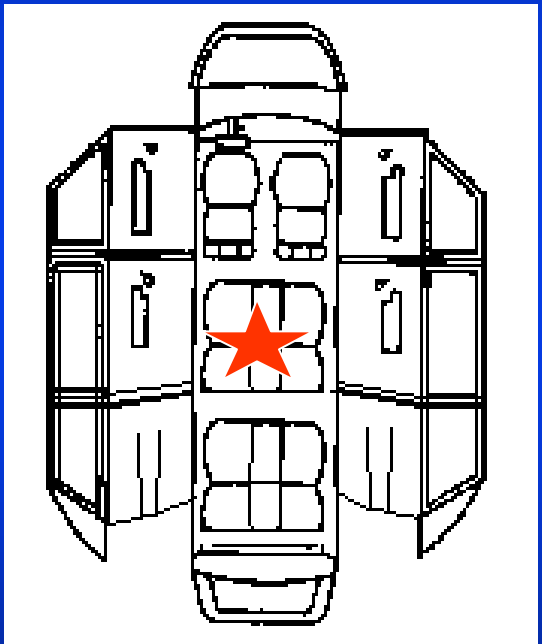
				
	HBB	**LBB**	**Shoulder Behind Back**	**Shoulder Under Arm**
Lumbar Flex Moment (Nm)	**24**	**20**	**73**	**41**
Lumbar Tension (N)	**1437**	**2114**	**5303**	**4704**

Applying simulations data to real pediatric crashes

CIREN: Case Studies

		Case 1	Case 2
Patient	Age	4 yrs old	5 yrs old
	Weight	37 lbs	60 lbs
	Height	36 in	45 in
Restraint	Type	3-point belt shoulder belt behind back	3-point belt shoulder belt under arm
	Position	middle row / middle seat	right rear
Crash	PDOF	+340	+350
	Crush	21 cm (8.3 in)	55 cm (21 in)
	Delta V	22 km / hr (13.6 mph)	43 km / hr (27 mph)
	Impact	Frontal	Frontal

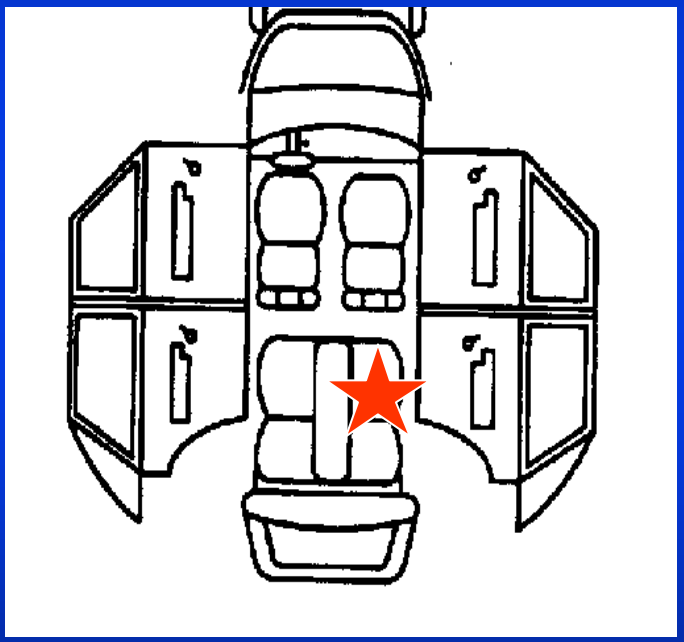
CIREN Cases 1: Case Vehicle



Seating Position

Frontal View of Case Vehicle
1993 Mercury Villager

CIREN Cases 2: Case Vehicle



Seating Position

Max Crush - 55 cm (21 in)

Frontal View of Case Vehicle
1993 Jeep Cherokee

Case 2:
External Injuries

Distended Stomach

Summary:
Role of Sled Test

- Compare among restraint systems forces in crash simulation
- Shoulder Belt Misuse Scenarios vs Booster
  - Head excursions increase
  - Lap belt forces similar
    - High shoulder belt forces on abdomen
  - Higher flexion moment and tension on lumbar spine
    - potential for Chance Fractures

Summary:
Role of Booster Seats

- Benefits of Booster Seats
  - Creates comfortable shoulder belt position
  - Alleviates misuse of shoulder belt
    - Placing behind back
    - Placing under arm
  - Creates more comfortable seating position to prevent slouching
    - Submarining

Thank You