5

OUT-OF-POSITION OCCUPANT INJURY MITIGATION

Donald Friedman, Liability Research
and
Keith Friedman, Friedman Research

Santa Barbara, California

Paper was presented at the 21st Annual Workshop on Human Subjects for Biomechanical Research. This paper has not been screened for accuracy nor refereed by any body of scientific peers and should not be referenced in the open literature.

INTRODUCTION

An out-of-position occupant, by our definition is one who is bigger or smaller, heavier, fatter or otherwise not like a 50th%tile male dummy, and is not positioned in the vehicle as specified by the FMVSS 208 test at the instant of vehicle impact.

ACCIDENT STATISTICS

The accident situation on which this paper is characterized is as follows:

U.S. SERIOUS TO CRITICAL AND FATALITIES BY ACCIDENT MODE

	SERIOUS/CRITICAL	FATAL
Collisions between:		
two passenger cars	109,000	5,000
car with light truck, van, utility	20,000	4,500
car with large truck	10,900	2,500
Single vehicle non-rollover	28,000	7,000
Rollover	15,000	4,500

SPECIFIC U.S. VEHICLE OCCUPANT INJURIES						
#	FATAL	AIS 5	AIS 4	AIS 3	AIS 2	AIS 1
a.	23,600	21,300	23,030	123,800	295,900	2,547,000
b.	8,800	10,650	11,515	61,900	147,950	1,273,500
	to	to	to	to	to	to
	5,280	6,390	6,909	37,140	88,770	764,100
c.	3,351	1,616	2,032	3,151	19,205	116,341

a. Car & LTV Injuries BY AIS

b. Maximum to Minimum head, face and neck injuries

c. NHTSA's estimate of head and face primary injuries

SERIOUS HEAD INJURIES / FATALITIES BY IMPACT POINT		
	AIS 3-5	Fatal
Passenger Cars:		
A-pillar	3071	1530
B-pillar	888	429
Roof side Rails	980	463
Front header	937	473
Rear header	22	12
Other pillar	76	35
Total Passenger cars	5974	2942
Total LTV's	828	408
Total all vehicles	6802	3350

NHTSA

INJURY MECHANISMS

About 1/3 of these injuries and fatalities are by restrained occupants, and only about 20 to 30% will be mitigated by padding upper interior surfaces, and encourage restraint usage. To devise mitigation strategies we need to understand why the head is striking these surfaces?

WHY IS THE HEAD STRIKING THESE SURFACES?
1. A-pillar and Front header Because most frontal accidents are offset occupants move towards point of impact structures are not designed to resist intrusion and restraints do not limit lateral and vertical movement 2. B-pillar Because occupants are close to Side impacts involve intrusion restraints do not restrict lateral motion is alongside the head 3. Roof Side Rails and Roof Because in rollovers restraints do not limit lateral and vertical movement roofs are not strong and crush is a big problem most cars and trucks have minimum headroom neck injuries result from head contacts Friedman

Offset frontal impact testing, if conducted would quickly focus attention and generate solutions to occupant protection in this mode.

Recognizing that consumers expectation includes protection in side and rollover accidents, might suggest the following mitigation measures:

MITIGATION MEASURES TO LIMIT HEAD STRIKES
A. Moving occupants inboard.
B. Padding interior surfaces.
C. Utilizing anchor points and restraints integrated into the seat.
D. Inclining and stiffening roof supports and members.
E. Adding headroom.

WHY DON'T THE RESTRAINTS LIMIT INJURIOUS CONTACT?
Lap and Shoulder Belt Harness Defects
pre-impact motion prior to retractor lock-up
inadvertent comfort feature slack
retractor skip-locking
webbing spool-out
lateral inertial motion out of shoulder harness
excessive elongation
Seat cushion and back track, hinge and padding failure
Excessive occupant soft tissue
Steering wheel and column F/D and/or intrusion
Unpadded head contact surfaces on pillars and roof
Structural intrusion

REAL WORLD CASE RESEARCH

What role do out-of-position occupants play?

As far as our 200 real world case research indicates, more than 50% (conservatively) of the victims of severe to fatal auto injury accidents fall into one of two categories: 1) They experience pre-impact motion; 2) They are overweight and/or outsized anthropometrically. These will be discussed in sequence.

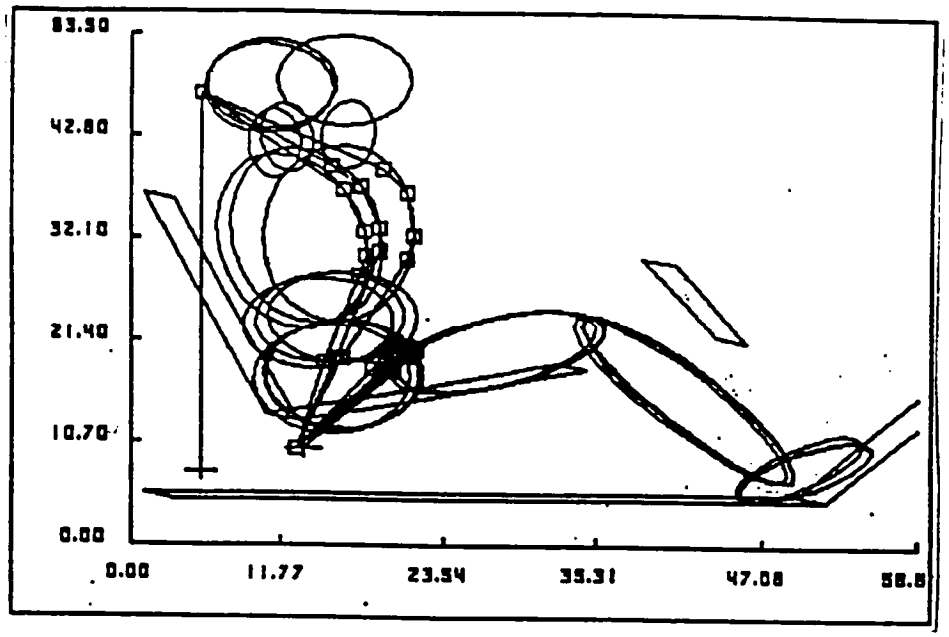
1. PRE-IMPACT MOTION

Belts in most LTV's and autos prior to the late 80's are sensitive to acceleration in the .55 to .7 g range as required by FMVSS 209. Most had sliding rather than cinching latch plate on continuous webbing from a single retractor. Beginning in about 1982 manufacturers phased out Automatic Locking Retractors (ALR's) for front seat lap belts.

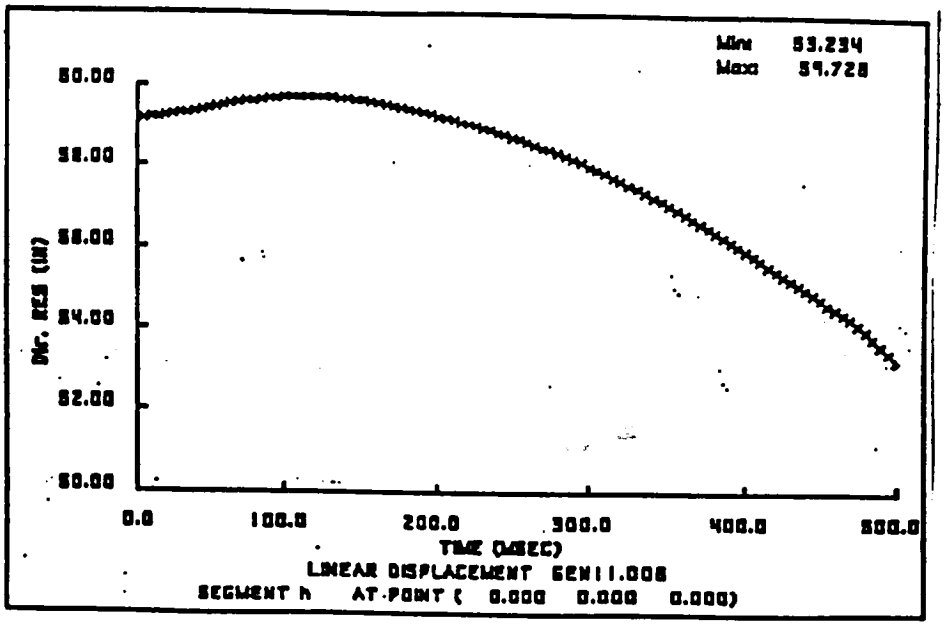
The result is that in impacts with pre-impact braking or braking and yawing, occupants experience significant upper torso motion prior to retractor lock-up, which means that webbing is extended as if it were slack which can migrate (be transferred) to the lap belt.

Pre-Impact motion prior to retractor lock-up is demonstrated in the following simulations (from computer output - we have substituted summary graphics for the purposes of this presentation).

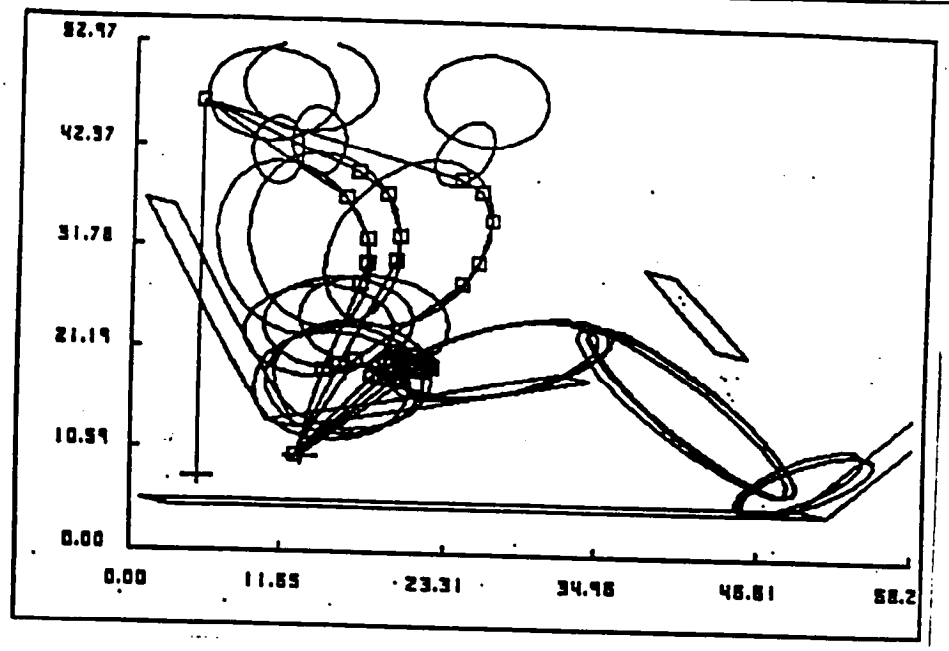
1. DYNAMAN GRAPHICS SHOWING MOTION OF OCCUPANT IN VEHICLE WITH 3-POINT RESTRAINT WHICH LOCKS AT 0.7g's EXPERIENCING 0.35g's FOR 400 ms



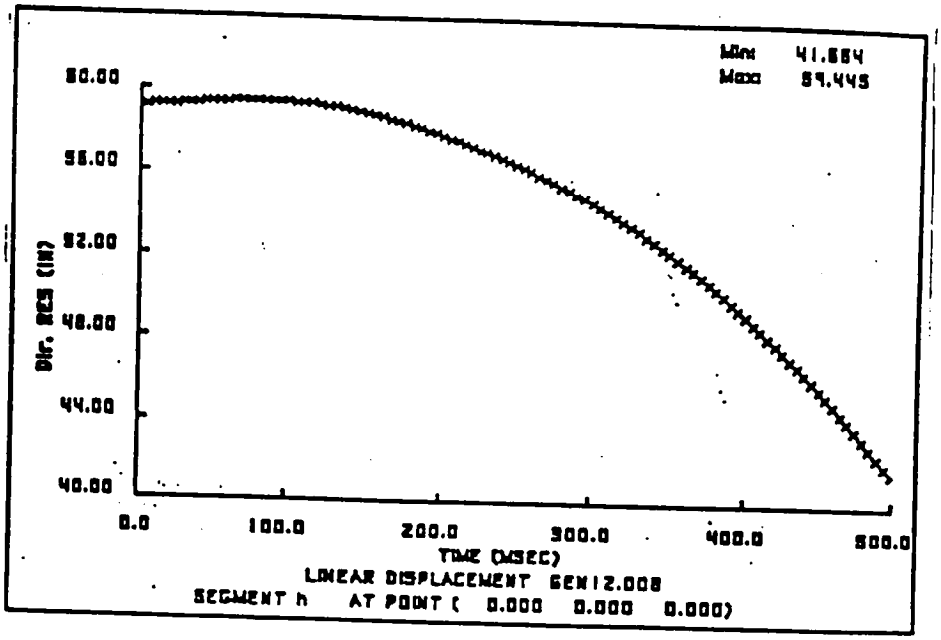
1. DYNAMAN GRAPHICS SHOWING MOTION OF OCCUPANT IN VEHICLE WITH 3-POINT RESTRAINT WHICH LOCKS AT 0.7g's EXPERIENCING 0.35g's FOR 400 ms



1. DYNAMAN GRAPHICS SHOWING MOTION OF OCCUPANT IN VEHICLE WITH 3-POINT RESTRAINT WHICH LOCKS AT 0.7g's EXPERIENCING 0.55g's FOR 400 ms

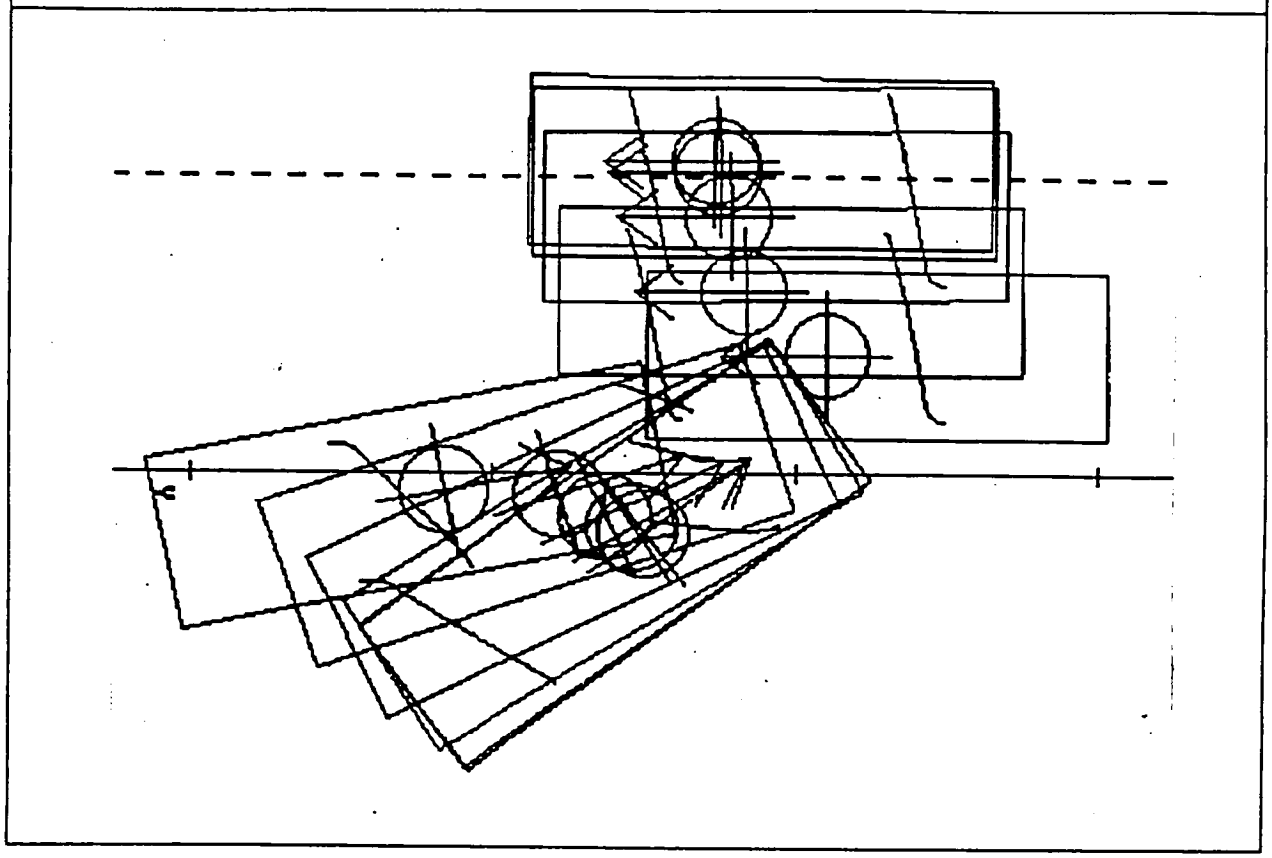


1. DYNAMAN GRAPHICS SHOWING MOTION OF OCCUPANT IN VEHICLE WITH 3-POINT RESTRAINT WHICH LOCKS AT 0.7g's EXPERIENCING 0.55g's FOR 400 ms

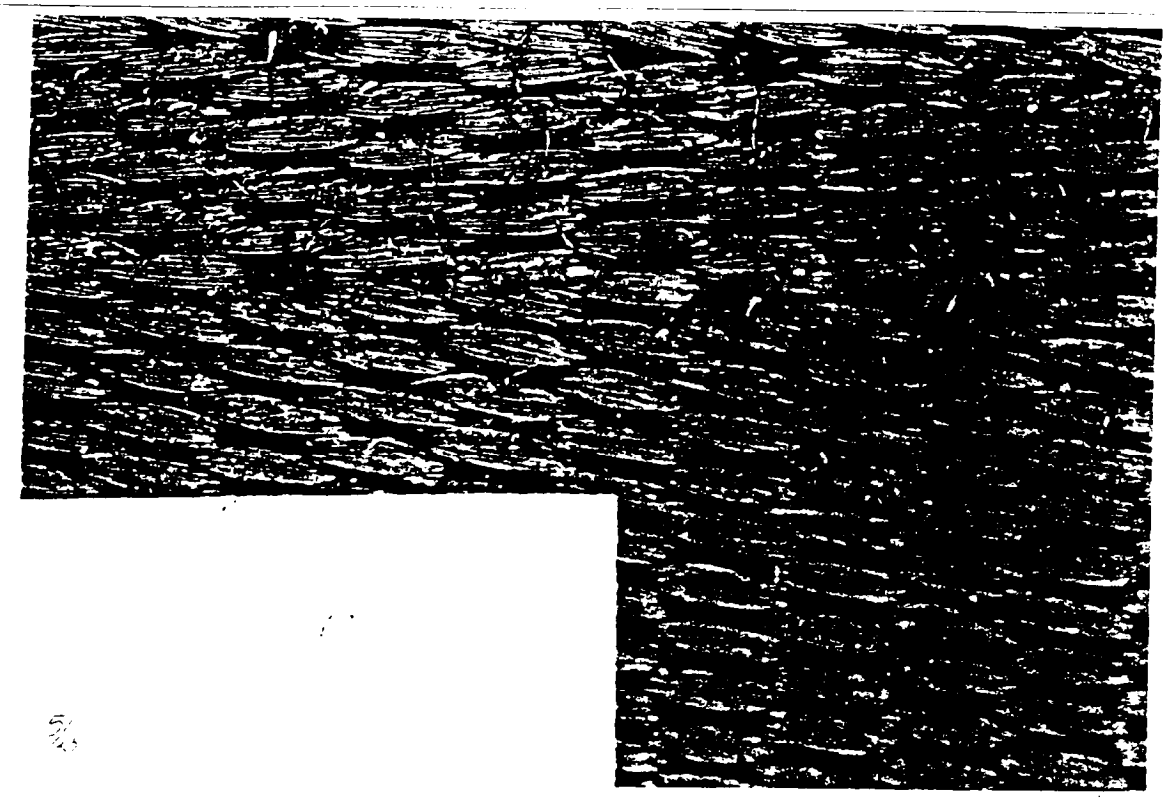


Frontal offset Case example (from computer output - we have substituted summary graphics for the purposes of this presentation).

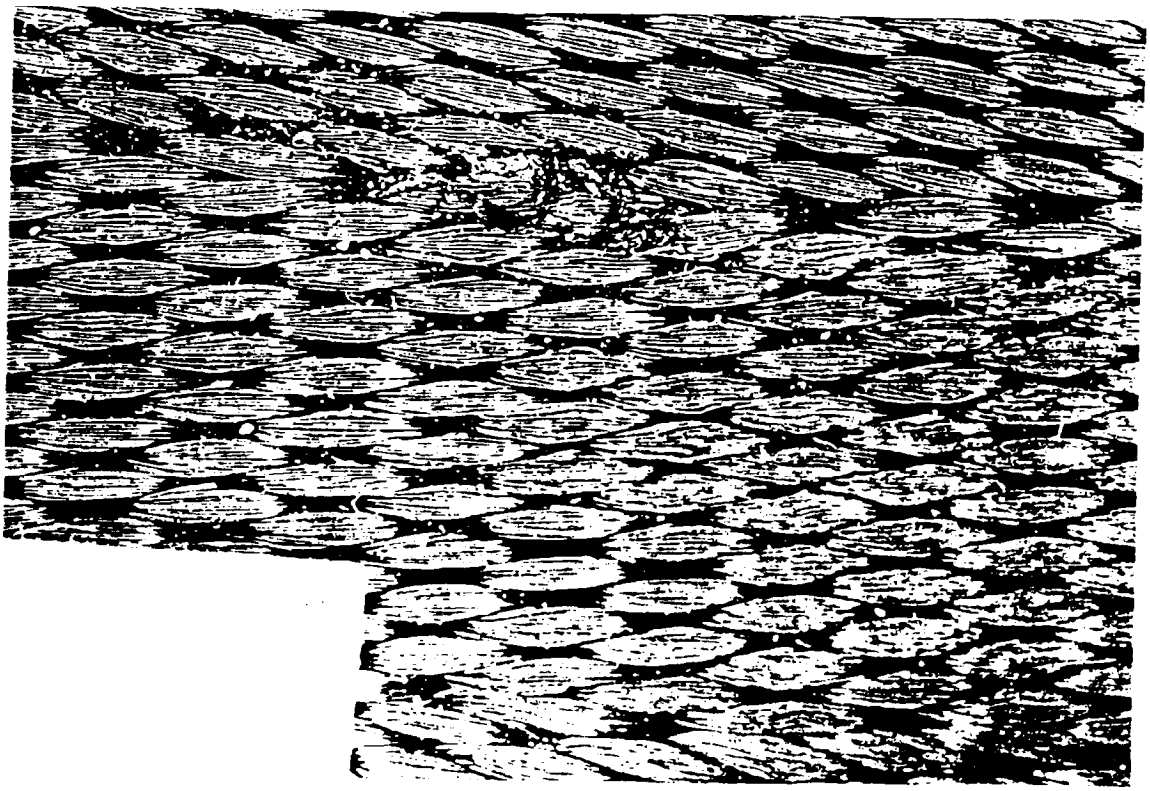
SMAC GALLERY OF FRONTAL OFFSET IMPACT



LOAD MARKING ON WEBBING FROM D-RING AT 62



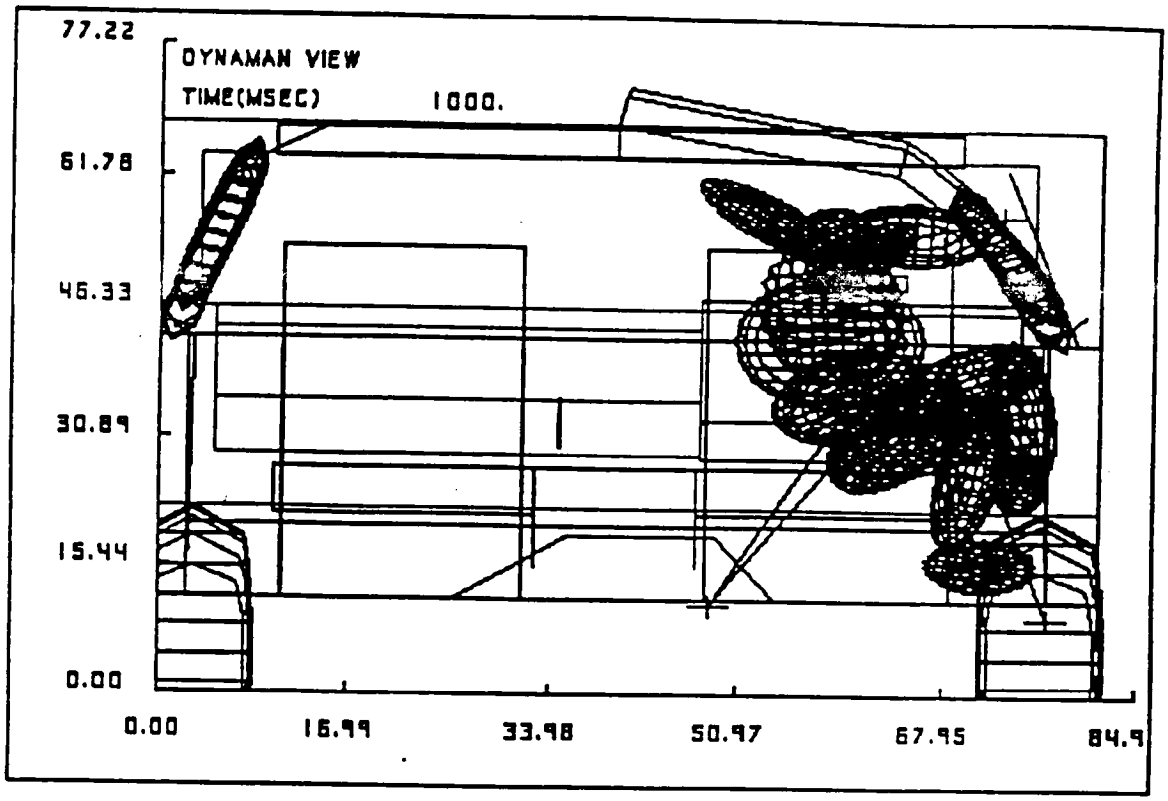
LOAD MARKING ON WEBBING FROM D-RING AT 79°



Rollover Case example (from computer output - we have substituted printed version of summary graphics for the purposes of this presentation).

DYNAMAN GRAPHICS OF PRE-ROLLOVER YAW
50 POUNDS HANDS ON WHEEL,
TORSO BELT OFF SHOULDER, EXCESS FORWARD

2B. ROLLOVER ROOF IMPACT ON RIGHT TEMPORAL/EAR



PADDED ROOF	
HIC	536 (970-990)
HEAD G's	103 @ 975
HEAD-SIDEGLASS	895/.8&100@900/930
HEAD-ROOF LF	605/.2&156@615/625
HEAD-HEADER LF	970/2.6&1493@980/985
HEAD-HEADER LR	970/2.0&738@980/990

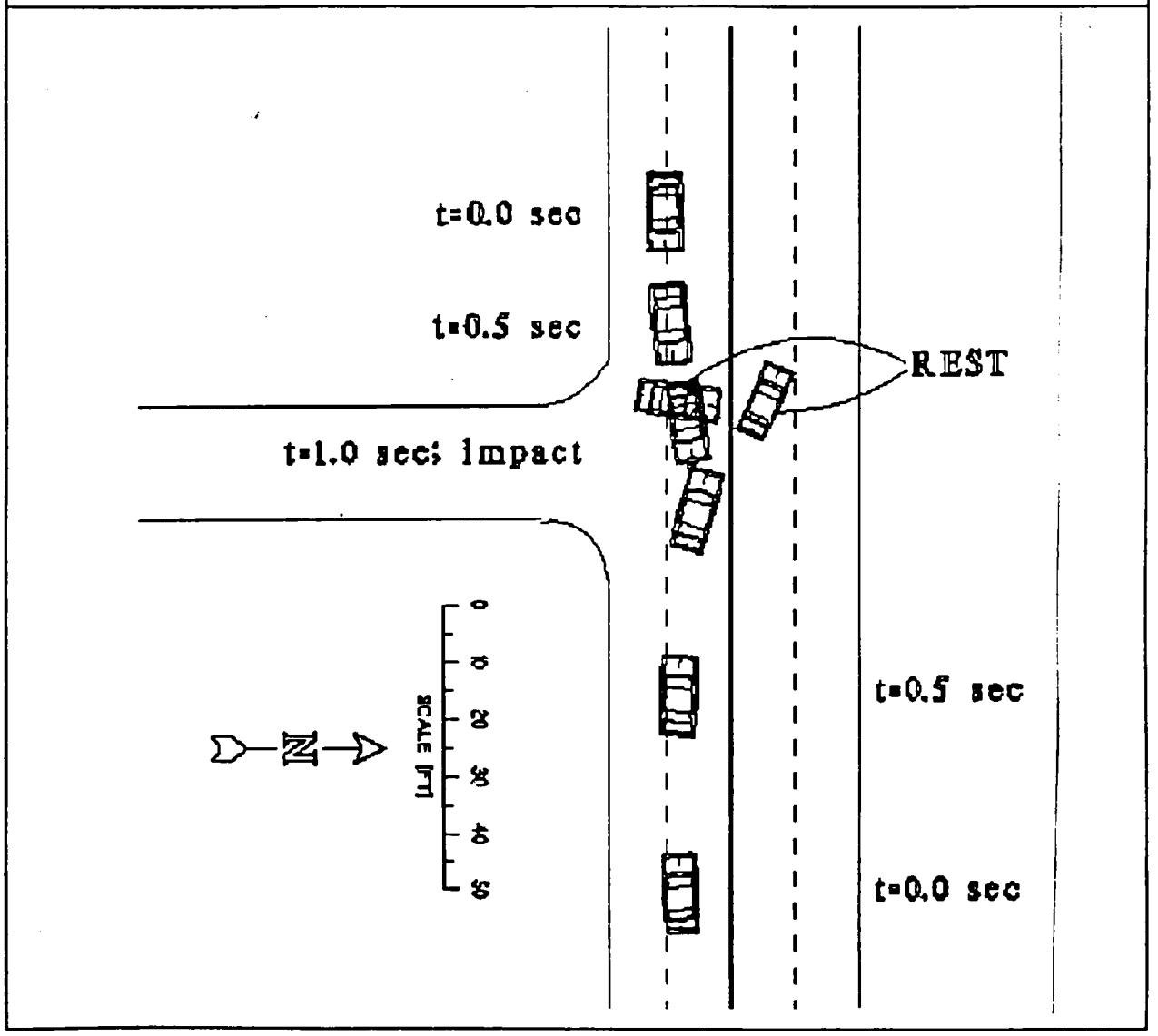
REDUCED INTRUSION	
HIC	46 (870-1020)
HEAD G's	74 @ 975
HEAD-SIDEGLASS	875/1.0&100@885/925
HEAD-ROOF LF	615/.6&27@660/690
HEAD-HEADER LF	975/.5&813@975/985
HEAD-HEADER LR	NONE

2. OVERWEIGHT AND/OR OUTSIZED ANTHROPOMETRICALLY

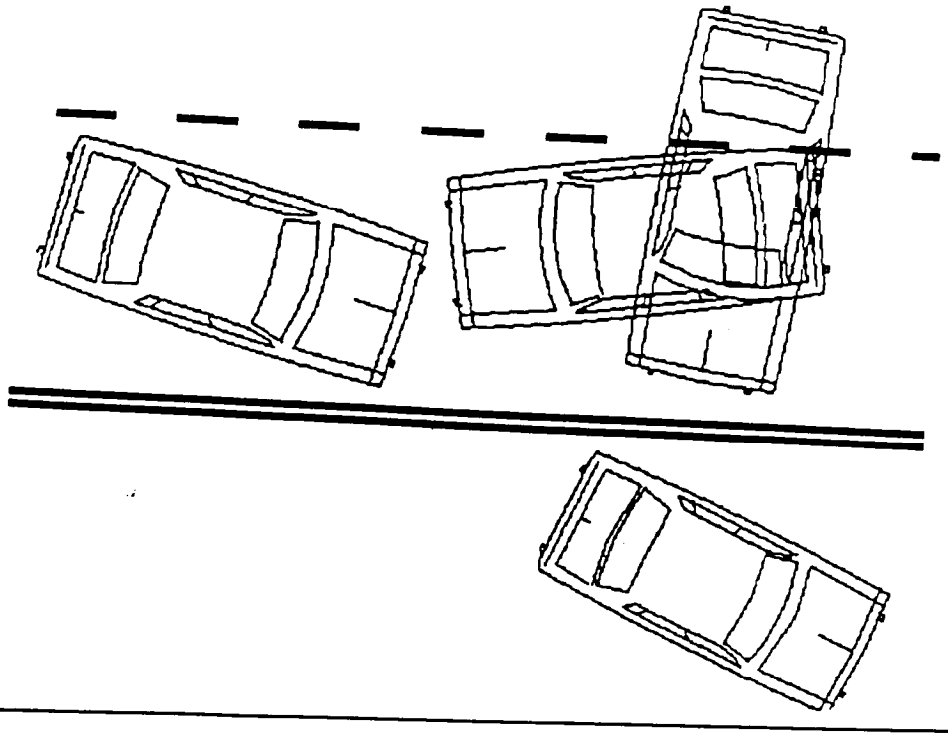
With respect to abdomen and waist more than 50% of our clients are 30 to 80 pounds overweight for their height. And that weight is soft tissue on which the belt lay rests. This has a significant effect on belted forward motion averaging an estimated 4" or the equivalent of 6" in belt slack, before the lap belt can pick-up the boney structure of the pelvis (if it can).

Frontal Case example (from computer output - substitute summary graphics in printed version)

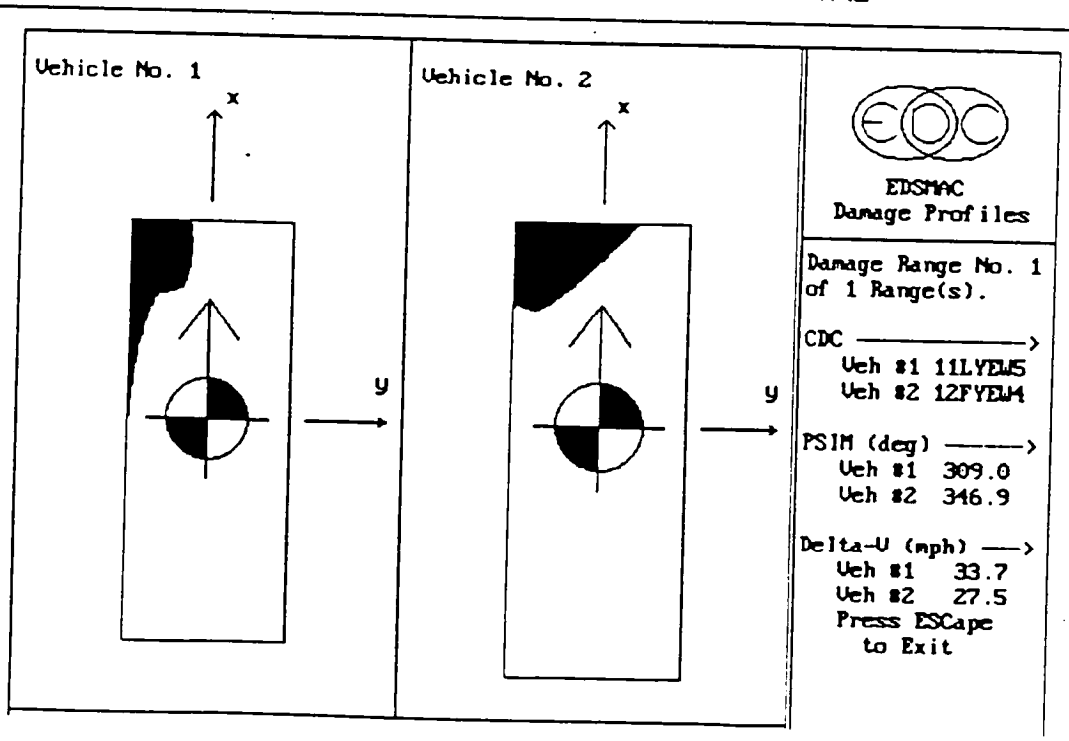
3A. SMAC GRAPHICS OF (SMITH/MCCLURE) OFFSET FRONTAL



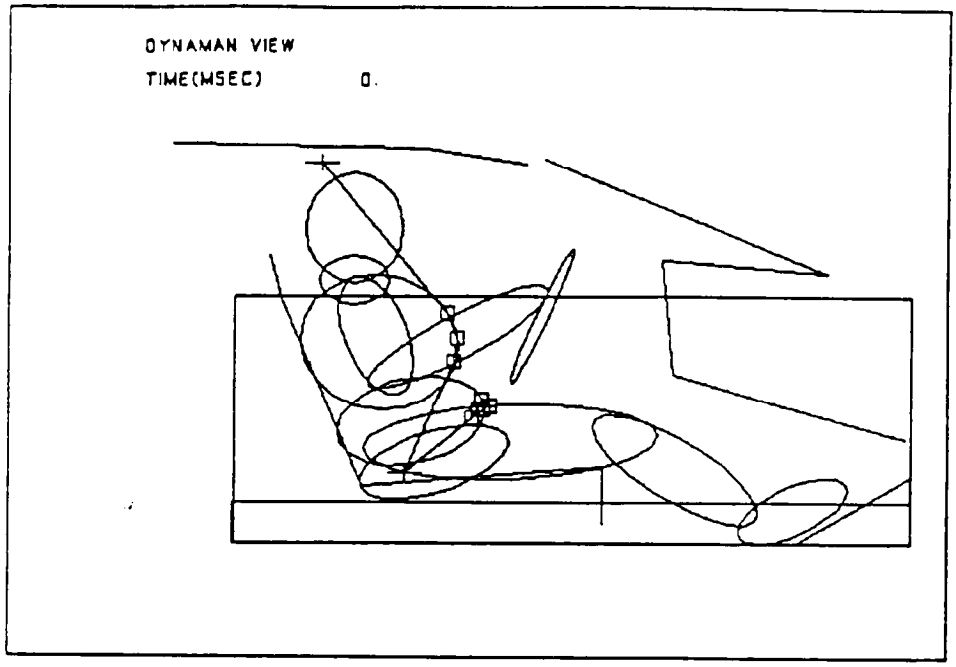
3A. SMAC GRAPHICS OF OFFSET FRONTAL



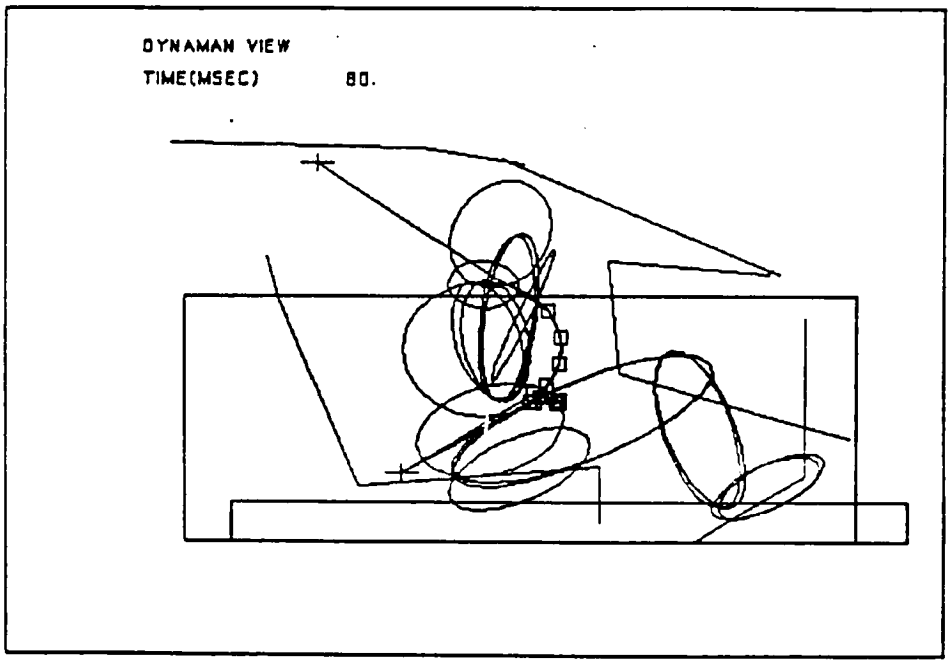
3A. SMAC GRAPHICS OF OFFSET FRONTAL



3B. DYNAMAN GRAPHICS OF OBESE 250#, 5"3" DRIVER



3B. DYNAMAN GRAPHICS OF OBESE 250#, 5"3" DRIVER



CONCLUSIONS

1. Large percentage of occupants are not represented by 50th%tile male.

2. Pre-Impact motions put occupants in position not represented by FMVSS 208 test conditions.

3. Occupant protection system design must consider the range of occupant sizes across the range of impact configurations by test.

4. Positioning adjustments and settings of anchorages, controls, pedals, steering wheel, seats and contact surfaces should be available with instructions and/or for dealer optional installation.

5. Alternative designs for compartment configuration should be considered, e.g. centralized integrated restraint seats, steering control arm rests, hand actuated throttle and braking.

References

DPvpl

outpos.doc

DISCUSSION

PAPER: **Out-Of-Position Occupant Injury Mitigation**

SPEAKER: Donald Friedman, Liability Research

QUESTION: Dr. Channing Ewing, Snell Memorial Foundation

I thought that was a very thought-provoking paper, but I don't agree that lateral restraints are effective in all cases. As a matter of fact, in recent years, they have been putting in some pretty effective lateral restraints. But you can't restrain the neck with the belt and the experience we had at the Naval Biodynamics Laboratory was that, if you had to restrain the body by putting a belt on, you're going to hit either side of your neck and you shouldn't do it at all. What we had to use was the shoulder board and what the automobile manufacturers have been putting in, I think is a good idea. It is a lateral bolster on either side of the passenger seat. The seat that you showed there had no such bolster and the net result is that you do have lateral capability. In this case, the effect of the seatbelt is simply to keep the torso between the bolsters.

A: I agree with you. That is perfect. I agree also and I thought I made that point at the end, that there are a variety of things we can do on the interior of the vehicle to provide some effective lateral restraint. I would also make the point, however, that we're losing a lot of people in rollovers and the extension of the restraints that allow us to use up the headroom before you even have completed a roll is not a good idea.

Q: Get a rope.

A: OK.

Q: Saami J. Shaibani, Lynchburg, VA

Don, I have a comment and then a question to follow. I found the lateral and the extent of it incredibly similar to the amount that I saw in the paper that I presented earlier and the fact that the model is picking up on that is encouraging, especially when you recognize that most modeling design is heavy, predicated or biased by getting the frontal impacts right, so I think that's encouraging. That's my comment. My question is out of the priorities that you've suggested here, what ranking, what do you think can be done in the immediate practical sense? You listed a whole number thing, some of which are probably a whole lot more ambitious, or radical, I think was the word you used. Can you give us a sense as to what can be done in the first instance and what the graduation in that might be?

A: Yes. It is my view that the first thing that we need to do is to get factors to admit that there is a problem. See, I don't think there is anything that I can suggest that these people don't already know. I think the problem is that there is no regulatory requirement to deal with it and so it's not dealt with. I think that there is now, for instance, or will be soon, a regulatory requirement to deal with padding of the A-post, B-post, roof rail, roof complex and that padding will compensate to some degree for deficiencies in the restraint system, whether those deficiences are because of something wrong with the retractor or

because they are out of position and, from a head injury point of view, obviously there are a significant number of such things. If I had my druthers, I would take as a first position, beyond including the padding, is finding a way to characterize the interior in its entirety by, of course, deflection properties. In other words, the steering wheel has been softened a lot and, at least as far as the rim is concerned, I have noticed that we don't have airbags. There have been some force-limiting padding put in the hubs, but I think that the whole question of why the steering wheel is there may succumb in the future to some alternative means so that we don't contact it. I think Chrysler's view about moving the "a" pillars forward, their forward concept design or something. Get them so that you don't hit them. Whether you're restrained or unrestrained, do what you can to provide the impact protection. That's my best suggestion.

Q: Just a quick follow-up Don. I know it's difficult to put all your ideas down, but can I encourage you to put a Don Friedman Wish List at the end of your paper so that we can get some sense from the important wheel-welled axle population that you've examined. Where do you think immediate efforts need to be made?

A: OK. Well, thank you.