
ADVANCED RESTRAINT SYSTEMS
SOC. I. TRA. S.
Rimini
November 2004
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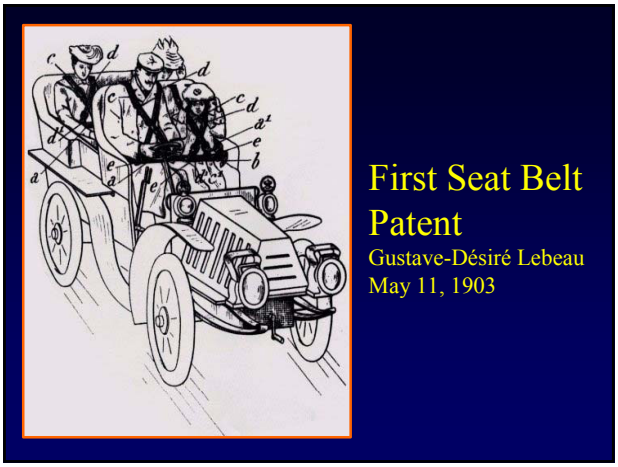
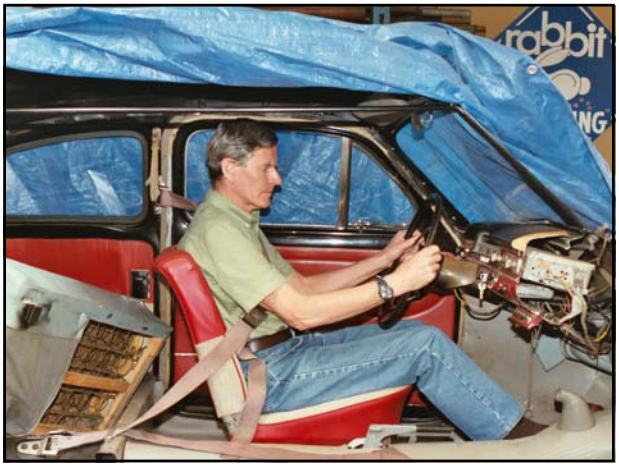
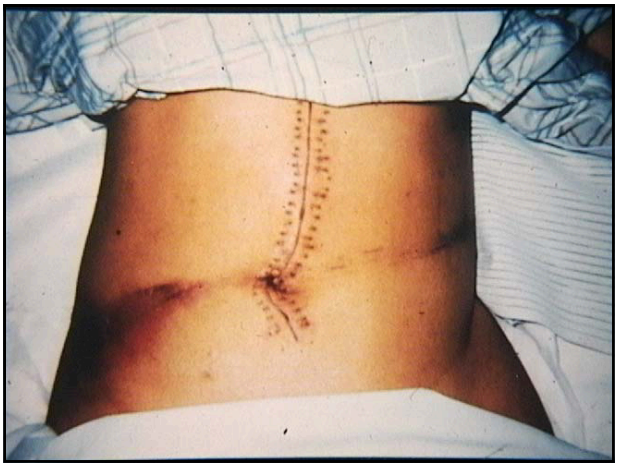
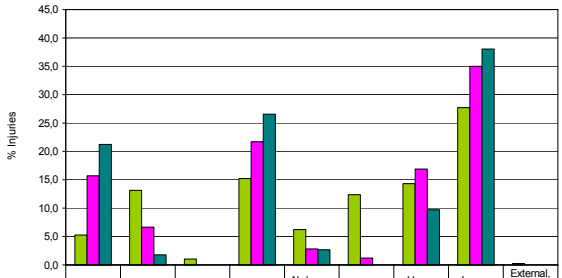
Professor of Transport Safety
U.K.


First Seat Belt Patent
Gustave-Désiré Lebeau
May 11, 1903



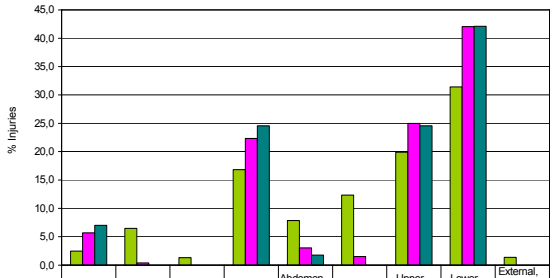


Driver Injuries without Airbag Deployment



	Head	Face	Neck	Thorax	Abdomen and Pelvis	spine	Upper Extremities	Lower Extremities	External, Burns & Other
AIS1+ (3309)	5,3	13,1	1,0	15,2	6,2	12,4	14,3	27,7	0,2
AIS2+ (497)	15,7	6,6	0,0	21,7	2,8	1,2	16,9	35,0	0,0
AIS3+ (113)	21,2	1,8	0,0	26,5	2,7	0,0	9,7	38,1	0,0

Driver Injuries with Airbag Deployment

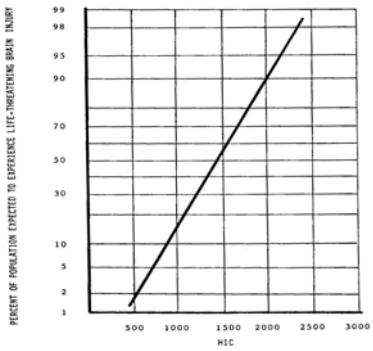


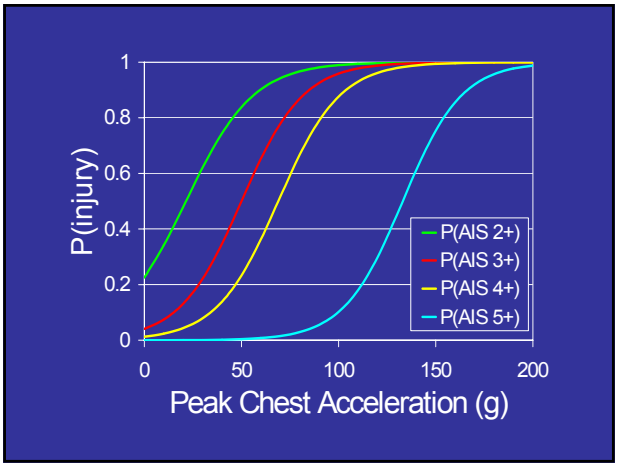
	Head	Face	Neck	Thorax	Abdomen and Pelvis	spine	Upper Extremities	Lower Extremities	External, Burns & Other
AIS1+ (2110)	2,5	6,5	1,3	16,8	7,9	12,4	19,9	31,4	1,4
AIS2+ (264)	5,7	0,4	0,0	22,3	3,0	1,5	25,0	42,0	0,0
AIS3+ (57)	7,0	0,0	0,0	24,6	1,8	0,0	24,6	42,1	0,0

SIGNIFICANT DIFFERENCES

Face	AIS1+	- 36.7%	Up. Ex.	AIS1+	+25.2%
	AIS2+	- 87.4%		AIS2+	+19.8%
	AIS3+	-		AIS3+	+51.4%
Head	AIS1+	- 38.7%			
	AIS2+	- 55.2%			
	AIS3+	- 61.4%			

FIGURE 1 - PERCENT OF POPULATION EXPECTED TO EXPERIENCE LIFE-THREATENING BRAIN INJURY DUE TO FRONTAL HEAD IMPACTS AS A FUNCTION OF HIC. (SEE REFERENCE 2). USA Delegation to ISO/TC22/SC12/WG6, Position Paper on HIC Levels. June 1983.



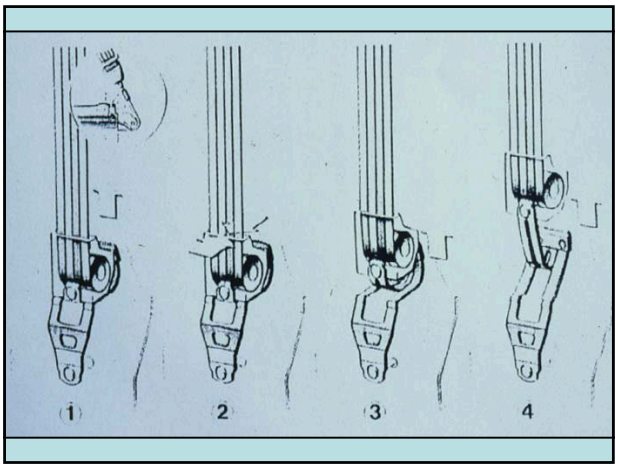


Buckle Pre-tensioner

Force Limited Belt

Function: Seat belt restraint designed to limit belt forces to predetermined level

Effect: Limits the maximum force applied to the body and allows the body to move more within the occupant compartment and over the ground, extracting a great amount of kinetic energy



Advanced Restraint Systems

Thorax Bag

- Integrated in seat therefore independent of seat position
- Protective effect obtained by keeping the occupant away from the impact zone, and dampening the blow from the intruding side of the vehicle
- Bag is inflated within 12 thousands of a second; four times faster than a frontal airbag

Advanced Restraint Systems

Head Thorax Bag


- Extension of thorax bag - greater volume
- In sewn version pressure from interaction causes head portion to inflate quicker

Advanced Restraint Systems

Inflatable tubular structure (ITS)

- Side impact protection, activates together with thorax bag
- Front occupant protection only
- Installed in the head-liner above the frontal doors
- Inflates to a diameter of about 15 centimetres (5 inches).

Advanced Restraint Systems

Inflatable Curtain


- Head protection in side impacts & rollovers
- Attached along roof rail and stowed behind trim panels
- Protects both front and rear passengers
- Potential to prevent partial and full ejection
- Deployment time 30ms

Advanced Restraint Systems

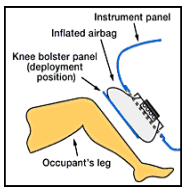
Anti-submarining/ Leg Bag


- Reduce the risk of submarining in a crash
- Keep the occupant's knees and legs safe distance from instrument panel
- Improve protection offered by frontal airbag and seat belt by keeping occupant in a more upright position.

Advanced Restraint Systems

Knee Bolster

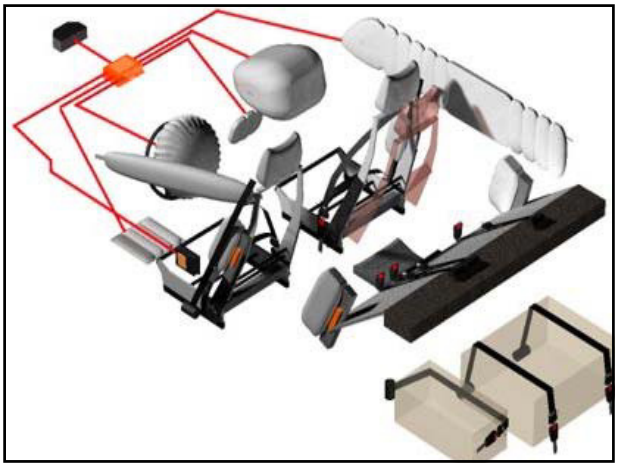


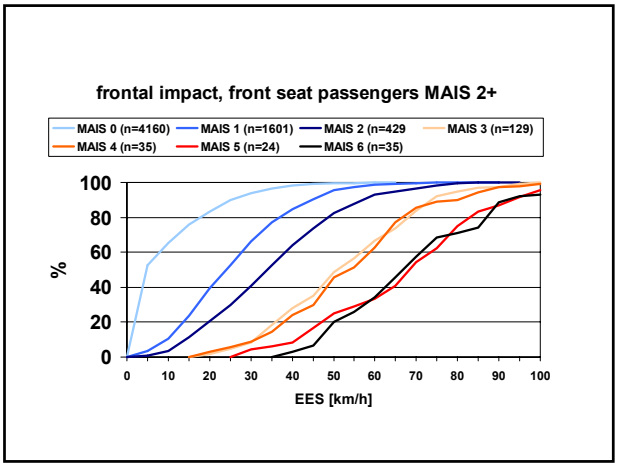


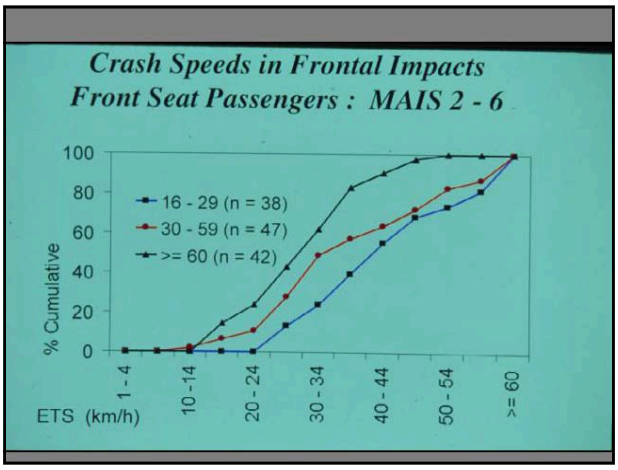
Advanced Restraint Systems

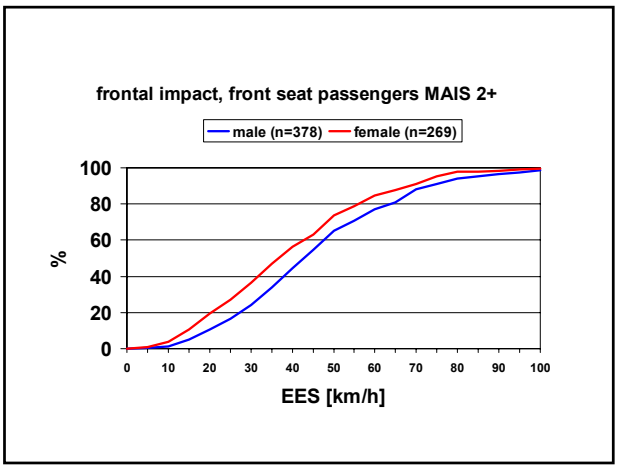
Inflatable carpet

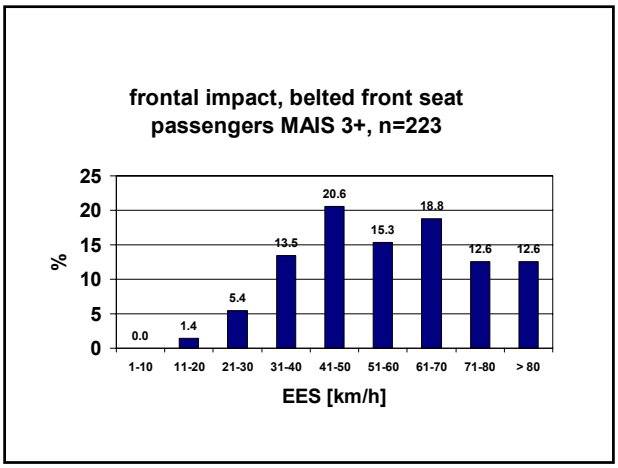

- Reduces loading to foot, ankle and lower leg by moving them away from toeboard before intrusion
- Acts as cushion to reduce acceleration of foot (heel), force and bending moments of lower leg (tibia)
- Keeps backward rotation motion within tolerable range by lifting heels away from toeboard
- Inflated in 20ms

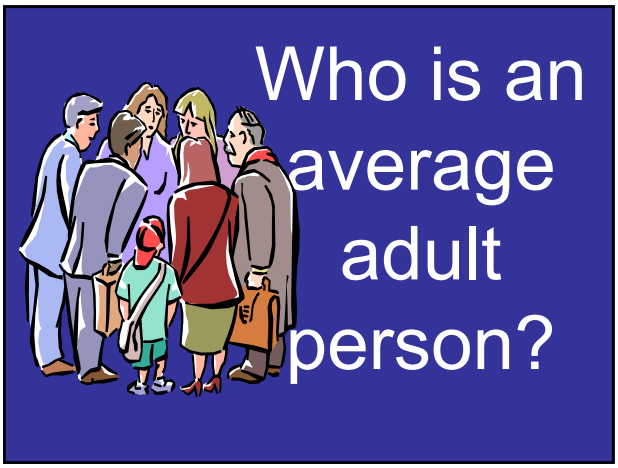


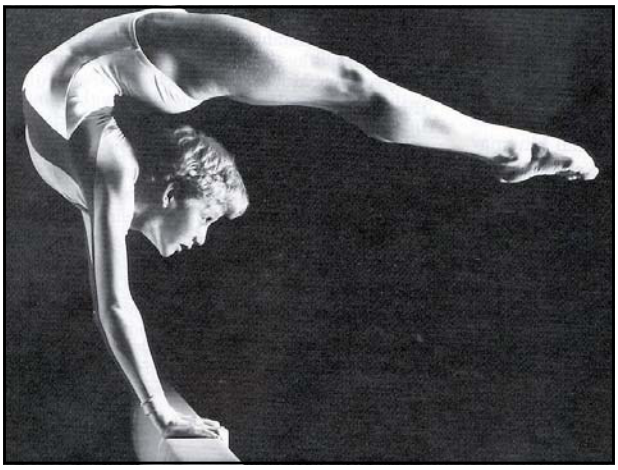

frontal impact, front seat passengers MAIS 2+
MAIS 0 (n=4160)
MAIS 1 (n=1601)
MAIS 2 (n=429
MAIS 3 (n=129)
MAIS 4 (n=35)
MAIS 5 (n=24)
MAIS 6 (n=35)
%
100
80
60
40
20
0
0 10 20 30 40 50 60 70 80 90 100
EES [km/h]


Crash Speeds in Frontal Impacts
Front Seat Passengers : MAIS 2 - 6
16 - 29 (n = 38)
30 - 59 (n = 47)
>= 60 (n = 42)
% Cumulative
100
80
60
40
20
0
1 - 4
10 - 14
20 - 24
30 - 34
40 - 44
50 - 54
>= 60
ETS (km/h)

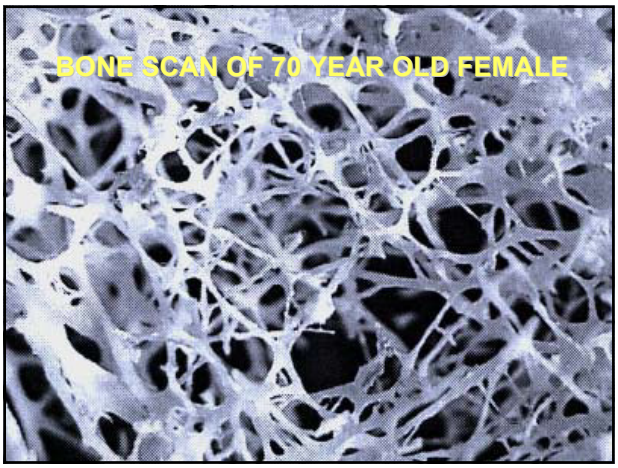

frontal impact, front seat passengers MAIS 2+
male (n=378)
female (n=269)
%
100
80
60
40
20
0
0 10 20 30 40 50 60 70 80 90 100
EES [km/h]

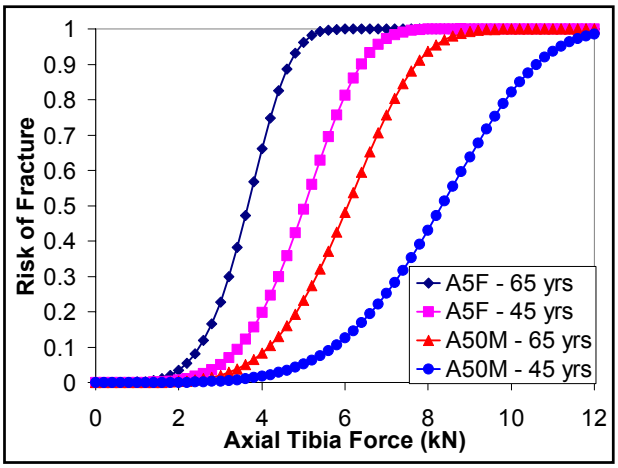

frontal impact, belted front seat passengers MAIS 3+, n=223
%
25
20
15
10
5
0
0.0
1.4
5.4
13.5
20.6
15.3
18.8
12.6
12.6
1-10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
> 80
EES [km/h]

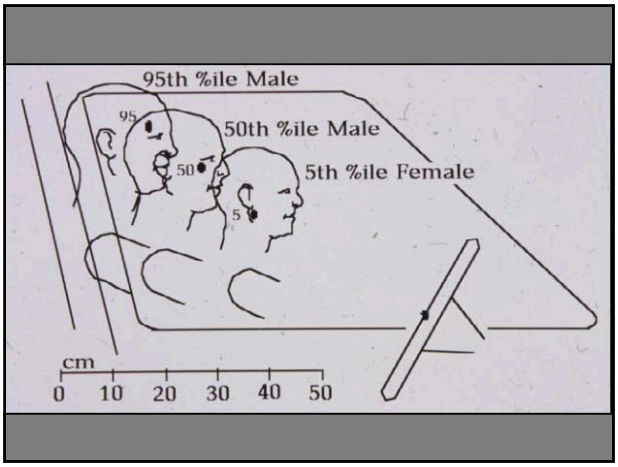

Who is an average adult person?




BONE SCAN OF 50 YEAR OLD MALE


BONE SCAN OF 70 YEAR OLD FEMALE


Risk of Fracture
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
Axial Tibia Force (kN)
A5F - 65 yrs
A5F - 45 yrs
A50M - 65 yrs
A50M - 45 yrs



Adult Front Passenger Seating Scenarios


Feet on dash


Child in lap

- Position essential for optimal protection
- Occupant position determined by:
  - mass measurement
  - occupant profiling
  - position detection


Reclined seat


Reaching

REAL WORLD VARIATIONS

- PRE-CRASH PHASE
- CRASH PHASE
- POST-CRASH PHASE

PRE CRASH VARIABLES

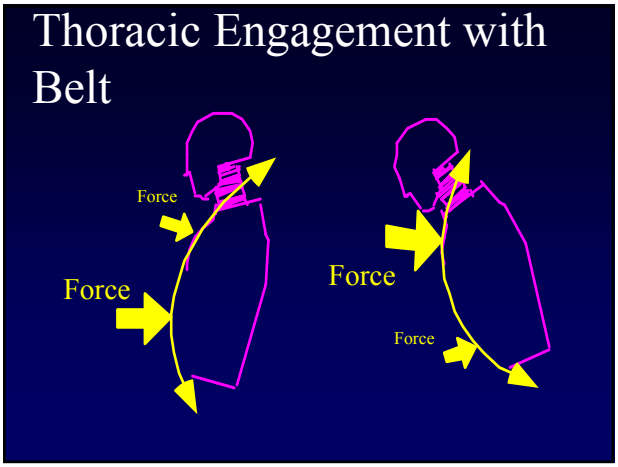
- Height, Weight, BMI, Sex, Age
- Pre-existing Medical Conditions
- Biomechanical Tolerance, Muscle Tone
- Stomach & Bladder Contents
- Alcohol, Drugs, Clothing, Restraint Use
- Belt Position, Pre-impact braking
- Sitting Position, Posture

CRASH VARIABLES

- Impact Direction, Velocity Change, Peak Vehicle Deceleration, Pulse Duration
- Peak Belt Load, Posture at Peak Load, Airbag Interactions, Point in Heart Cycle
- Loads and Durations of Localised Contacts
- Rear Loading, Interactions with Other Occupants

POST-CRASH VARIABLES

- Type and Severity of Injuries
- Combinations of Injuries
- Response Times of EMS
- Quality and Speed of Diagnosis of Injuries
- Quality of Treatment
- Resulting Disabilities



Advanced Restraint Systems

- Adaptive systems
  - Adapt to crash scenario
    - Multi stage inflators
    - 2 stage load limiters
  - Adapt to occupant characteristics
    - Airbag on/off switch
    - Adaptive load limiter
    - Adaptive venting
    - Adaptive tear seams
  - Adapt to both crash scenario & occupant
    - Adaptive venting
    - Adaptive generator
    - Adaptive load limiter

Advanced Restraint Systems

- Crash Adaptive Systems
  - Multi stage inflators
    - Normally two stages
    - single stage - low severity crashes
    - dual stage - high severity crashes
    - All propellant dispelled!!!
  - 2 stage load limiter
    - In initial onset of the crash, occupant only restrained by the belt, restraining force of the seat belt held at a relatively high, constant level.
    - As occupant moves forward and into the airbag, load limiter switches to "the second gear" – a lower restraining force
    - Prevent the risk of peak load
    - even load on the occupant's chest during the whole crash

THE FUTURE

- More sensing of occupant position
- Sensing of occupant's weight, bone density
- Smart key codes
- Greater variability of belt characteristics
- Greater variability of bag characteristics

The Next Breakthrough –

Pre-Crash Sensing Proximity Radar