MINICARS, INC.

35 LA PATERA LANE ● GOLETA, CALIFORNIA 93017 ● TELEPHONE (805) 964-6271

RESEARCH SAFETY VEHICLE

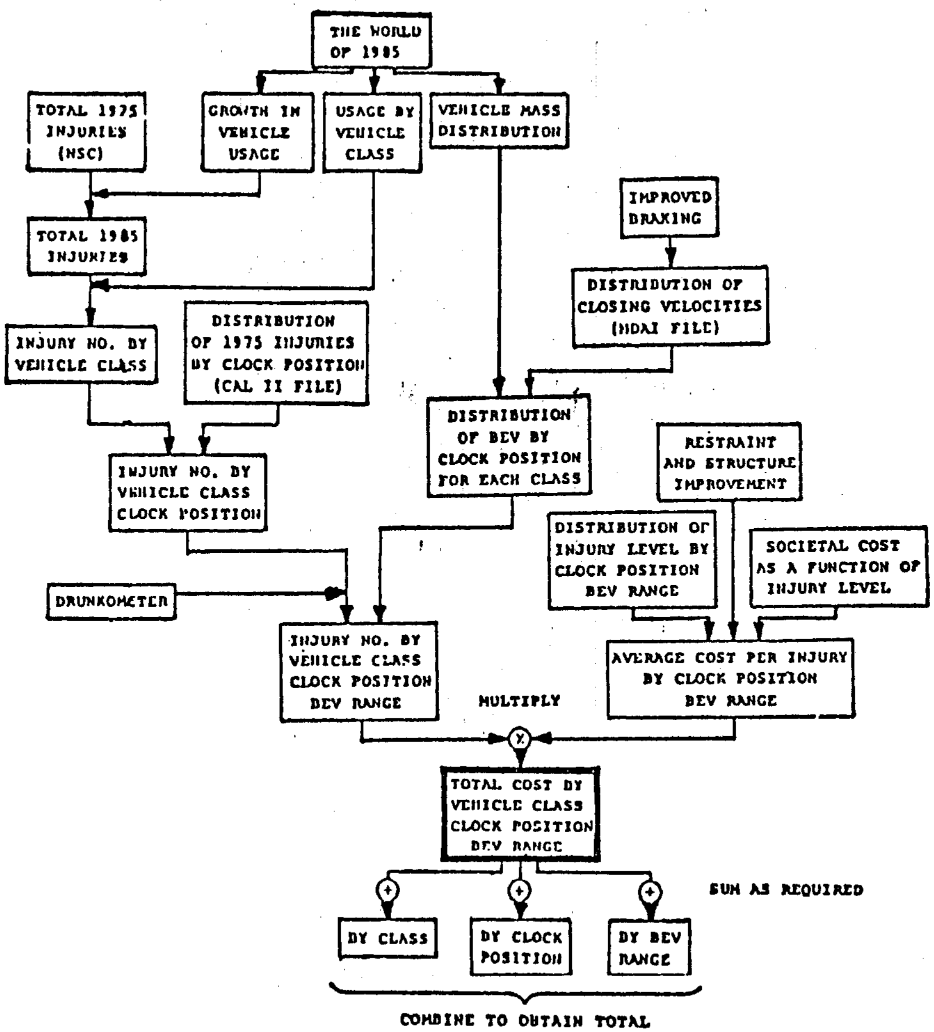
PHASE I

ACCIDENT ANALYSIS METHODOLOGY

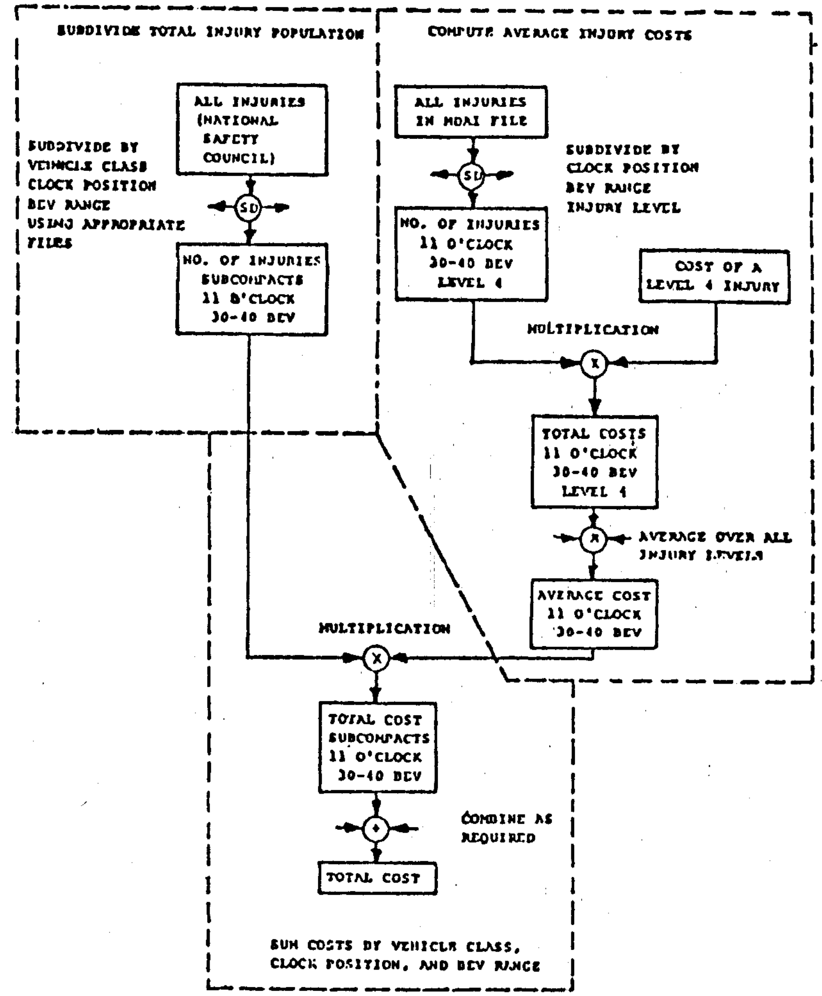
Abstracted from RSV Phase I Briefing

May 1, 1974

SOCIETAL COST METHODOLOGY

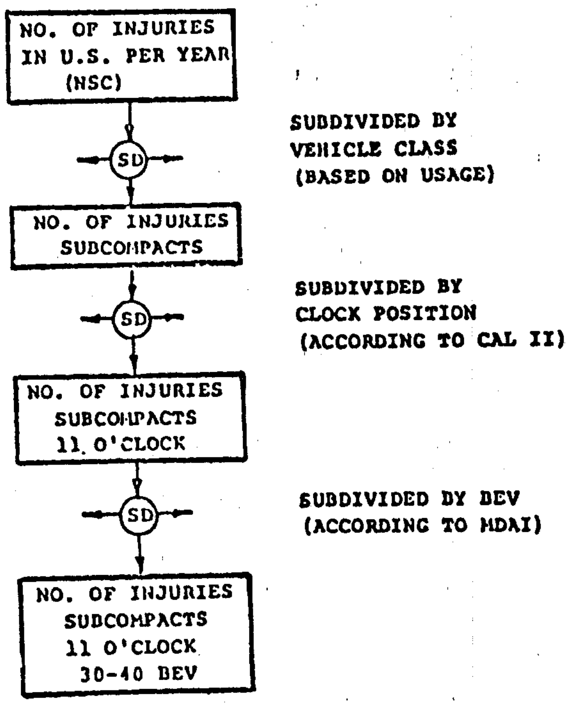


NOW FOR MORE DETAILS ON THE BENEFIT/COST METHODOLOGY. NOTE THAT THE MAJOR INPUTS ARE: (A) FUTURE AUTOMOTIVE PROJECTIONS (ACCIDENT EXPOSURE AND VEHICLE MASSES); (B) TOTAL NUMBER OF INJURIES, BY VEHICLE CLASS, CLOCK POSITION, AND VELOCITY; (C) DISTRIBUTION OF CLOSING VELOCITIES; AND (D) THE EFFECTS OF VEHICLE IMPROVEMENTS ON THESE QUANTITIES.

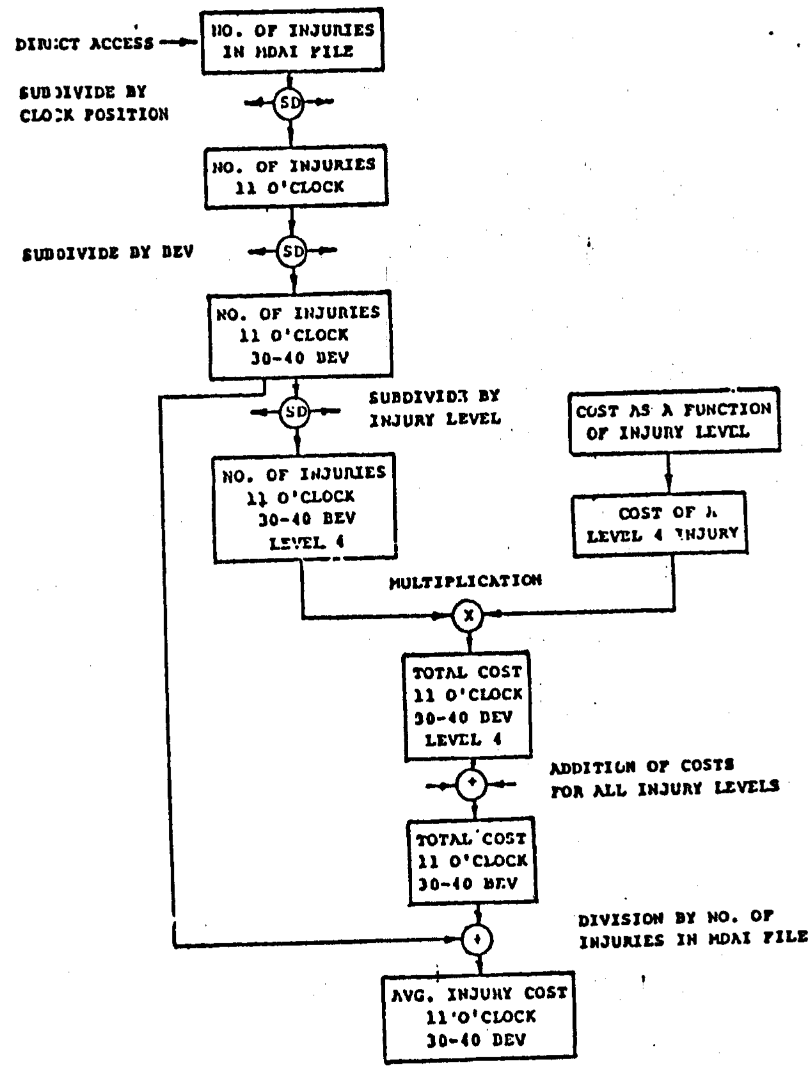


THE BASIC METHODOLOGY HAS THREE PARTS: FIRST, THE INJURY POPULATION IS SUBDIVIDED; SECOND, THE AVERAGE INJURY COST IS COMPUTED IN EACH STATISTICAL CELL; AND THIRD, THE FREQUENCY AND SEVERITY ARE MULTIPLIED FOR EACH CELL, AND THE RESULTS ARE COMBINED AS REQUIRED.

SUBDIVISION OF TOTAL INJURY POPULATION

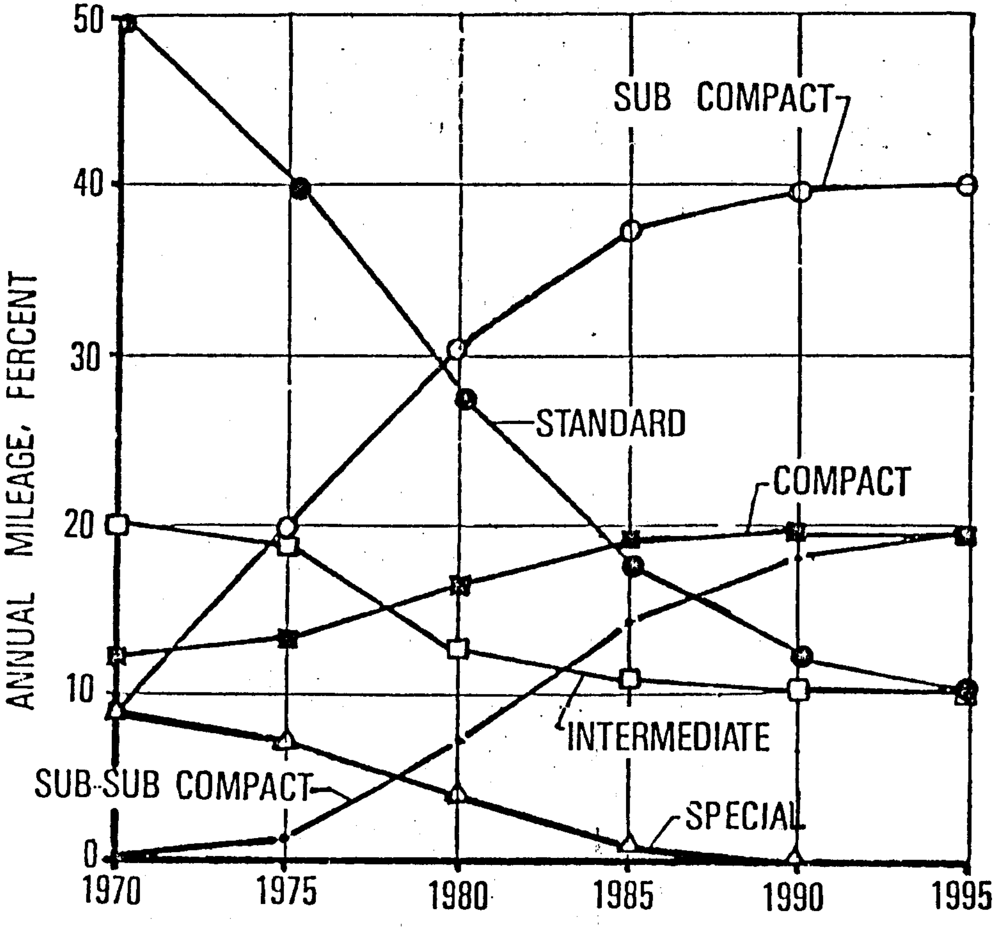


SUBDIVISION OF THE INJURY POPULATION INVOLVES DIFFERENT ACCIDENT FILES, ACCORDING TO THEIR SIZE AND DETAIL. BIASES IN THE MDAI FILE ARE CORRECTED SO THAT THE APPROPRIATE DISTRIBUTION OF SEVERE AND MILD INJURIES IS PRESENT IN EACH VELOCITY RANGE AND CLOCK POSITION.

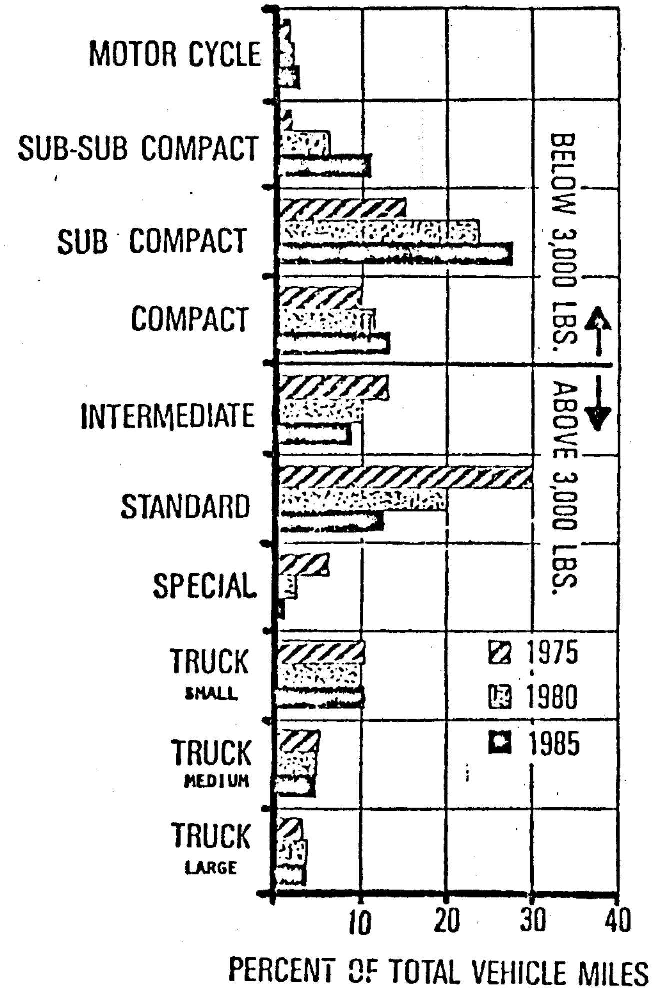


THE CALCULATION OF AVERAGE INJURY COST IS BASED ON EXAMINING EACH VELOCITY RANGE-CLOCK POSITION CELL, AND SUBDIVIDING IT ACCORDING TO INJURY SEVERITY, AS MEASURED BY THE AMA INJURY LEVEL. COSTS ARE ASSIGNED TO EACH INJURY LEVEL, SO THE AVERAGE COST DEPENDS ON THE DISTRIBUTION OF INJURY LEVELS IN EACH CELL.

AUTO USAGE BY CLASS

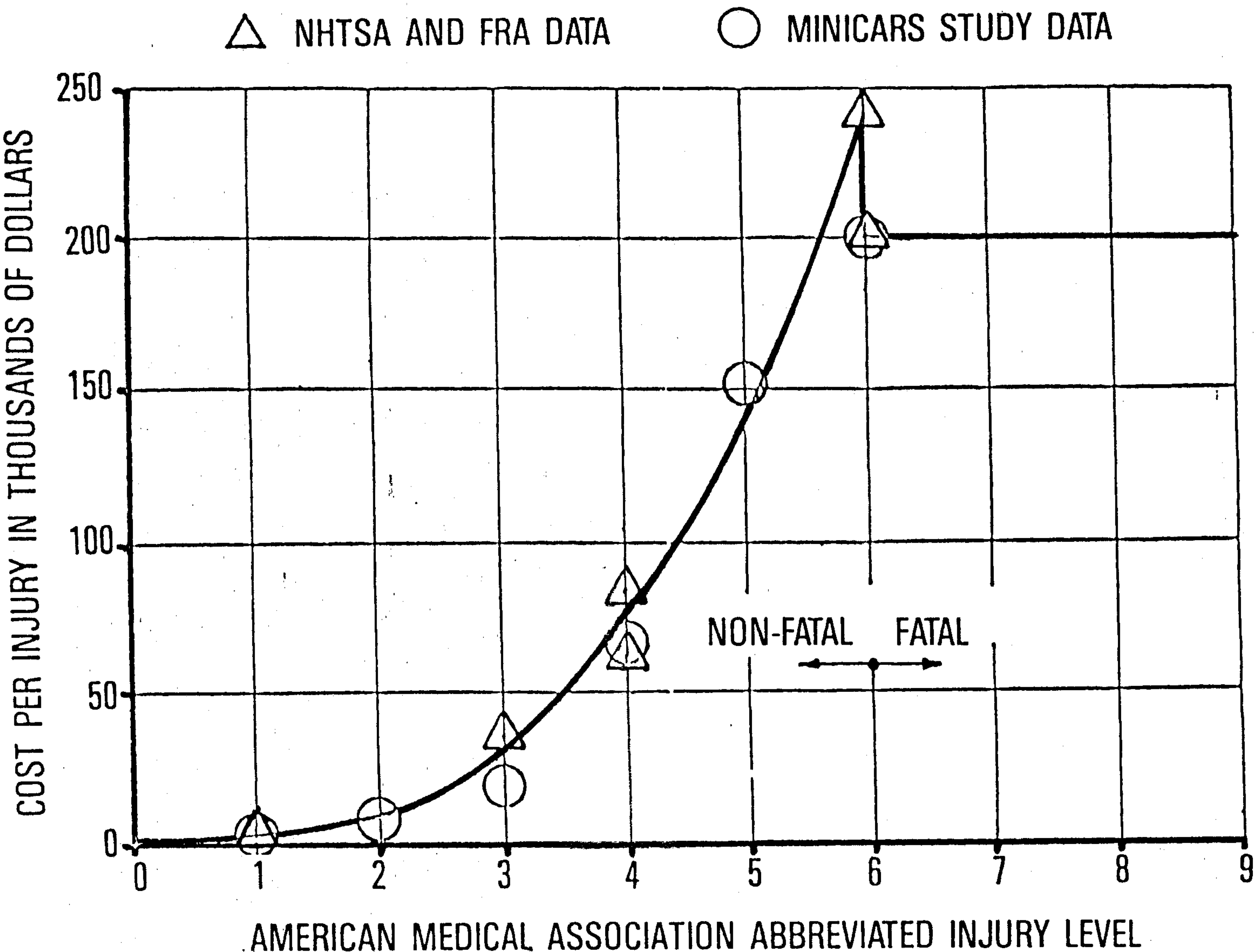


IN EACH VEHICLE CLASS, THE NUMBER OF INJURIES DEPENDS STRONGLY ON THE NUMBER OF VEHICLES. THIS IS CALCULATED FROM YEARLY SALES PROJECTIONS AND SCRAPPAGE RATES.



ACCIDENT EXPOSURE IS PROPORTIONAL TO VEHICLE USAGE, IN VEHICLE-MILES PER YEAR. USAGE TRENDS DIFFER SLIGHTLY FROM CAR POPULATION TRENDS BECAUSE NEW CARS ARE DRIVEN MORE THAN OLD ONES. IN 1985, SUBCOMPACTS WILL COMPRISE 36 PERCENT OF THE POPULATION, BUT WILL PRODUCE 38 PERCENT OF THE INJURIES. COMPARED TO HEAVIER CARS, THESE INJURIES WILL TEND TO BE MORE SEVERE, AND THE COSTS WILL BE HIGHER.

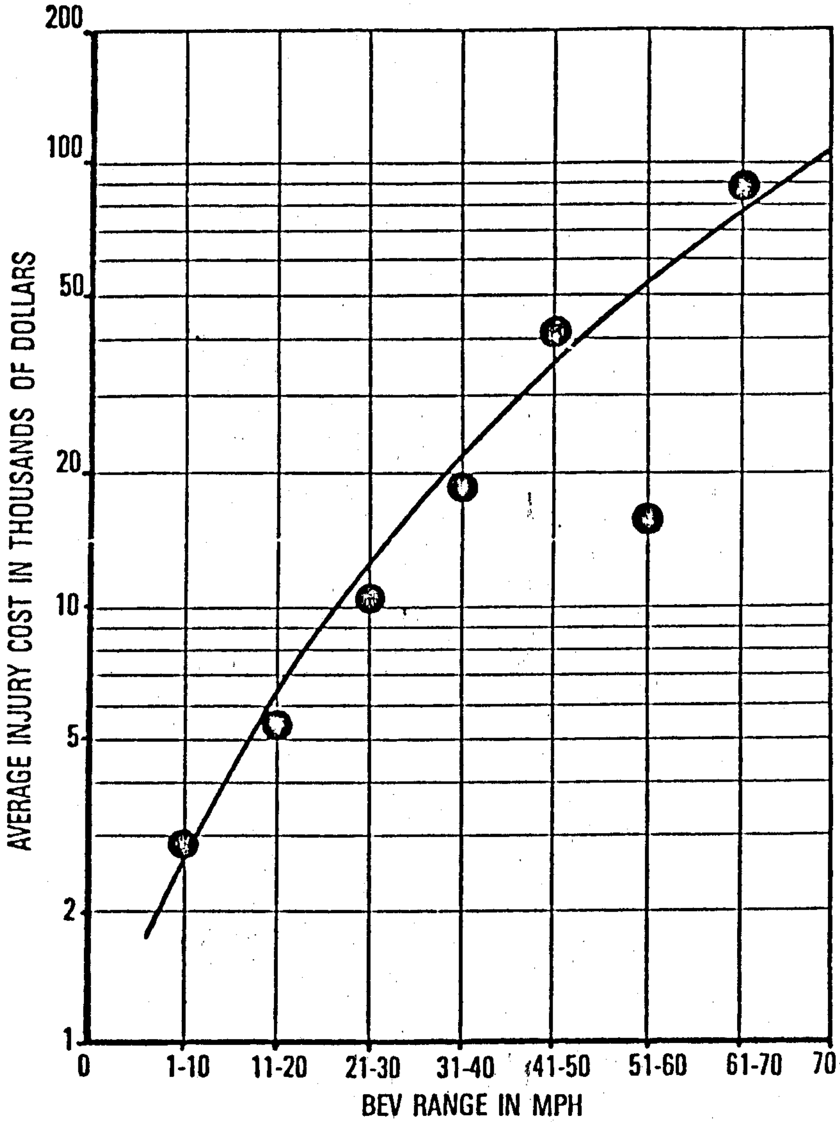
SOCIETAL COST VERSUS AMA INJURY SCALE



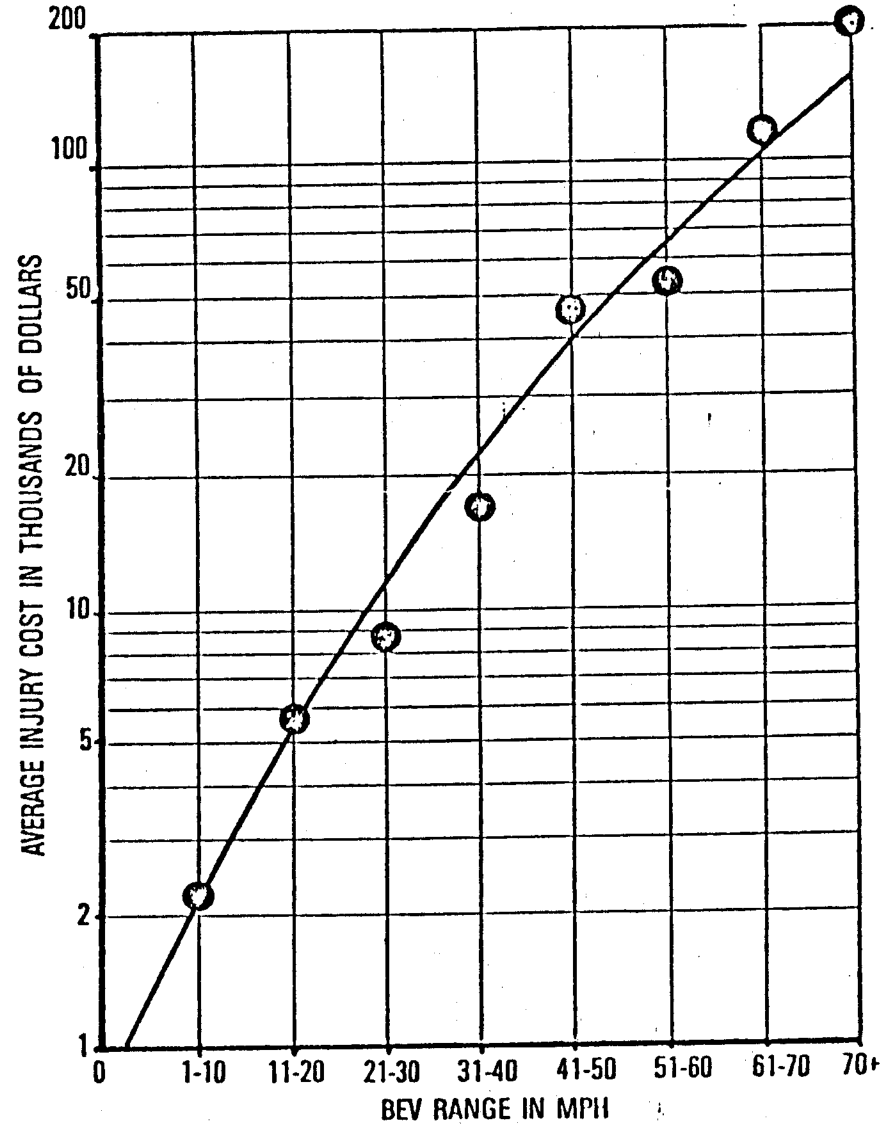
COSTS ARE CALCULATED FOR EACH INJURY LEVEL ON THE AMA ABBREVIATED INJURY SCALE, IN WHICH 1 THROUGH 6 ARE INJURIES OF INCREASING

AVERAGE INJURY COST IN A GIVEN STATISTICAL CELL DEPENDS ON THE DISTRIBUTION OF THESE INJURY LEVELS IN THE CELL.

VEHICLE TO VEHICLE FULL FRONTAL IMPACTS

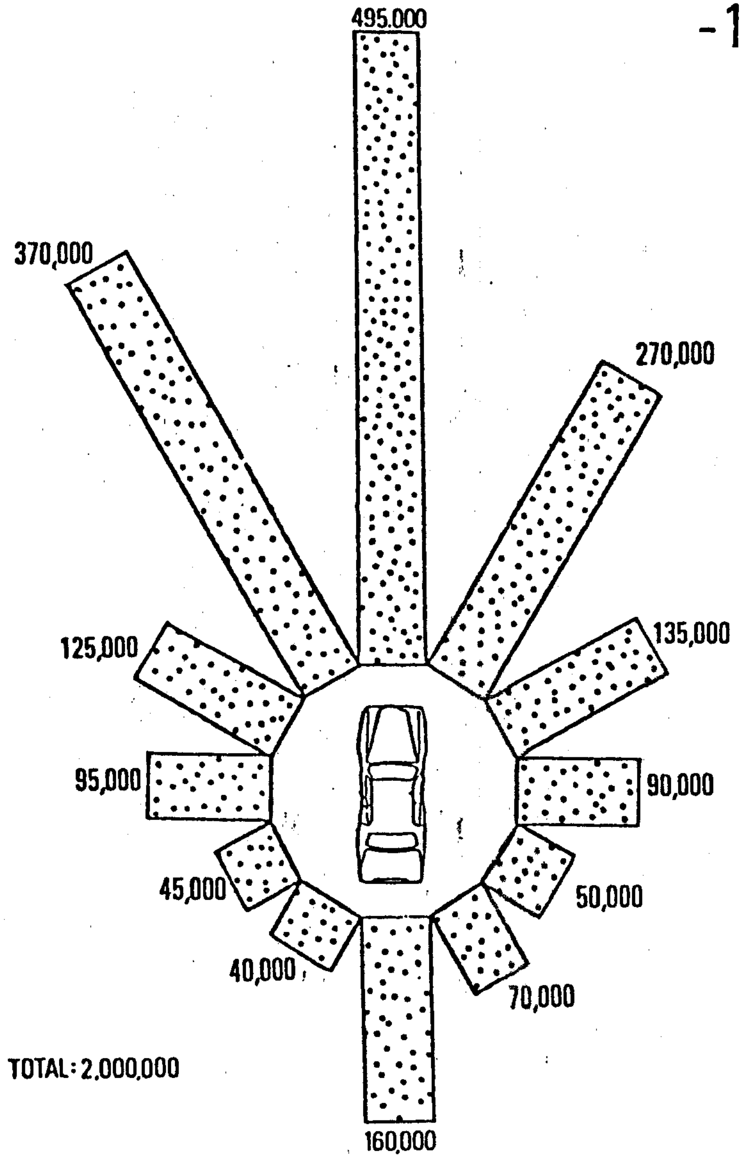


FIXED OBJECT FRONTAL IMPACTS



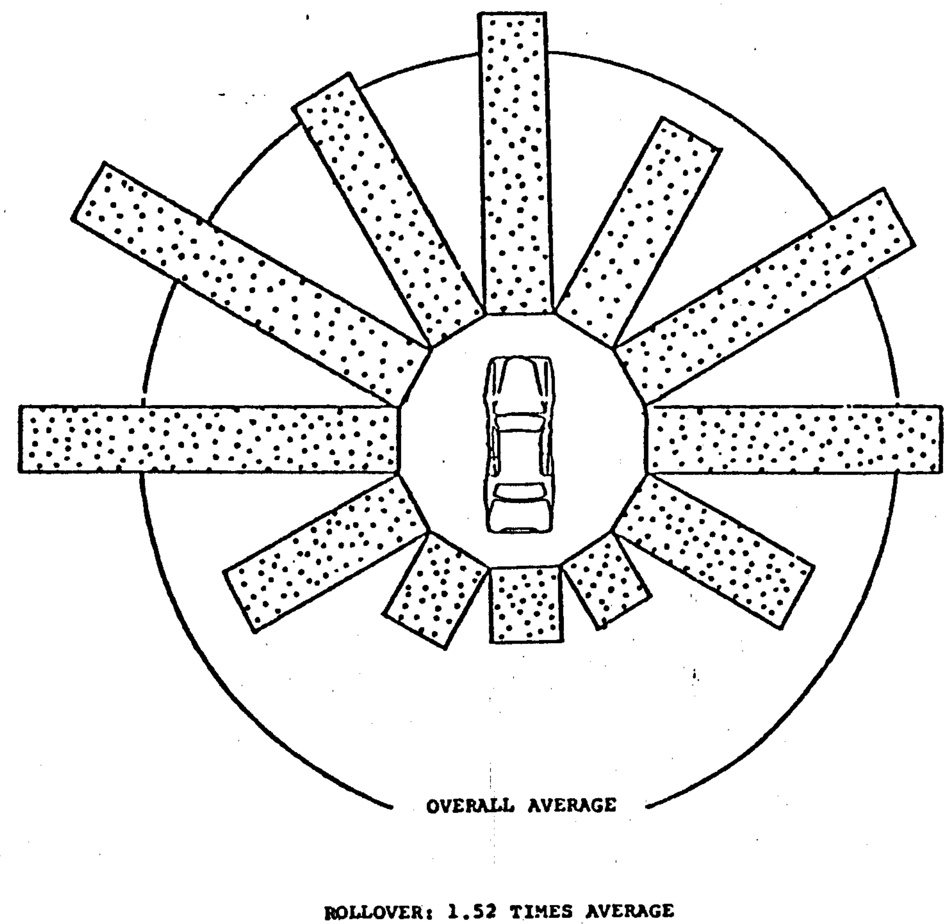
AVERAGE INJURY COST IS A FUNCTION OF VELOCITY AND ACCIDENT MODE (CODED BY CLOCK POSITION, FOR VEHICLE-TO-VEHICLE AND FIXED-OBJECT CRASHES). A MONOTONIC RELATIONSHIP WITH VELOCITY IS EXPECTED, THOUGH SMALL SAMPLE SIZES AT THE HIGHER VELOCITIES CAUSE SOME SCATTER. THE SAME COST CURVES ARE USED FOR ALL CLASSES, BUT SMALL CARS TEND TO GET INTO HIGHER-VELOCITY ACCIDENTS, DUE TO THEIR MOMENTUM DISADVANTAGE. SMALL CAR COSTS THUS TEND TO BE HIGHER.

NUMBER OF INJURIES BY CLOCK POSITION--1975



TOTAL SOCIETAL COSTS DEPEND ON BOTH THE FREQUENCY (NUMBER OF INJURIES) AND THE SEVERITY (AVERAGE INJURY COST). EACH CLOCK POSITION DENOTES AN AREA OF DAMAGE WHICH DESCRIBES THE ACCIDENT MODE.

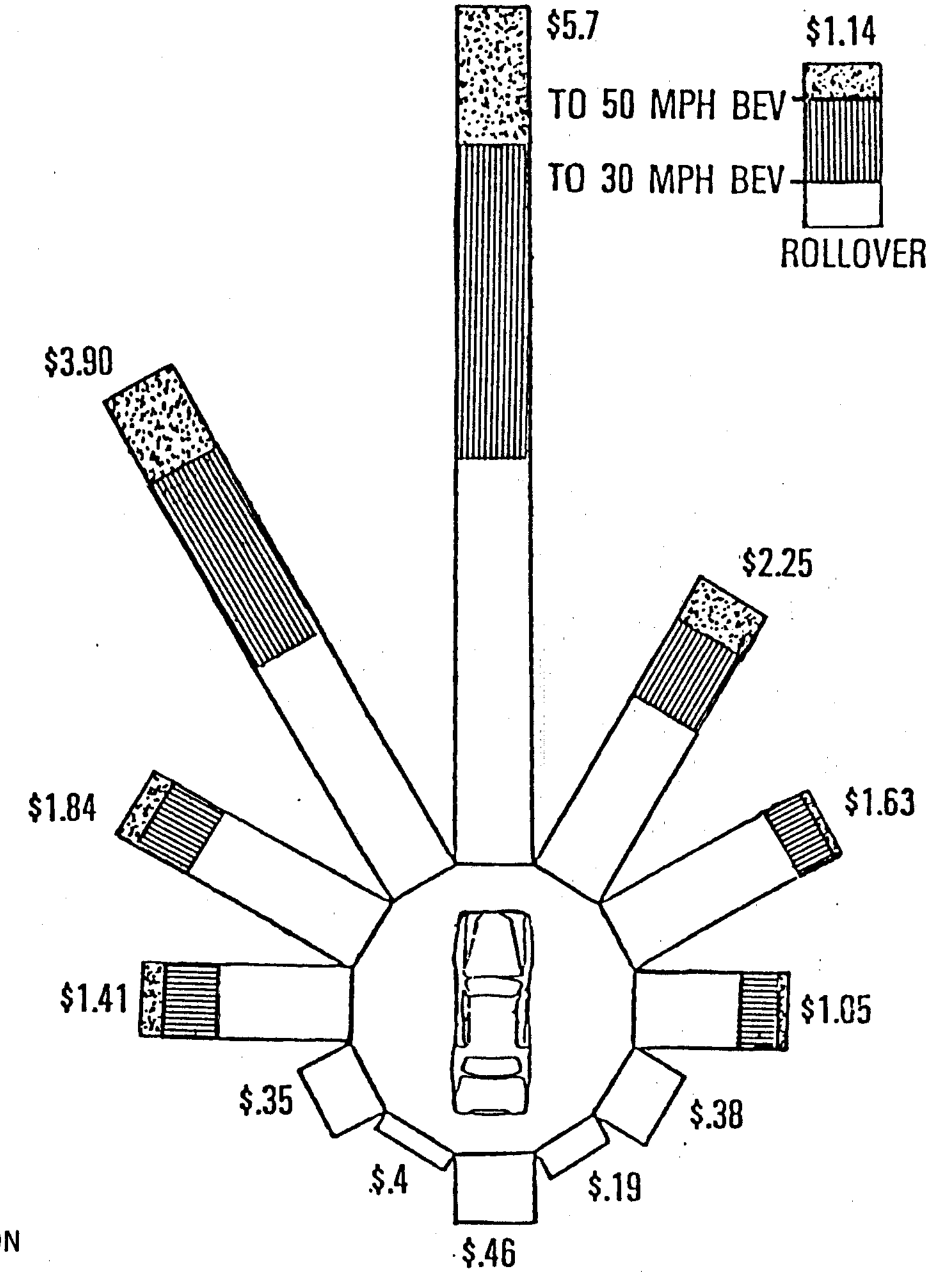
RELATIVE SEVERITY BY CLOCK POSITION



NOTE THE DIFFERENCES BETWEEN FREQUENCY AND SEVERITY FOR THE VARIOUS MODES. THE PRODUCT OF THE TWO IS THE SOCIETAL COST. THESE CLOCK POSITION CHARTS ARE SUMMED OVER ALL VEHICLE CLASSES AND ALL VELOCITY RANGES.

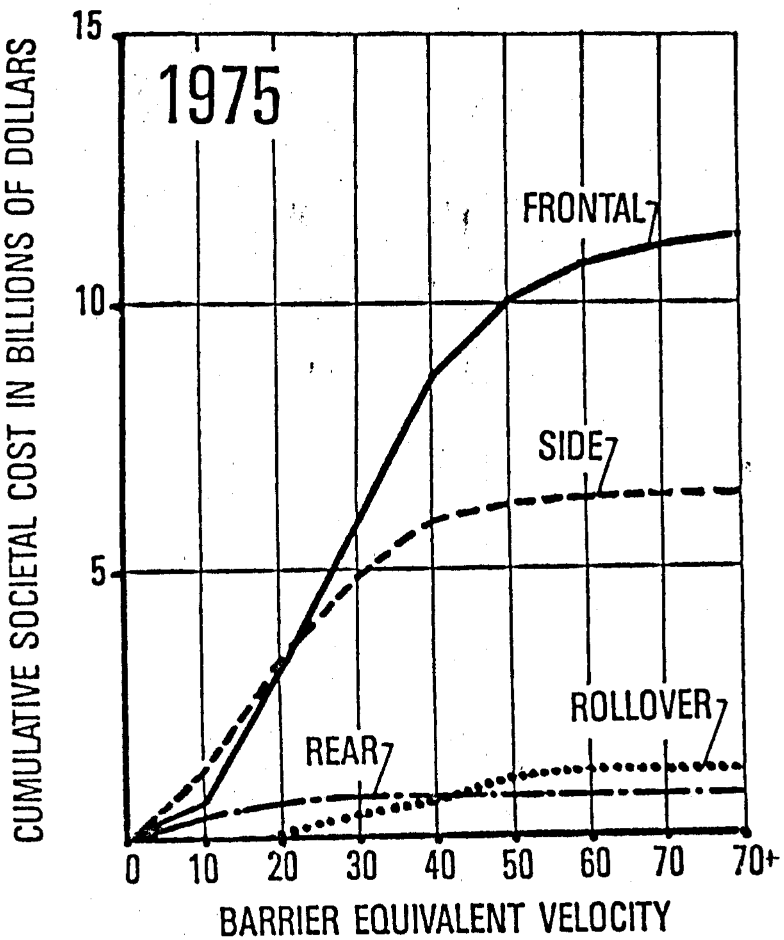
SOCIETAL COST BY CLOCK POSITION—1975

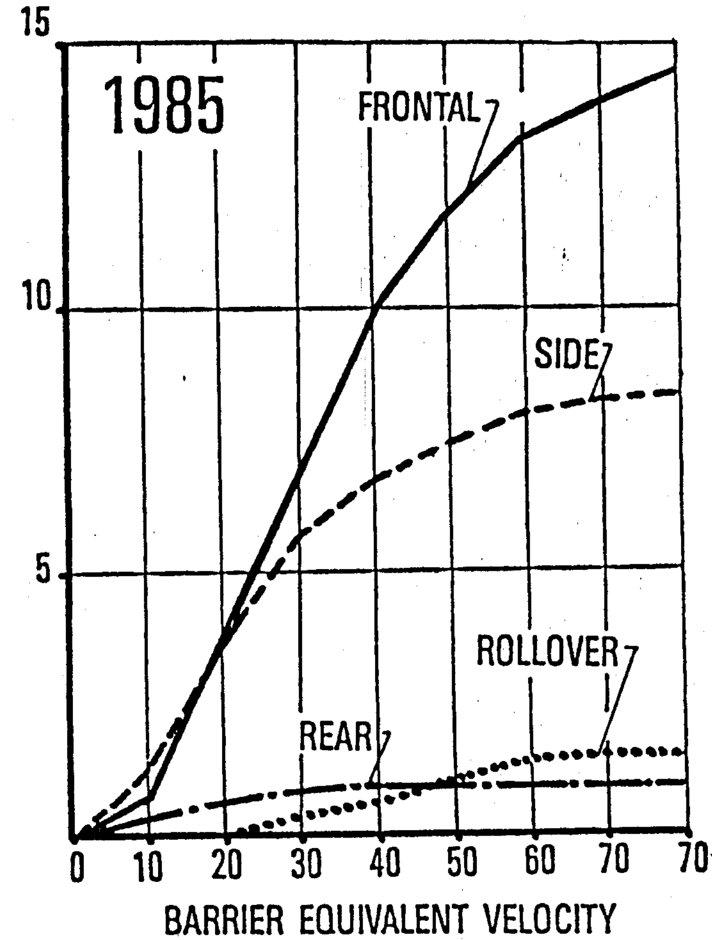
COST IN BILLIONS OF DOLLARS



TOTAL SOCIETAL COST, FOR ALL VEHICLE CLASSES, IS SHOWN AS A FUNCTION OF CLOCK POSITION AND VELOCITY. THIS COST IS DUE TO OCCUPANT INJURIES ONLY; YET THE TOTAL IS $20.44 BILLION ANNUALLY.

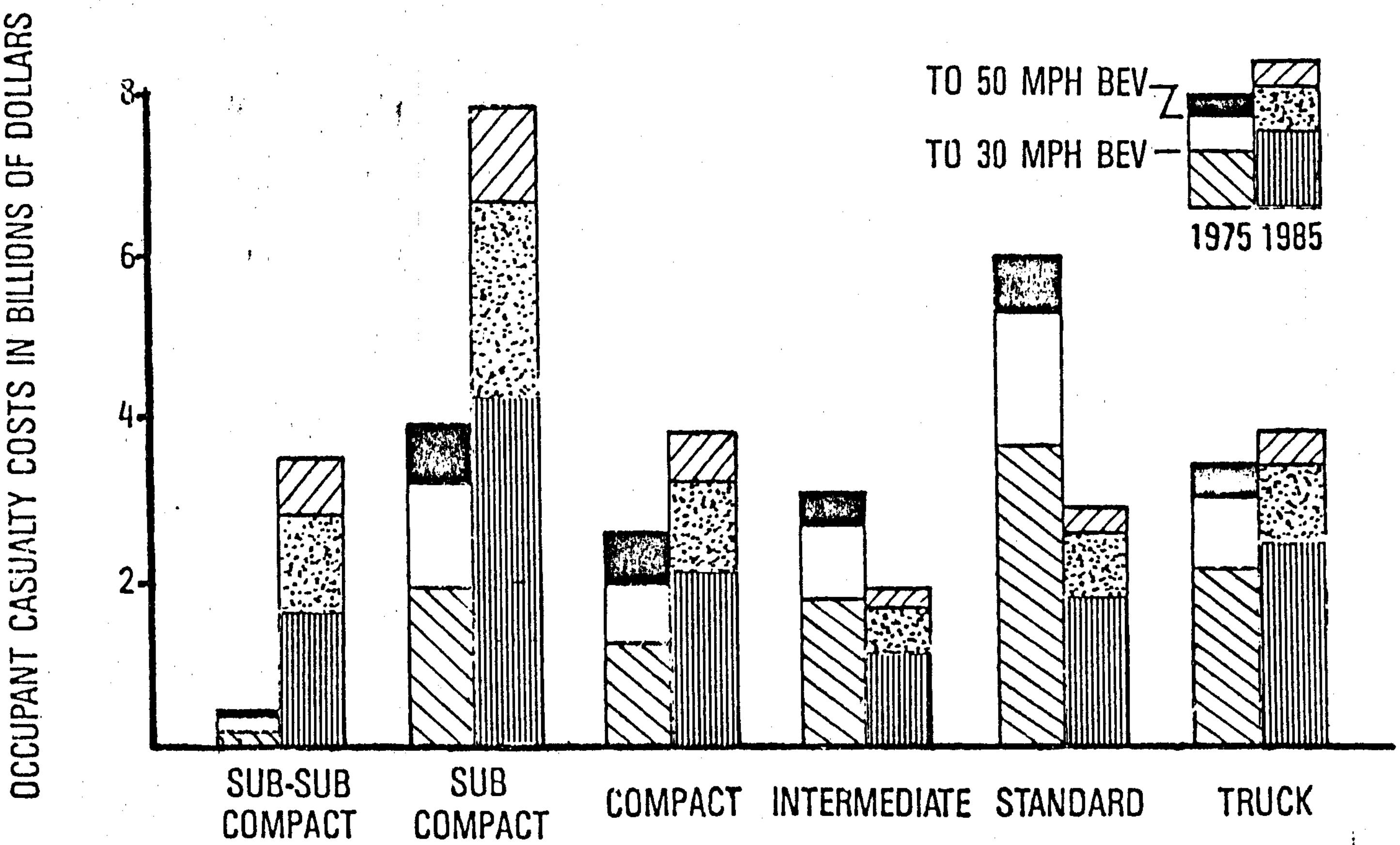
CUMULATIVE SOCIETAL COST BY VELOCITY FOR EACH ACCIDENT MODE





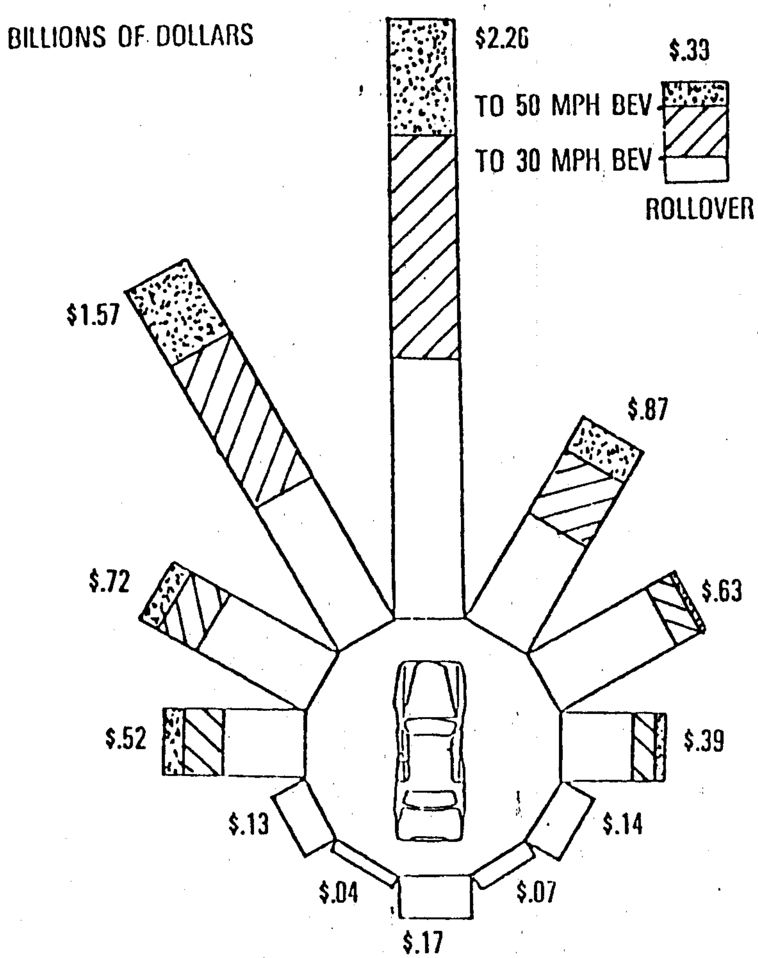
VELOCITY DISTRIBUTIONS AID IN ESTABLISHING VELOCITY PERFORMANCE GOALS. IF COSTS ARE TO BE REDUCED SUBSTANTIALLY, 50 MPH FRONTAL PERFORMANCE AND 30 MPH SIDE PERFORMANCE ARE WARRANTED, ESPECIALLY IN 1985. BETWEEN NOW AND THEN, THE COST OF OCCUPANT INJURIES WILL INCREASE BY 21 PERCENT.

SOCIETAL COST OF ACCIDENT INJURIES BY CAR CLASS, 1975-1985



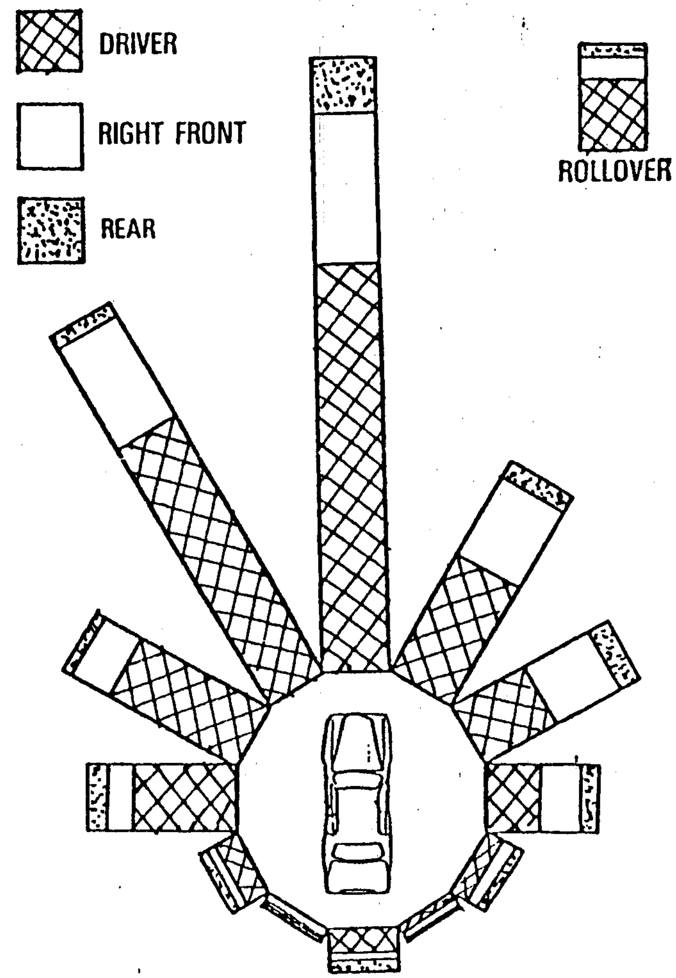
THE BRUNT OF THIS INCREASE TO $24.74 BILLION ANNUALLY WILL BE CARRIED BY SMALL CARS. THEIR SHARE WILL GROW FROM 35 TO 61 PERCENT, WITH SUBCOMPACTS ALONE RISING FROM 19 TO 26 PERCENT. SINCE THE RSV IS DESIGNED FOR THE GREATEST PUBLIC GOOD, IT IS AIMED AT THE SUBCOMPACT CLASS, AS A MINIMUM. NOTE ALSO THE LARGER PORTION OF COSTS ABOVE 50 MPH FOR SMALL CARS, WHICH JUSTIFIES HIGHER SPEED PERFORMANCE FOR THOSE VEHICLES.

SOCIETAL COST BY CLOCK POSITION – 1985
SUBCOMPACT CLASS ONLY

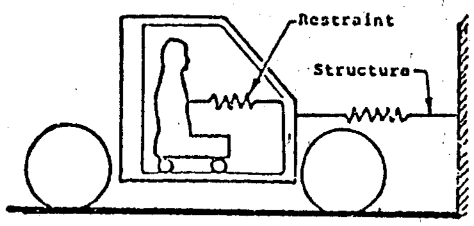


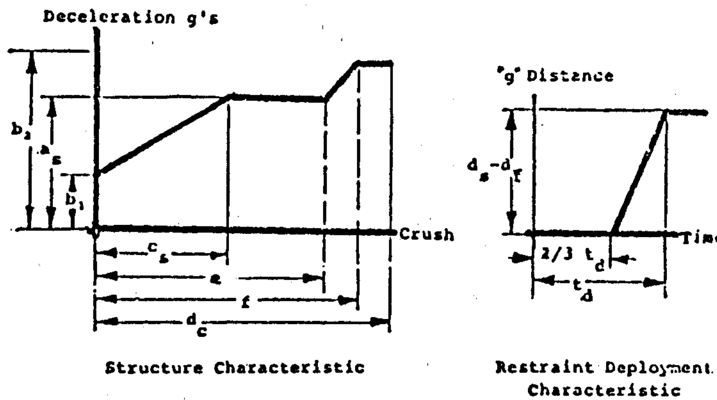
THESE ARE THE COSTS THAT ARE AMENABLE TO REDUCTION BY IMPROVEMENTS IN 1985 SUB-COMPACTS. 30 MPH PERFORMANCE WILL BE ADEQUATE IN THE SIDE, BUT CERTAINLY NOT IN THE FRONT.

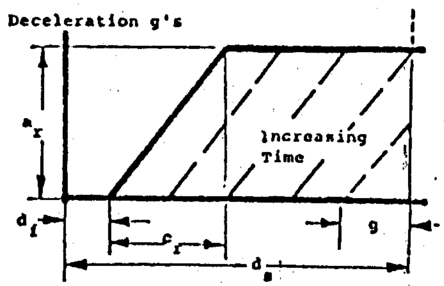
SOCIETAL COST BY SEAT POSITION



NOTE THE PREPONDERANCE OF COSTS FOR THE DRIVER COMPARED TO OTHER SEATING POSITIONS (DUE TO OCCUPANCY, PRIMARILY). DIFFERENT RESTRAINT PERFORMANCE AND COST ARE THUS JUSTIFIED FOR VARIOUS POSITIONS.

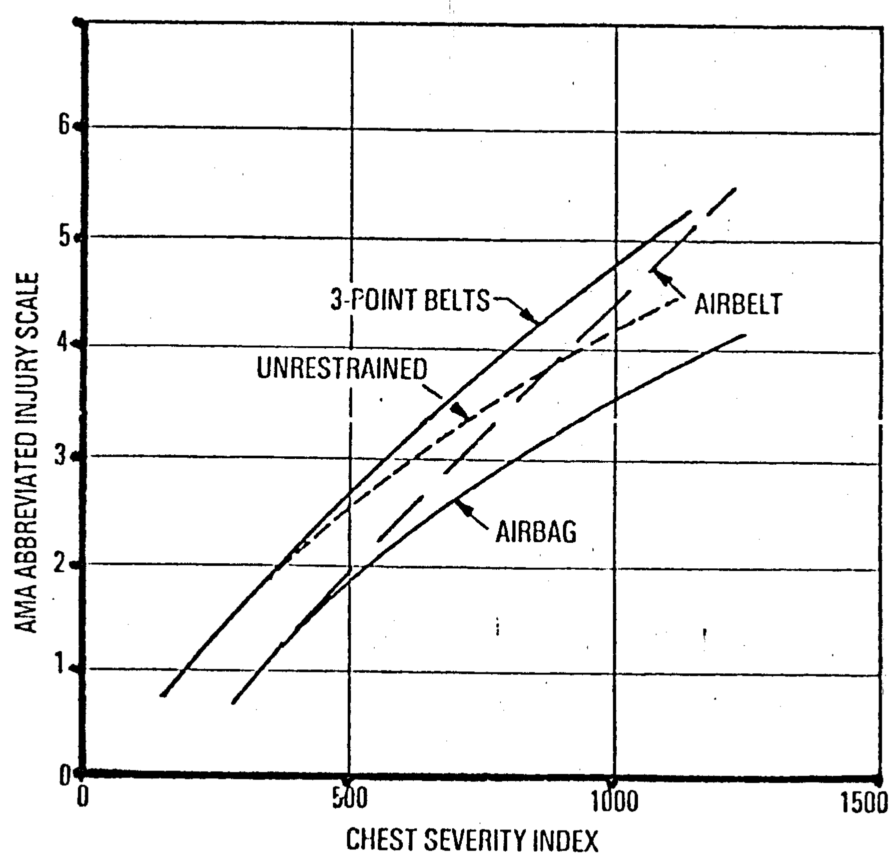






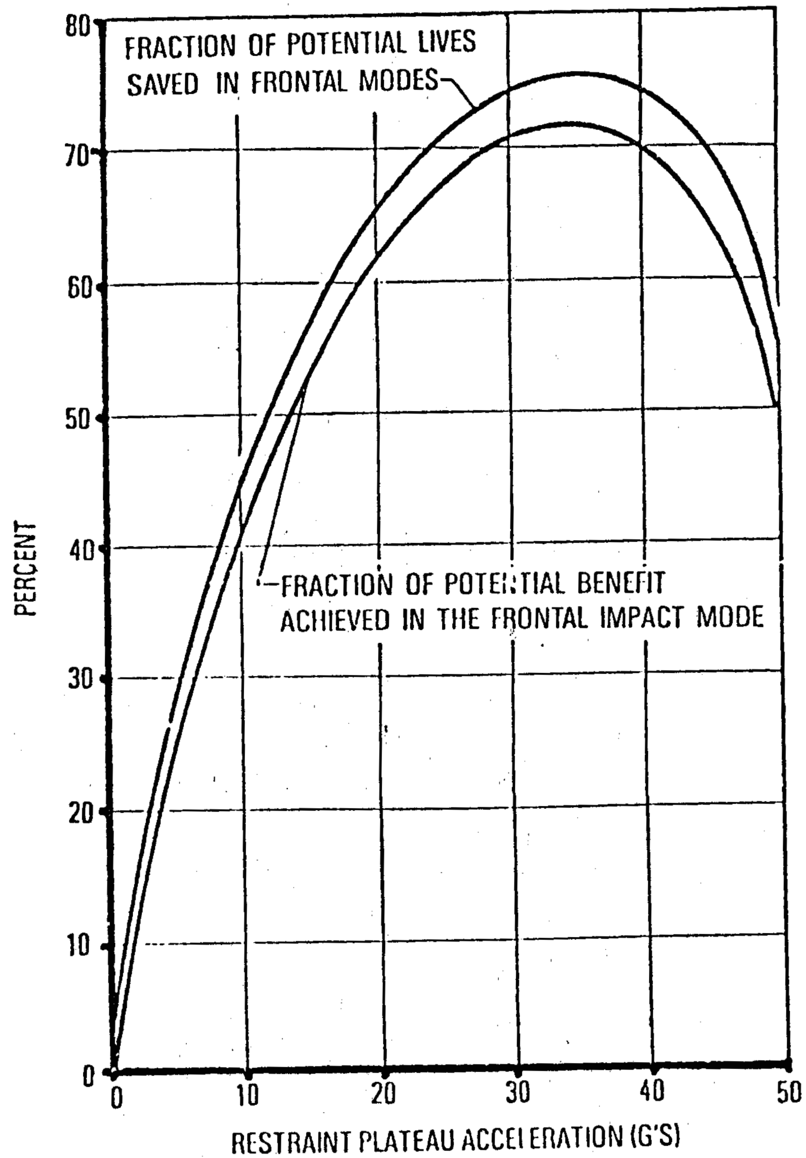
BENEFITS OF STRUCTURE AND RESTRAINT IMPROVEMENTS ARE CALCULATED BY RUNNING A SIMPLE COMPUTER SIMULATION IN 1 MPH INCREMENTS FROM 1 THROUGH 80 MPH, AND CALCULATING THE RESULTING CHEST SEVERITY INDEX (CSI) IN EACH CRASH. OBLIQUE AND CAR-TO-CAR IMPACTS ARE SIMULATED BY ADJUSTING THE STRUCTURAL FORCE-DEFLECTION CURVE APPROPRIATELY. RESTRAINT FORCE IS A FUNCTION OF BOTH TIME AND OCCUPANT STROKE.

AIS VS CSI



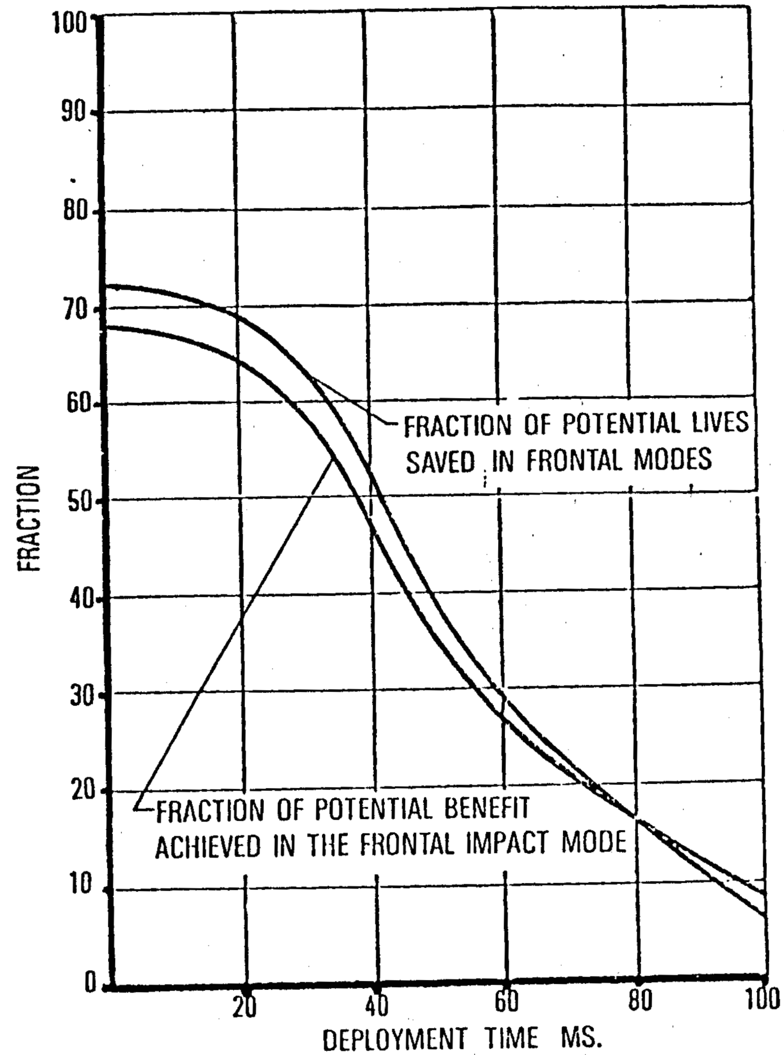
THESE CURVES ALLOW THE CONVERSION FROM TEST PARAMETERS (CSI) TO REAL-WORLD PARAMETERS (AMA INJURY LEVEL), AND THENCE TO SOCIETAL COST. DIFFERENCES IN THE CURVES ARE DUE TO LOAD DISTRIBUTION; AN AIRBELT DOES NOT DISTRIBUTE LOADS AS WELL AS AN AIRBAG, BUT TENDS TO PRODUCE LOWER CSI'S BECAUSE OF SUPERIOR DEPLOYMENT TIME.

RESTRAINT PERFORMANCE IN FRONTAL MODE



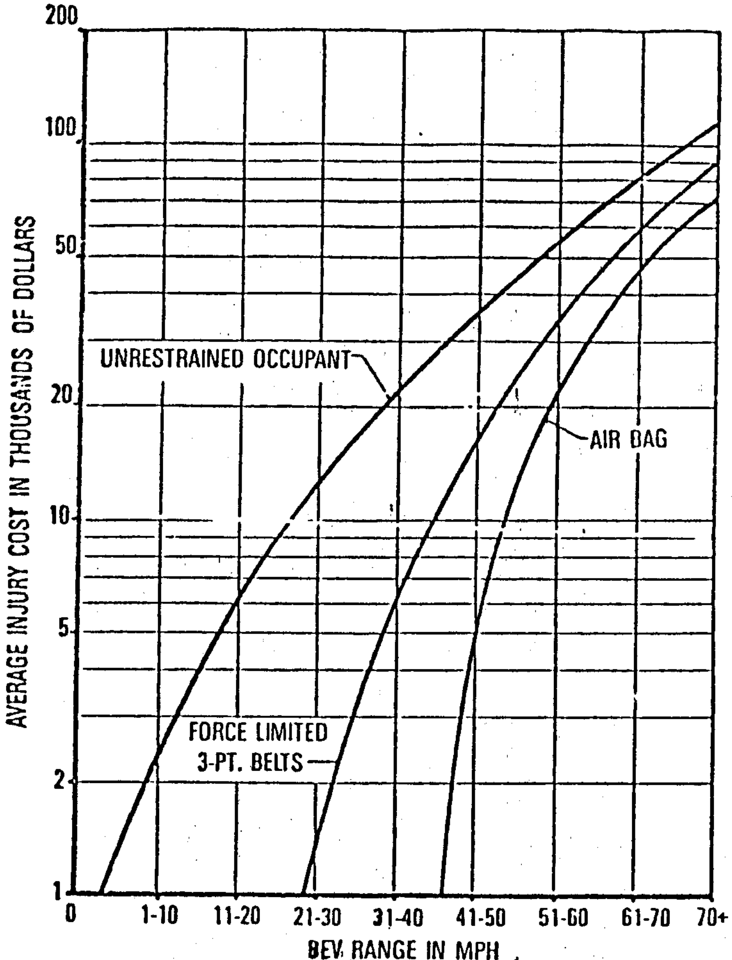
THE METHODOLOGY PERMITS PARAMETRIC STUDIES TO BE MADE. WE FIND, FOR EXAMPLE, THAT A 35G RESTRAINT (FOR A 50TH PERCENTILE MALE) IS NEARLY OPTIMAL OVER THE FULL ANTHROPO-

RESTRAINT PERFORMANCE VS. DEPLOYMENT TIME



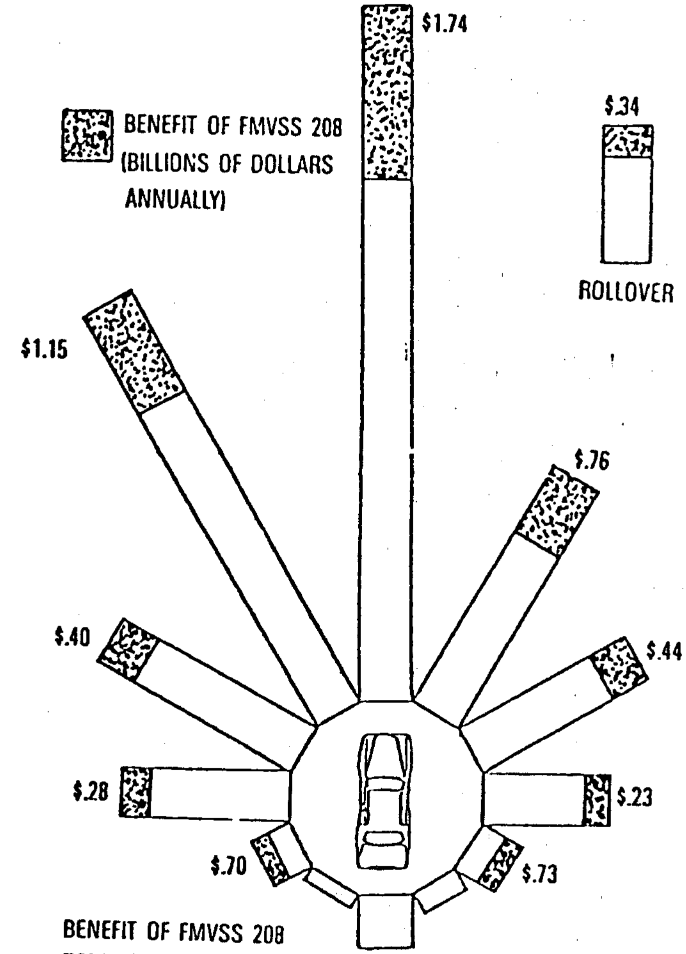
FURTHERMORE, RAPID DEPLOYMENT IS CRUCIAL TO THE REDUCTION OF BOTH FATALITIES AND SOCIETAL COST IN THE FRONTAL MODES.

AVERAGE COST PER INJURY
3-PT VS. AIRBAG



THE METHODOLOGY ENABLES A CALCULATION (NOT AN ESTIMATE) OF CRASHWORTHINESS BENEFITS IN EVERY VELOCITY RANGE, BY COMPARING AVERAGE INJURY COSTS, "BEFORE" AND "AFTER." TOTAL BENEFIT IS THE PRODUCT OF AVERAGE BENEFIT AND THE NUMBER OF INJURIES IN THE PARTICULAR SEATING POSITION, REDUCED ACCORDING TO RESTRAINT SYSTEM USAGE.

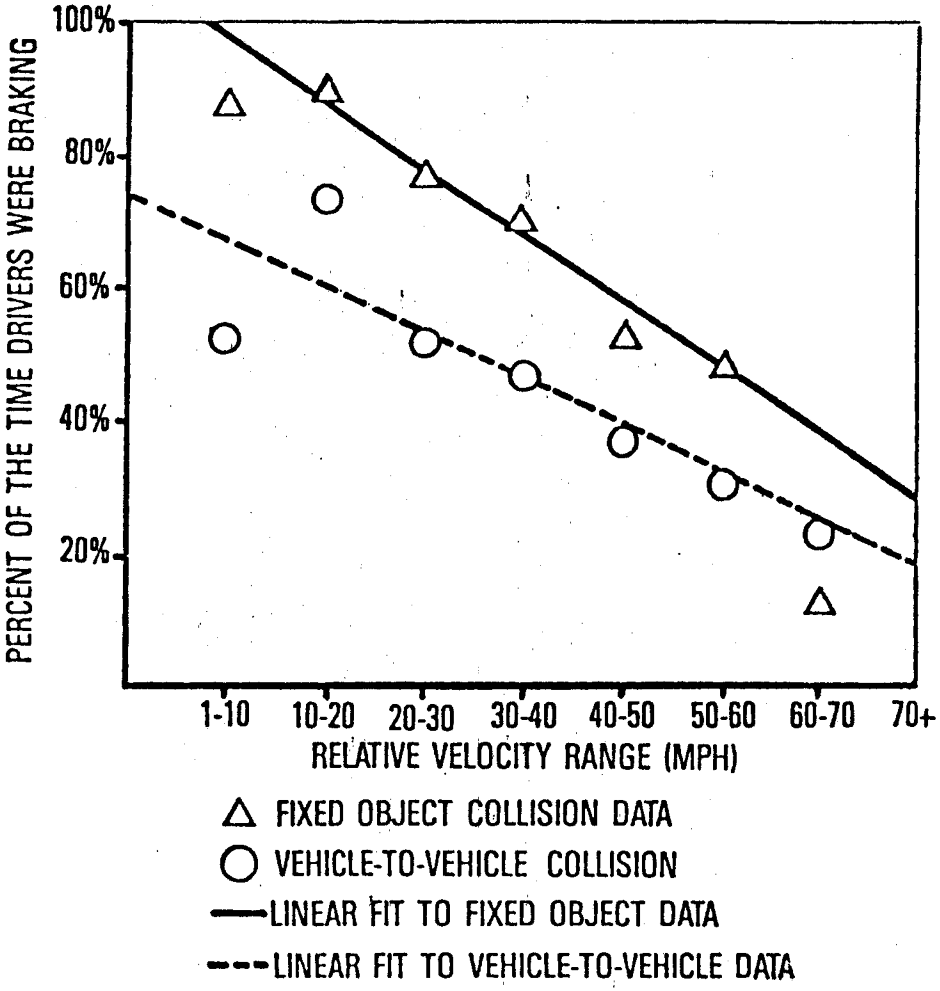
EFFECT OF FMVSS 208



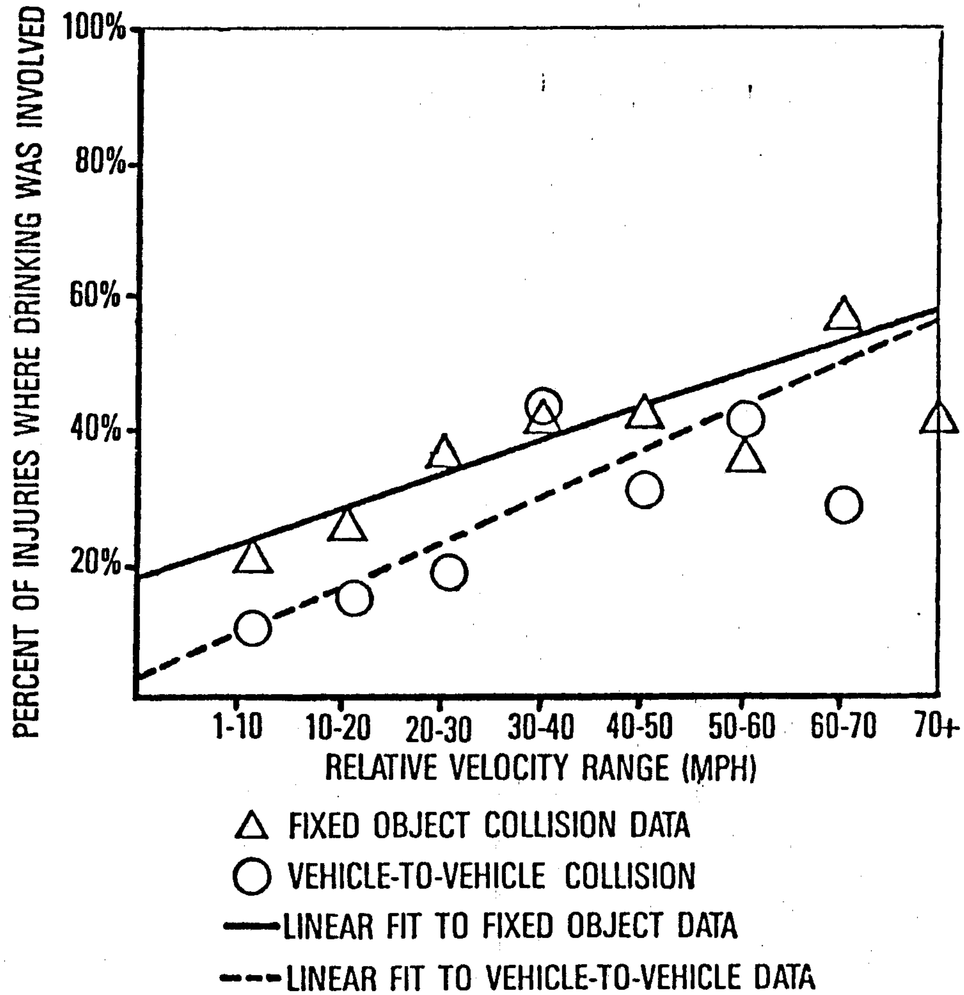
BENEFIT OF FMVSS 208
TOTAL $6.5 BILLION ANNUALLY

THE ABILITY TO CALCULATE CRASHWORTHINESS BENEFITS PERMITS THE INCLUSION OF THE EFFECTS OF FMVSS 208. WHAT REMAINS IN 1985 IS THE COST AMENABLE TO REDUCTION BY THE RSV, I.E., THE POTENTIAL RSV BENEFITS. THIS ASSUMES THE REPLACEMENT OF ALL 1985 SUBCOMPACTS BY RSV'S, AND IGNORES THE PENETRATION OF THE RSV INTO THE SUB-SUB-COMPACT AND COMPACT MARKETS.

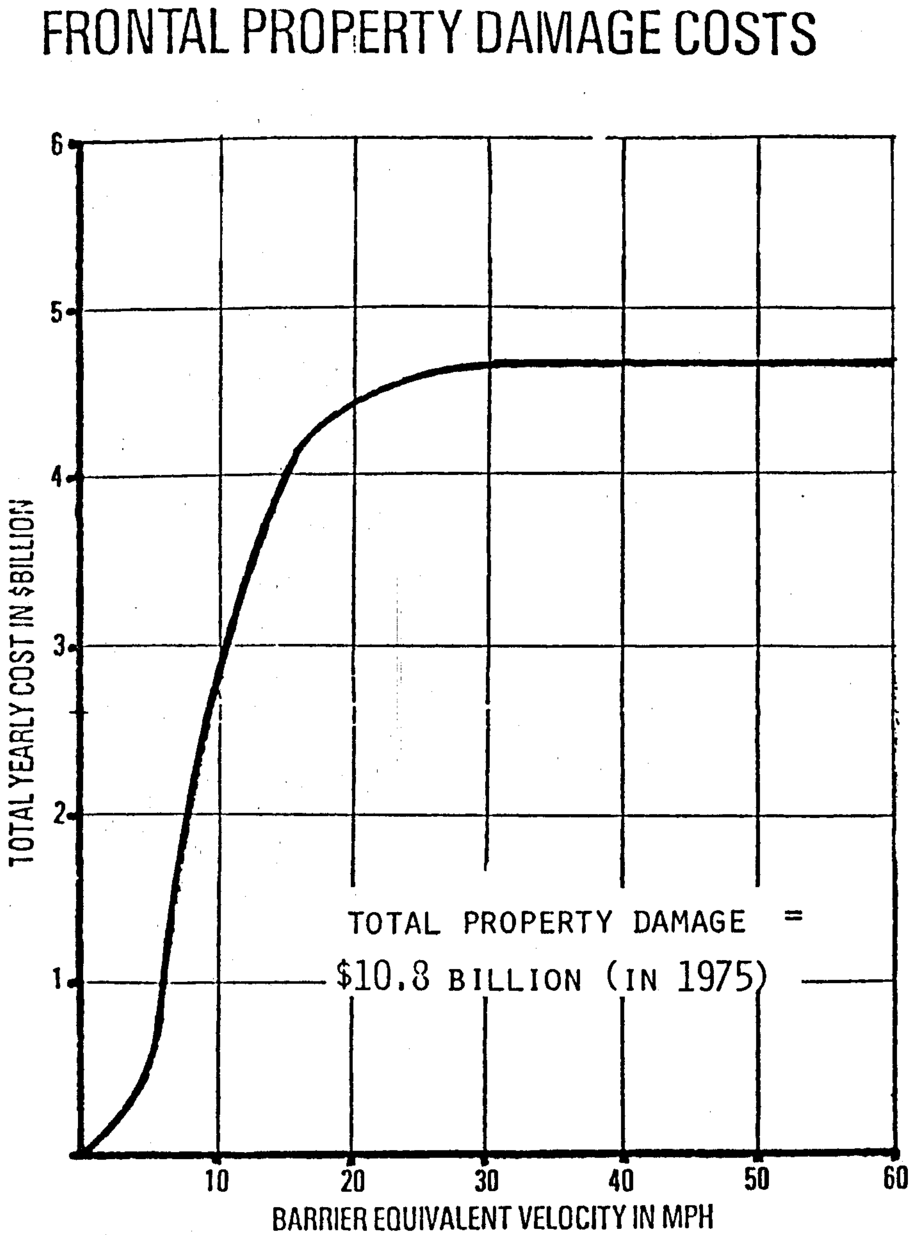
PRE-IMPACT BRAKING

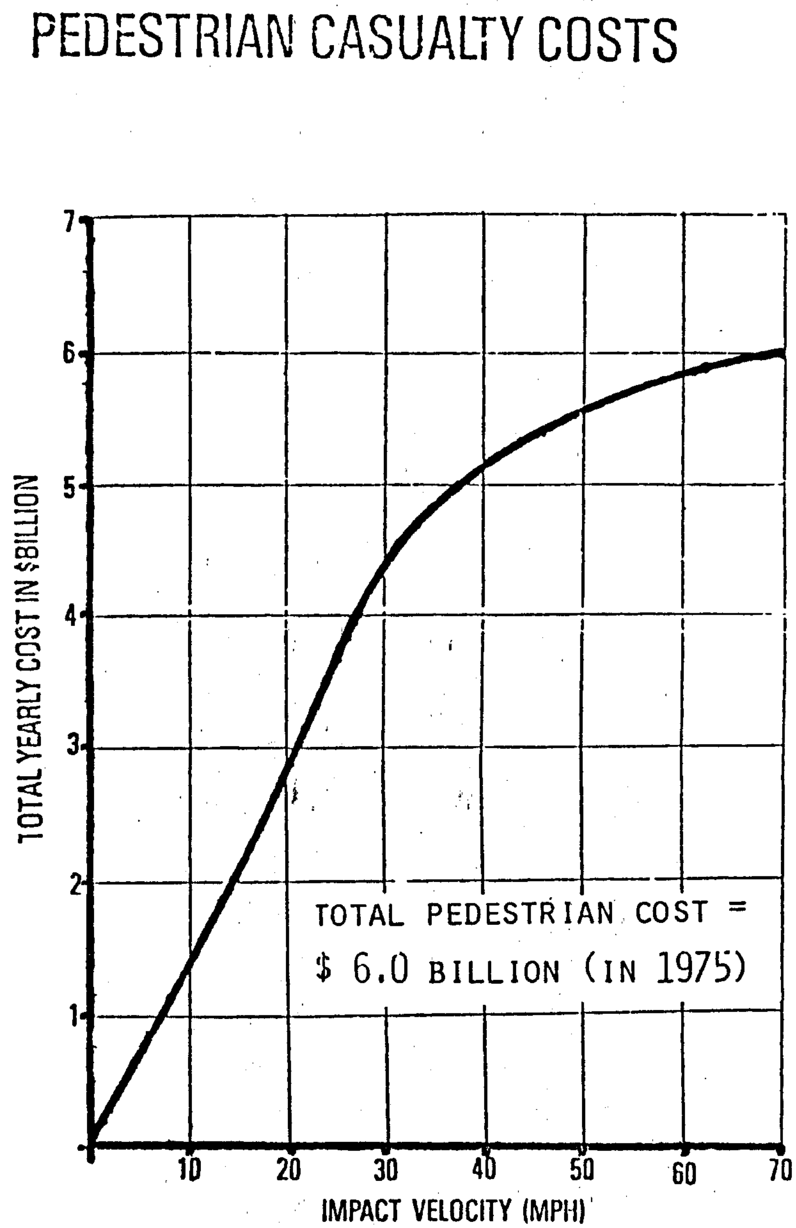


DRIVER IMPAIRMENT



BRAKING AND DRIVER IMPAIRMENT ARE TWO OTHER QUANTIFIABLE FACTORS IN THE PRODUCTION (AND THE REDUCTION) OF SOCIETAL COSTS. THE BRAKING FRACTIONS CAN BE BOOSTED TOWARD 100 PERCENT BY SEMI-AUTOMATIC BRAKE APPLICATION (WITH THE AID OF RADAR), AND IMPACT VELOCITIES CAN BE FURTHER REDUCED BY BETTER BRAKING PERFORMANCE. DRIVER IMPAIRMENT IS OVER-REPRESENTED AT THE HIGHER VELOCITIES, WHICH CREATES POTENTIAL BENEFIT FOR A DRIVER IMPAIRMENT DETECTOR.





IMPROVED BRAKING, IN CONJUNCTION WITH A LOW-DAMAGE BODY GLOVE AND IMPROVED BUMPERS, RESULTS IN REDUCED DAMAGEABILITY. IMPROVED PEDESTRIAN PROTECTION WILL REDUCE THE COSTS OF PEDESTRIAN AND CYCLIST INJURIES, THOUGH NOT IN A WAY THAT IS PRESENTLY QUANTIFIABLE. POTENTIAL BENEFITS FOR BOTH PROPERTY DAMAGE AND PEDESTRIAN PROTECTION SYSTEMS CAN BE INFERRED FROM THESE CUMULATIVE COST DISTRIBUTIONS.

MINICARS, INC.

RSV PHASE I

THE CURRENT ACCIDENT SCENE

WE IN THE TRAFFIC SAFETY BUSINESS LIKE TO TALK ABOUT HOW BAD THE CURRENT ACCIDENT SCENE IS -- AFTER ALL, AS MANY AMERICANS DIE IN TRAFFIC EACH YEAR AS DIED IN VIETNAM THROUGHOUT OUR INVOLVEMENT THERE, ETC. THE FACT IS THAT LESS THAN ONE PERCENT OF OUR POPULATION IS SIGNIFICANTLY INJURED ANNUALLY, AND TWO HUNDREDTHS OF ONE PERCENT ARE KILLED. SO WE HAVE TO FOCUS OUR ATTENTION VERY CAREFULLY IF WE ARE TO REDUCE ACCIDENT COSTS IN AN EFFICIENT WAY.

THIS IS NOT TO SAY THAT THERE IS LITTLE BENEFIT TO BE GAINED BY OUR EFFORTS. ON THE CONTRARY, CURRENT LOSSES TO SOCIETY ARE ESTIMATED TO BE ABOUT $40 BILLION EACH YEAR, AND THIS NUMBER WILL SOAR UNLESS WE DO THE RIGHT THINGS -- LIKE UNDERTAKE THE RSV PROGRAM.

THE FIRST STEP IS TO FIND OUT HOW BAD THE PROBLEM IS -- WHERE THE COSTS ARE COMING FROM, AND HOW THEY MAY BE REDUCED. THE KEY TO THIS IS AN ORDERLY METHODOLOGY THAT ANATOMIZES THE PRESENT SITUATION AND DESCRIBES IT QUANTITATIVELY. FOR THAT PURPOSE WE DIVIDE UP THE PRESENT COST OF ACCIDENTS INTO MODE/VELOCITY CELLS, SO COSTS CAN BE ANALYZED ACCORDING TO HOW THE CAR CRASHES AND HOW FAST IT CRASHES.

THE HOW OF CRASHES DEPENDS PRIMARILY ON WHERE THE VEHICLE IS STRUCK, AND WHAT IT HITS. SO WE DISTINGUISH BETWEEN FIXED-OBJECT, VEHICLE-TO-VEHICLE, AND ROLLOVER ACCIDENTS, AND WE SUBDIVIDE THE FIXED-OBJECT AND VEHICLE-TO-VEHICLE ACCIDENTS ACCORDING TO WHERE THE VEHICLE SUFFERS THE MOST DAMAGE (FRONT, LEFT FRONT, SIDE, ETC.). IN THE ACCIDENT FILES, THIS IS DESCRIBED BY A CLOCK POSITION, WHERE 12 O'CLOCK IS STRAIGHT AHEAD, 3 O'CLOCK IS ON THE RIGHT SIDE, AND SO ON.

THE HOW FAST IS RATHER MORE COMPLICATED. ESSENTIALLY, WE COMPUTE THE VELOCITY CHANGE SEEN BY THE CAR DURING THE ACCIDENT, AND CALCULATE THE COMPONENT OF THAT VELOCITY CHANGE THAT IS IN THE DIRECTION OF THE DAMAGE AREA. IN A CAR-TO-CAR COLLISION, THIS REQUIRES SIMULTANEOUS ACCESS TO SIX QUANTITIES IN THE ACCIDENT FILES: BOTH CAR MASSES, BOTH VELOCITIES, THE CLOCK POSITION OF DAMAGE AREA, AND THE CLOCK POSITION OF IMPACT FORCE. TO THE END PRODUCT WE HAVE GIVEN THE NAME BARRIER EQUIVALENT VELOCITY, OR BEV.

BECAUSE THE BEV DEPENDS ON THE MASS OF THE CAR (I.E., LITTLE CARS TEND TO EXPERIENCE HIGHER BEV'S THAN BIG CARS), WE HAVE ALSO SUBDIVIDED THE ACCIDENT DATA BY VEHICLE CLASS. THIS HELPS US DETERMINE WHICH CLASSES ARE CONTRIBUTING THE HIGHEST COSTS, AND WHAT THE PERFORMANCE REQUIREMENTS OUGHT TO BE FOR ANY IMPROVEMENTS TO THOSE CARS. SPECIFICALLY, WE CAN FIND OUT WHAT KIND OF CAR THE RSV SHOULD BE, AND HOW SAFE IT SHOULD BE.

IN TERMS OF ACCIDENT MODE, WE FIND THAT THE LARGEST PART OF CURRENT SOCIETAL COSTS IS COMING FROM FRONTAL CRASHES -- AND THAT FRONTAL OFFSET AND FRONTAL OBLIQUE CRASHES TAKEN TOGETHER ARE GENERATING EVEN MORE COST THAN SQUARE-ON FRONTAL CRASHES. THESE HIGH COSTS ARE THE RESULT NOT ONLY OF THE HIGHER BEV OF THESE CRASHES (A PROBLEM THAT WE WILL RETURN TO), BUT OF THEIR GREAT FREQUENCY. SIDE IMPACTS, WHICH TYPICALLY INCLUDE A CAR BEING STRUCK IN THE DOOR BY THE FRONT OF ANOTHER CAR, ARE ALSO GENERATING SIGNIFICANT COSTS.

THE FACT THAT THE BULK OF THE SOCIETAL COST IS COMING FROM FRONTAL CRASHES SHOWS THAT CRASH PROTECTION MUST BE VERY GREAT IN THE FRONT OF THE CAR. AND THE FACT THAT FRONTAL CRASHES OTHER THAN SQUARE-ON LINED-UP FRONT-TO-FRONT CRASHES (OR SQUARE-ON CRASHES INTO BARRIERS) ARE GENERATING SO MUCH COST SHOWS THAT THIS CRASH PROTECTION MUST NOT BE SENSITIVE TO THE DIRECTION IN WHICH THE CRASH FORCE IS APPLIED. IN OTHER WORDS, SINCE VERY HIGH COST IS COMING FROM CRASHES DISTRIBUTED ALL OVER THE FRONT OF THE CAR, THE SAFETY PERFORMANCE FOR THE FRONTAL MODES MUST NOT ONLY BE HIGH, BUT EQUALLY HIGH FOR ALL DIRECTIONS OF CRASH FORCE. SO WE CAN LAY DOWN THE FIRST BASIC PRINCIPLE OF SAFETY PERFORMANCE: FRONTAL CRASH PERFORMANCE MUST BE ALL-DIRECTIONAL.

THE SECOND MAJOR PRINCIPLE EMERGES FROM CONSIDERING THE BEV'S AT WHICH ACCIDENT COSTS ARE INCURRED. OBVIOUSLY, HIGHER-SPEED CRASHES TEND TO BE MORE EXPENSIVE. THE LOWER-SPEED ACCIDENTS ARE VERY FREQUENT, BUT THE RELATIVELY RARE HIGHER-SPEED COLLISIONS ARE SO COSTLY THAT A SIGNIFICANT PORTION OF THE COST EXISTS AT SPEEDS CLEAR UP TO 50 MPH IN THE FRONT. SO WE HAVE THE SECOND PRINCIPLE: FRONTAL PERFORMANCE MUST BE GOOD TO HIGH SPEEDS.

THE FUTURE ACCIDENT SCENE

THIS SECOND PRINCIPLE IS EVEN MORE VALID FOR LITTLE CARS THAN FOR BIG ONES, BECAUSE OF THE TENDENCY TO SEE HIGHER BEV'S. HERE WE FIND THE REASONS WHY ACCIDENT COSTS ARE EXPECTED TO SOAR UNLESS SOMETHING IS DONE: WE ARE GOING TO HAVE A LOT MORE SMALL CARS ON THE ROAD. WHILE THIS MAKES SURVIVAL EASIER FOR THE PEOPLE IN BIG CARS, THEIR SAVINGS WILL BE FAR OUTWEIGHED BY THE ADDED COSTS IN LITTLE CARS.

OTHER FACTORS ALSO OPERATE AGAINST THE SMALLER CAR. AS PRESENTLY DESIGNED, IT OFFERS LESS FRONTAL CRUSH LENGTH THAN LARGER CARS, AND LESS INTERIOR DISTANCE OVER WHICH A RESTRAINT CAN WORK TO SAFELY DECELERATE AN OCCUPANT.

BY THE MID-1980'S, THE SMALLER CARS WILL MAKE UP MORE THAN HALF OF THE VEHICLE POPULATION, BUT WILL GENERATE MORE THAN 60 PERCENT OF THE SOCIETAL COSTS. SO WE ARE LED TO A THIRD MAJOR PRINCIPLE: THE RSV MUST BE A SMALL CAR.

THIS CONCLUSION IS REINFORCED BY OTHER CONSIDERATIONS THAT HAVE NOTHING TO DO WITH SAFETY. AFTER ALL, THE PRIMARY SOURCE OF COST IN A CAR IS WEIGHT. BOTH THE MANUFACTURING COST AND THE OPERATING COST (FUEL AND MAINTENANCE) ARE DIRECTLY RELATED TO WEIGHT; WITH THE COST OF BOTH MATERIALS AND FUEL GOING UP, WE HAVE NO CHOICE BUT TO MAKE THE CAR AS ECONOMICAL AS POSSIBLE. SO WE HAVE A COROLLARY: NOT ONLY MUST THE RSV BE A SMALL CAR -- IT MUST BE AS LIGHT AND AS EFFICIENT AS WE CAN MAKE IT. FURTHERMORE, THE CAR SHOULD BE MISERLY WITH ENERGY AND EMISSIONS.

ASIDE FROM IMPROVING THE OCCUPANT SURVIVABILITY, OTHER THINGS CAN BE DONE TO THE CAR TO REDUCE THE SOCIETAL COST OF ACCIDENTS. ONE OF THESE IS TO IMPROVE THE BRAKING, BOTH WITH RESPECT TO BRAKING DECELERATION AND FREQUENCY OF APPLICATION. ANOTHER IS TO REDUCE THE NUMBER OF HIGH-SPEED ACCIDENTS THAT INVOLVE IMPAIRED DRIVERS (MOST IMPAIRMENT BEING DUE TO DRINKING).

BUT HOW MANY OF THESE FEATURES SHOULD WE BUILD INTO THE CAR? AND HOW GOOD SHOULD THE PERFORMANCE BE? THE ONLY WAY TO FIND OUT IS TO PUT TOGETHER A LOT OF DIFFERENT COMBINATIONS OF STRUCTURAL DESIGNS, RESTRAINTS, BRAKING OPTIONS, ETC., AND SEE HOW MUCH THEY COST. WE THEN TRY DIFFERENT COMBINATIONS IN THE TRAFFIC MIX AND SEE HOW MUCH GOOD THEY DO. OF COURSE,

THIS MIND-BOGGLING EXPERIMENT CAN'T BE DONE WITH ACTUAL CARS, BUT WE CAN DO IT ANALYTICALLY, AS A RESULT OF OUR PHASE I RSV EFFORTS. THE CONCEPT OF HAVING VARIOUS SAFETY SYSTEMS COMPETE FOR THE AVAILABLE BENEFIT IS A CENTRAL PART OF OUR BENEFIT/COST METHODOLOGY.

DESIGNING THE CAR

THE BENEFIT/COST TRADE-OFF INDICATES THAT THE FOLLOWING SYSTEMS SHOULD BE INCLUDED IN THE RSV: RADAR-ACTIVATED 1.2G BRAKES, ADVANCED AIRBAGS FOR BOTH FRONT SEAT OCCUPANTS, LAP BELTS IN THE REAR, AND A 50-PERCENT-EFFECTIVE IMPAIRED DRIVER DETECTOR (WHICH WOULD ONLY HAVE THE EFFECT OF LIMITING THE TOP SPEED OF THE VEHICLE). IN THE REAR SEATS, HOWEVER, INFLATABLE BELTS ARE SUBSTITUTED FOR THE LAP BELTS, AS A RESEARCH GOAL.

THESE SYSTEMS ARE CHOSEN ON THE BASIS OF THEIR COST AND THEIR PERFORMANCE, WHICH ARE, IN TURN, BASED ON THE FOLLOWING DESIGN CONSIDERATIONS:

- THOUGH OTHER STRUCTURAL TECHNIQUES MIGHT PROVIDE THE KIND OF SAFETY PERFORMANCE REQUIRED, THE ONLY ONE THAT CAN PROVIDE THE ALL-DIRECTIONAL PERFORMANCE AT LOW WEIGHT IS A BULK STRUCTURE -- FOAM-FILLED SHEET METAL. NO MATTER HOW EFFECTIVE SUCH TECHNIQUES AS HYDRAULICS MIGHT BE, THEIR WEIGHT PENALTY, ESPECIALLY THE HIGHER WEIGHT ASSOCIATED WITH MAKING THEM ALL-DIRECTIONAL, RULES THEM OUT.

- MAXIMUM PERFORMANCE AT MINIMUM WEIGHT COMES FROM KEEPING THE HARD MASSES OUT OF THE FRONT OF THE CAR -- THAT IS, BY PUTTING THE ENGINE IN THE REAR.

- TO IMPROVE SIDE IMPACT PROTECTION WITH MINIMAL WEIGHT, IT IS NECESSARY THAT THE DOOR STRUCTURE BE RELIEVED OF AS MUCH OF THE PROTECTION BURDEN AS POSSIBLE. THIS IN TURN REQUIRES THAT THE SILL BE AS STIFF AS POSSIBLE, AND THAT IT BE AS HIGH AND AS WIDE AS WE CAN MAKE IT, WITHOUT UNDULY COMPROMISING ENTRANCE AND EGRESS.

- THE HIGH BEV'S FOR SMALLER CARS DEMAND THE USE OF A RESTRAINT THAT HAS HIGH EFFECTIVENESS AT THE HIGHER VELOCITIES. THIS REQUIRES THAT THEY BE QUICK-ACTING AND FORCE-LIMITED, WITH PROPER CONTROL OF OCCUPANT KINEMATICS DURING CRASHES. INFLATABLE RESTRAINTS ALREADY DEVELOPED BY MINICARS MEET ALL THESE CRITERIA.

- RAISING THE DECELERATION LEVEL OF BRAKING CARRIES WITH IT THE DANGER OF INCREASING REAR-END COLLISIONS, SO WE NEED A DUAL-MODE SYSTEM: A "NORMAL" MODE ASSOCIATED WITH FOUR-WHEEL DISC BRAKES AND ANTI-SKID FEATURES, AND AN "EMERGENCY" MODE USED ONLY WHEN A COLLISION IS UNAVOIDABLE. A RADAR/MICROPROCESSOR SYSTEM CAN BE APPLIED, THOUGH THE "NORMAL" MODE WOULD GENERALLY BE DRIVER-ACTIVATED.

- PROPERTY DAMAGE COSTS CAN BE SUBSTANTIALLY REDUCED BY A 10-MPH BUMPER IN THE FRONT AND A 5-MPH BUMPER IN THE REAR. AN EXTERIOR BODY GLOVE FURTHER REDUCES THESE COSTS, IN ADDITION TO REDUCING THE NEED FOR HIGH-QUALITY SHEET METAL FINISHES, AND INCREASING THE PROTECTION OFFERED TO PEDESTRIANS. SEMI-AUTOMATIC BRAKE APPLICATION WILL REDUCE THESE COSTS STILL FURTHER.

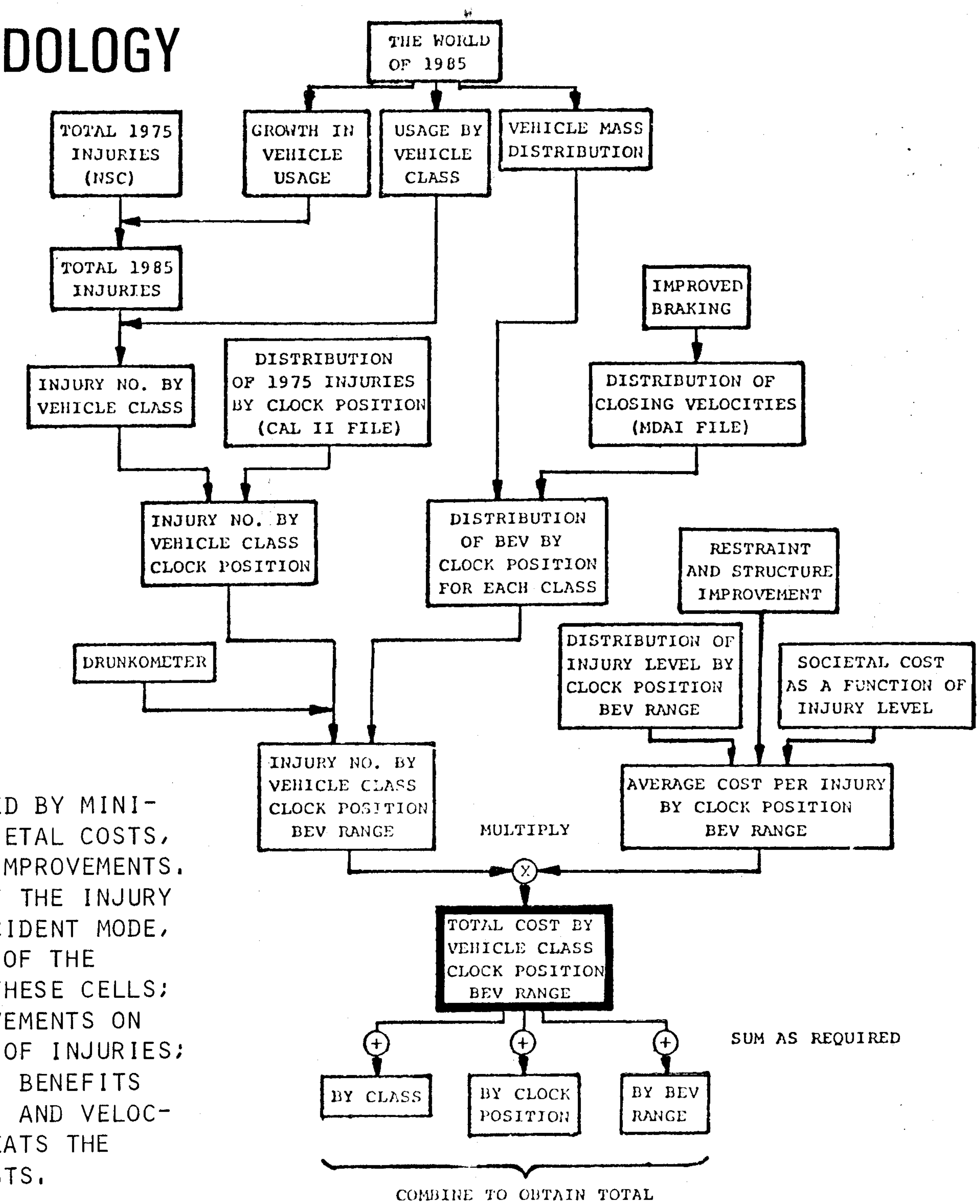
- STRUCK PEDESTRIANS WHO LAND ON THE HOOD CAN BE SAVED IF THEY ARE RETAINED THERE, RATHER THAN SLIDING OFF AND STRIKING THE ROAD. THUS A LIGHT, SIMPLE, RELIABLE PEDESTRIAN RETAINER SHOULD BE PROVIDED.

- ALL OTHER FUNCTIONAL SYSTEMS (I.E., THOSE NOT SPECIFICALLY SAFETY-RELATED) SHOULD SIMPLY REPRESENT THE PRESENT AUTOMOTIVE STATE OF THE ART.

THESE DESIGN CONSIDERATIONS RESULTED IN A CAR HAVING A CURB WEIGHT OF 1,918 POUNDS AND A HIGHWAY FUEL ECONOMY OF 37 MILES PER GALLON. YET IT WILL HAVE ADVANCED SAFETY PERFORMANCE -- 50 MPH PERFORMANCE IN FRONTAL MODES, AND 30 MPH PERFORMANCE IN SIDE IMPACT MODES.

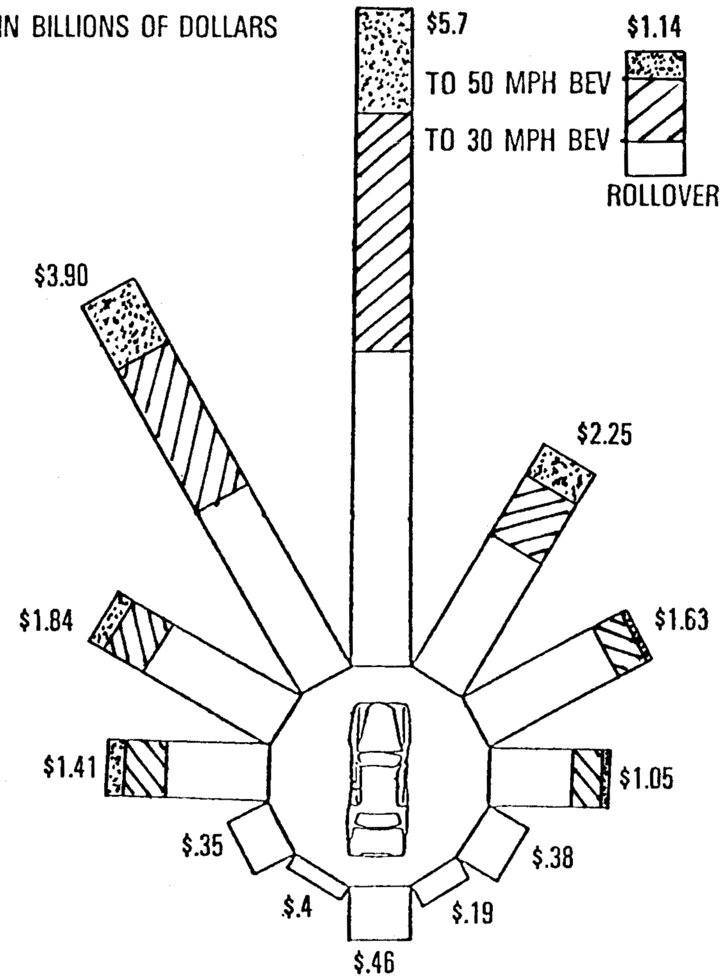
THE REMAINDER OF THE PAPER WILL GIVE FURTHER DETAIL ON ALL ASPECTS OF OUR PHASE I EFFORTS. FIRST, WE WILL PRESENT, IN NINE PAGES, AN OVERVIEW WHICH SUMMARIZES THE CALCULATION OF SOCIETAL COSTS, THE BENEFIT/COST TRADE-OFFS, THE ECONOMY, ENERGY, AND ENVIRONMENT CONSIDERATIONS, AND THE PRELIMINARY DESIGN. IN THE SUCCEEDING THIRTY-FIVE PAGES, WE PRESENT MORE DETAIL ON SOCIETAL COSTS, FUTURE AUTOMOTIVE PROJECTIONS, SOCIETAL BENEFITS, AND THE BENEFIT/COST TRADE-OFF. WE THEN SHOW HOW THIS METHODOLOGY, COMBINED WITH EXPERIENCE ON OTHER PROGRAMS, RESULTS IN OUR PRELIMINARY DESIGN, WHICH IS TREATED IN FURTHER DETAIL. FOR A THOROUGH DISCUSSION OF ALL THESE TOPICS, WE REFER YOU TO OUR PHASE I FINAL REPORT, IN THREE VOLUMES.

SOCIETAL COST METHODOLOGY



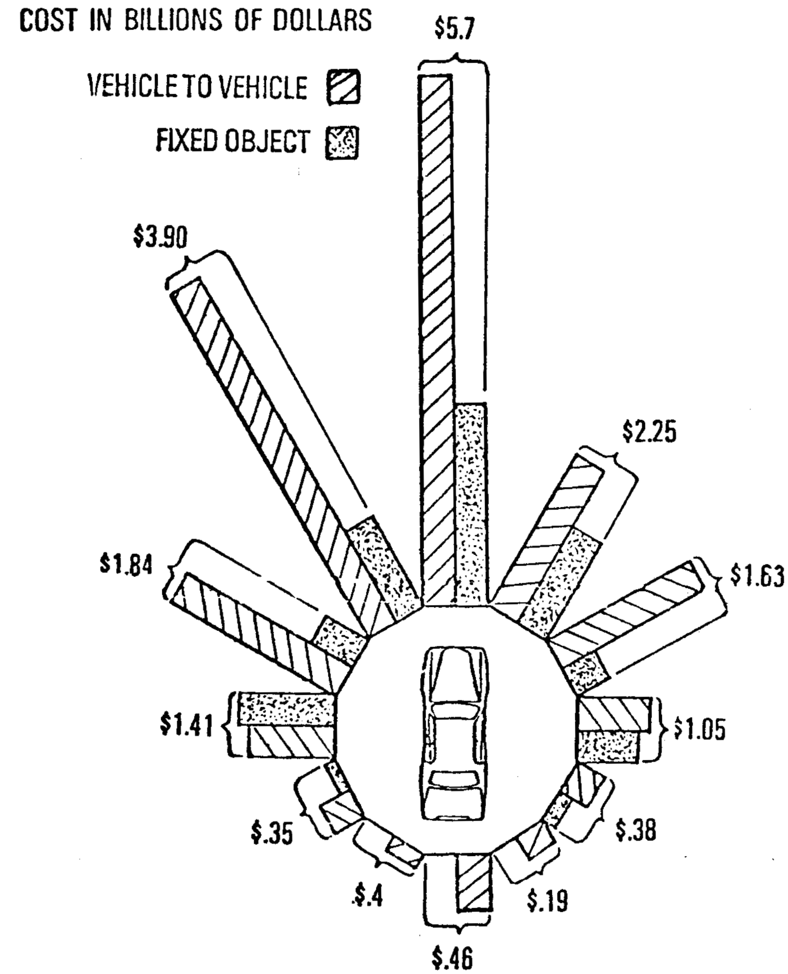
THIS IS THE METHODOLOGY DEVELOPED BY MINICARS FOR THE CALCULATION OF SOCIETAL COSTS, AND THEIR REDUCTION BY VEHICLE IMPROVEMENTS. IT CONTAINS (A) A SUBDIVISION OF THE INJURY POPULATION BY VEHICLE CLASS, ACCIDENT MODE, AND VELOCITY; (B) A CALCULATION OF THE AVERAGE INJURY COST IN EACH OF THESE CELLS; (C) THE EFFECT OF VEHICLE IMPROVEMENTS ON BOTH THE FREQUENCY AND SEVERITY OF INJURIES; AND (D) A SUMMATION OF COSTS AND BENEFITS BY VEHICLE CLASS, ACCIDENT MODE, AND VELOCITY. A SEPARATE CALCULATION TREATS THE REDUCTION OF PROPERTY DAMAGE COSTS.

SOCIETAL COST BY CLOCK POSITION – 1975



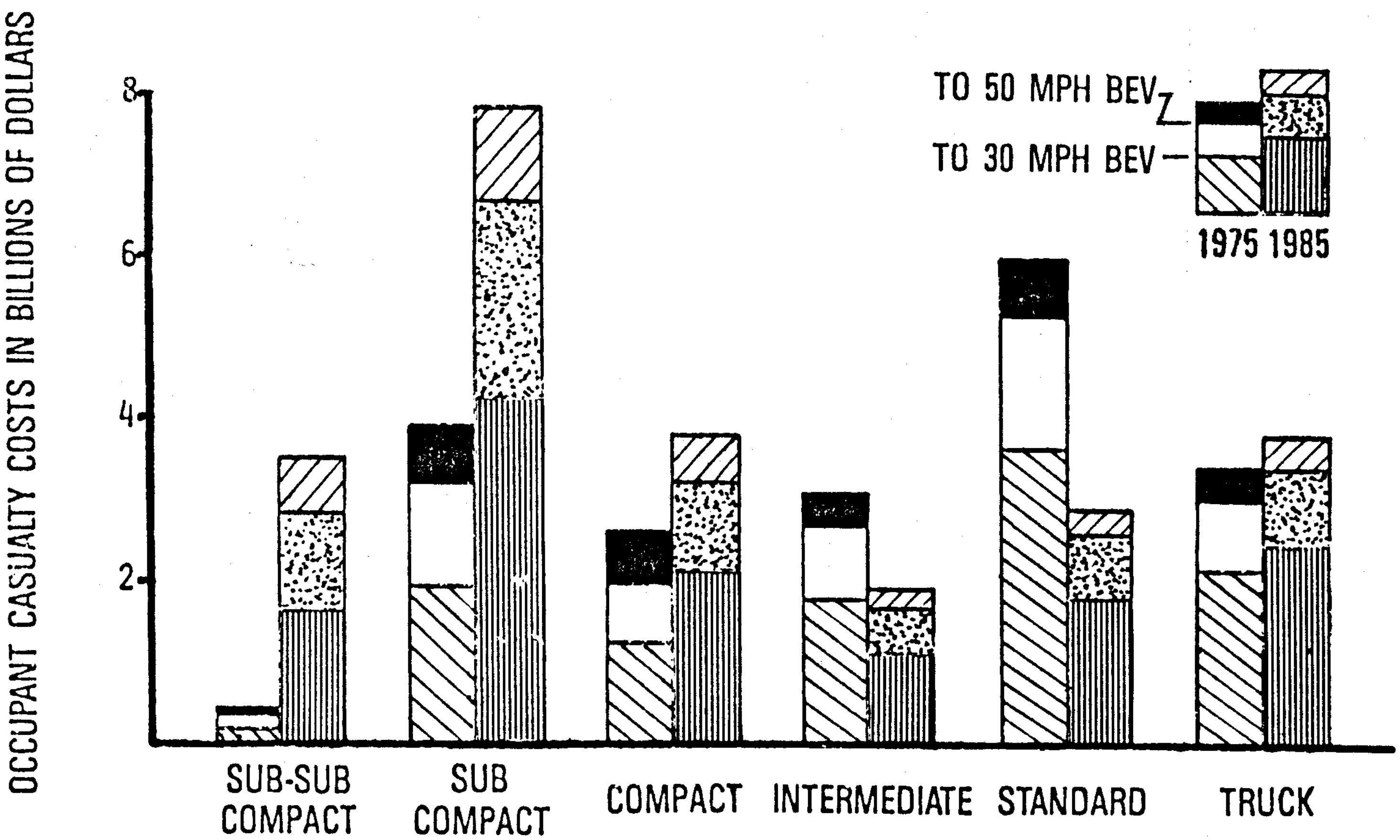
SOCIETAL COSTS OF INJURIES FOR PRESENT-DAY ACCIDENTS ARE SHOWN HERE. CUMULATIVE COSTS TO 30 AND 50 MPH ARE SHOWN, AS WELL AS THE DISTRIBUTION OF COSTS BY ACCIDENT MODE -- WHICH IS DESCRIBED BY THE CLOCK POSITION OF PRINCIPLE DAMAGE AREA. ROLLOVER ACCIDENTS ARE CODED AS 13 O'CLOCK.

FIXED OBJECT VS. VEHICLE TO VEHICLE



THE SOCIETAL COSTS OF INJURIES MAY BE FURTHER RESOLVED INTO A NUMBER OF FACTORS IMPORTANT TO SPECIFIC VEHICLE DESIGN SUCH AS THE FIXED-OBJECT AND VEHICLE-TO-VEHICLE COMPONENTS AS SHOWN HERE.

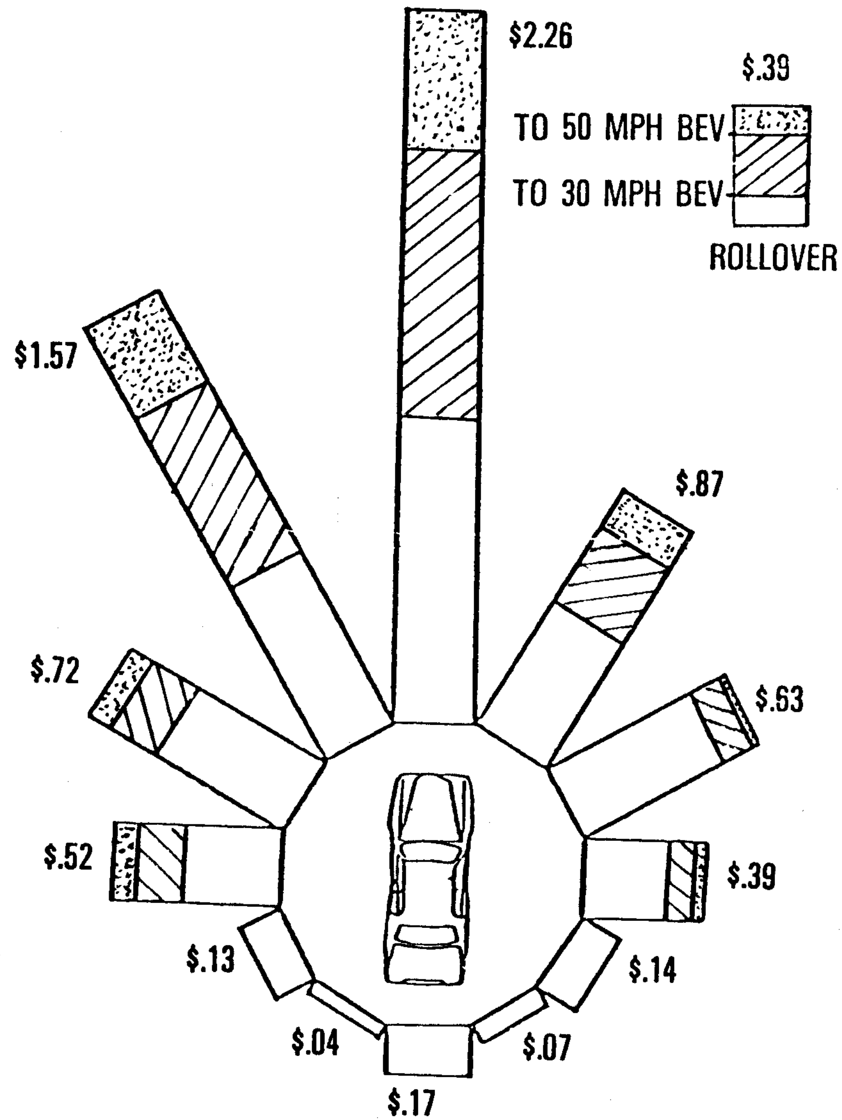
SOCIETAL COST OF ACCIDENT INJURIES BY CAR CLASS, 1975-1985



HERE IS A PRESENTATION OF THE SOCIETAL COSTS, BY VEHICLE CLASS, WHICH HELPS TO DIRECT ATTENTION TOWARD THE MOST URGENTLY-NEEDED VEHICLE IMPROVEMENTS. PRESENT-DAY SOCIETAL COSTS TOTAL $20 BILLION ANNUALLY. BY 1985, WE EXPECT THOSE COSTS TO INCREASE BY 22 PERCENT. ALSO THE COST BURDEN WILL HAVE SHIFTED DRAMATICALLY TO THE SMALL CARS. IF THE RSV IS TO HAVE MAXIMUM SAFETY IMPACT, IT MUST BE TARGETED AT THE MOST COSTLY CLASS -- SUBCOMPACT CARS. SAFETY THUS DICTATES A LIGHT CAR -- A CONCLUSION THAT IS REINFORCED BY OTHER FACTORS.

SOCIETAL COST BY CLOCK POSITION – 1985
SUBCOMPACT CLASS ONLY

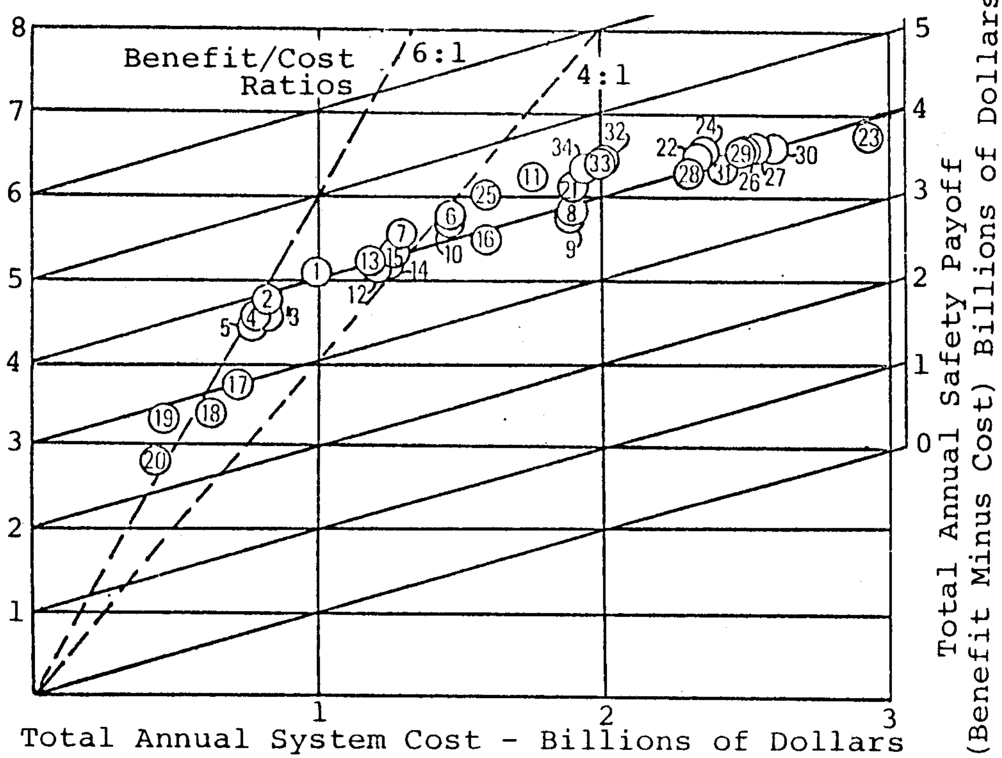
BILLIONS OF DOLLARS



FOCUSING ON THE 1985 SUBCOMPACTS, WE FIND THE SOCIETAL COSTS OF INJURIES AND FATALITIES TO BE DISTRIBUTED BY MODE AND VELOCITY AS SHOWN. NOTE (A) THE PREPONDERANCE OF COSTS IN THE FRONTAL AND FRONTAL OBLIQUE MODES, WITH LESS IN THE SIDE AND VERY LITTLE IN THE REAR; AND (B) THE SIGNIFICANT COSTS ABOVE 50 MPH IN THE MOST COSTLY MODES. THIS IS ESSENTIALLY THE ACCIDENT ENVIRONMENT TO BE INFLUENCED BY THE RSV. THIS ENVIRONMENT TELLS US WHAT THE RSV SHOULD BE LIKE.

BENEFITS AND COSTS OF SAFETY PACKAGES

RUN NO.	A.AVOID SYS	DRIV REST	R.PASS REST	REAR REST	STRUC MOD	IMP DRIVER	SYS COST ($)	SYS BEN (BIL$)	TSYS COST (BIL$)	BEN/COST RATIO	SAFETY PAYOFF (BIL$)
11	DRIV-.9G	AIRBAG	AIRBAG	LAP	RSVI	IPD-50%	299.	6.29	1.75	3.59	4.54
34	DRIV-.9G	AIRBAG	AIRBAG	FL 3-PT	RSVI	IPD-50%	329.	6.40	1.93	3.32	4.47
25	DRIV-.9G	AIRBAG	FL ABLT	LAP	RSVI	IPD-50%	271.	6.06	1.58	3.82	4.47
32	DRIV-.9G	AIRBAG	AIRBAG	FL ABLT	RSVI	IPD-50%	344.	6.44	2.02	3.19	4.43
33	DRIV-.9G	AIRBAG	AIRBAG	PL 3-PT	RSVI	IPD-50%	341.	6.41	2.00	3.20	4.41
6	NO SYS	AIRBAG	AIRBAG	LAP	RSVI	IPD-50%	249.	5.84	1.46	3.99	4.38
7	DRIV-.9G	AIRBAG	AIRBAG	LAP	RSVI	NO SYS	219.	5.62	1.29	4.37	4.34
27	DRIV-1.2G	AIRBAG	FL ABLT	3-PT	RSVI	IPD-50%	324.	6.15	1.90	3.24	4.25
24	DRIV-.9G	AIRBAG	AIRBAG	AIRBAG	RSVI	IPD-50%	402.	6.58	2.36	2.79	4.22
10	DRIV-1.2G	AIRBAG	AIRBAG	LAP	RSVI	NO SYS	249.	5.67	1.46	3.88	4.21
22	RADAR-1.2G	AIRBAG	AIRBAG	LAP	RSVI	IPD-50%	399.	6.50	2.34	2.78	4.16
13	NO SYS	AIRBAG	AIRBAG	FL 3-PT	RSVI	NO SYS	199.	5.30	1.17	4.54	4.13
1	NO SYS	AIRBAG	AIRBAG	LAP	RSVI	NO SYS	169.	5.12	0.99	5.16	4.13
15	NO SYS	AIRBAG	AIRBAG	FL ABLT	RSVI	NO SYS	214.	5.36	1.26	4.27	4.11
21	DRIV-1.2G	AIRBAG	AIRBAG	AIRBAG	RSVI	IPD-50%	432.	6.63	2.53	2.62	4.10
26	RADAR-1.2G	AIRBAG	AIRBAG	FL 3-PT	RSVI	IPD-50%	429.	6.60	2.51	2.63	4.09
12	NO SYS	AIRBAG	AIRBAG	3-PT	RSVI	NO SYS	193.	5.21	1.13	4.61	4.08
29	RADAR-1.2G	AIRBAG	AIRBAG	3-PT	RSVI	IPD-50%	423.	6.56	2.48	2.65	4.08
14	NO SYS	AIRBAG	AIRBAG	PL 3-PT	RSVI	NO SYS	211.	5.30	1.24	4.29	4.07
30	RADAR-1.2G	AIRBAG	AIRBAG	FL ABLT	RSVI	IPD-50%	444.	6.63	2.60	2.55	4.03
28	RADAR-1.2G	AIRBAG	FL ABLT	3-PT	RSVI	IPD-50%	394.	6.32	2.31	2.74	4.01
8	RADAR-1.2G	AIRBAG	AIRBAG	LAP	RSVI	NO SYS	319.	5.87	1.87	3.14	4.00
16	NO SYS	AIRBAG	AIRBAG	AIRBAG	RSVI	NO SYS	272.	5.56	1.59	3.49	3.96
31	RADAR-1.2G	AIRBAG	FL ABLT	FL ABLT	RSVI	IPD-50%	416.	6.39	2.43	2.63	3.96
2	NO SYS	AIRBAG	FL ABLT	LAP	RSVI	NO SYS	141.	4.77	0.82	5.79	3.95
9	DRIV-1.5G	AIRBAG	AIRBAG	LAP	RSVI	NO SYS	319.	5.80	1.87	3.10	3.92
4	NO SYS	AIRBAG	FL 3-PT	LAP	RSVI	NO SYS	133.	4.63	0.78	5.95	3.85
3	NO SYS	AIRBAG	PL 3-PT	LAP	RSVI	NO SYS	139.	4.66	0.81	5.73	3.85
23	RADAR-1.2G	AIRBAG	AIRBAG	AIRBAG	RSVI	IPD-50%	502.	6.77	2.94	2.30	3.82
5	NO SYS	AIRBAG	3-PT	LAP	RSVI	NO SYS	130.	4.50	0.76	5.92	3.74
17	NO SYS	FL ABLT	FL ABLT	LAP	RSVI	NO SYS	123.	3.78	0.72	5.24	3.06
19	NO SYS	FL 3-PT	FL 3-PT	LAP	RSVI	NO SYS	77.	3.31	0.45	7.34	2.86
18	NO SYS	PL 3-PT	PL 3-PT	LAP	RSVI	NO SYS	104.	3.42	0.61	5.60	2.81
20	NO SYS	3-PT	3-PT	LAP	RSVI	NO SYS	71.	2.86	0.42	6.89	2.45



WE CONSIDERED A VARIETY OF SAFETY SYSTEMS WHICH COULD BE INCLUDED IN THE RSV, AND WHICH COULD AFFECT SOCIETAL COSTS IN A QUANTIFIABLE WAY. THESE ARE: (A) BRAKING, (B) RESTRAINTS, (C) STRUCTURE, AND (D) IMPAIRED DRIVER DETECTORS (TO LIMIT VEHICLE SPEED IF THE DRIVER IS IMPAIRED). OVER 5,000 COMBINATIONS COULD BE CONSIDERED. WE ANALYZED THE 34 MOST PROMISING. THE ONE HAVING MAXIMUM SAFETY PAYOFF (TOTAL BENEFIT MINUS TOTAL COST) INCLUDED DRIVER ACTIVATED .9G BRAKES, AIRBAGS IN THE FRONT SEATS, LAP BELTS IN THE REAR, AND A 50 PERCENT EFFECTIVE IMPAIRED DRIVER DETECTOR. ONLY ONE STRUCTURAL CONFIGURATION WAS CONSIDERED -- THE RSV DESIGN -- BECAUSE IT DELIVERED THE HIGHEST PERFORMANCE AT THE LOWEST COST. ON THE BASIS OF OCCUPANT INJURY, THESE RESULTS TELL US WHAT SYSTEMS SHOULD BE IN THE RSV. WE WERE THUS ABLE TO ACTUALLY DESIGN THE CAR TO MAXIMIZE SAFETY PAYOFF.

FUEL ECONOMY

PROPULSION SYSTEM

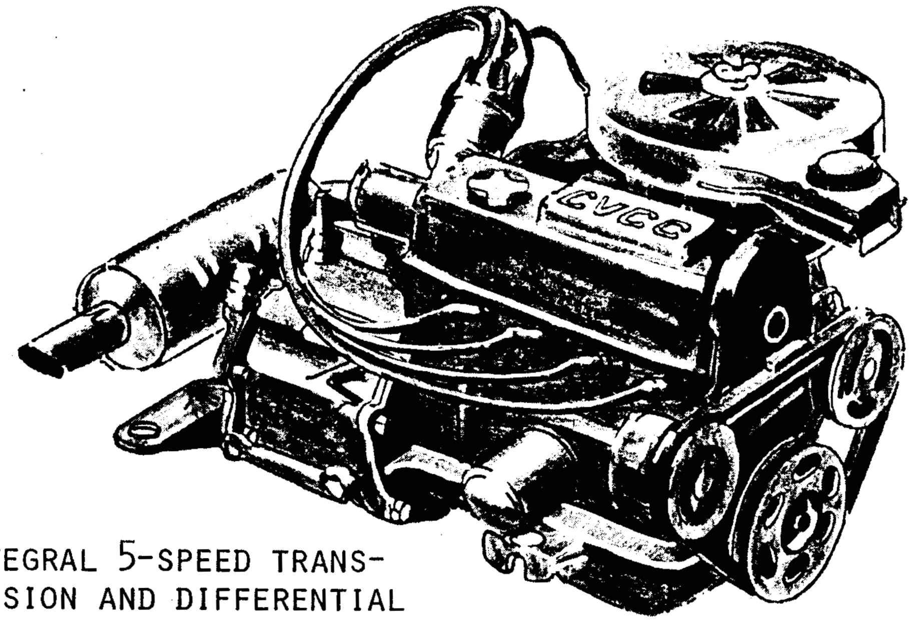
STRATIFIED CHARGE IN-LINE 4-CYLINDER ENGINE 1500 CC (90 CU IN)

RSV MILEAGE PERFORMANCE:

EPA URBAN CYCLE 27.3 MPG

EPA SUBURBAN CYCLE 36.9 MPG

EPA COMBINED CYCLE 30.95 MPG



INTEGRAL 5-SPEED TRANSMISSION AND DIFFERENTIAL

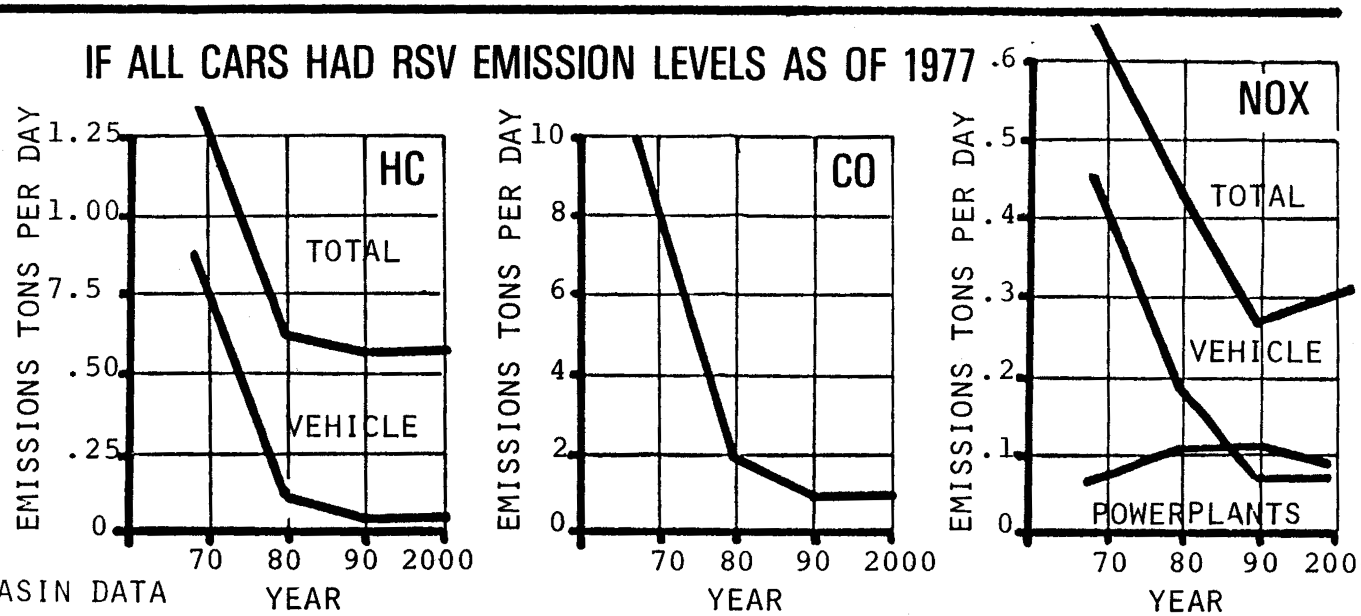
EMISSIONS

HC 0.26 GM/MI

CO 2.57 GM/MI

NOX .4 GM/MI

IF ALL CARS HAD RSV EMISSION LEVELS AS OF 1977



LOS ANGELES AIR BASIN DATA

THE ENGINE SHOULD ALSO BE FUEL-EFFICIENT AND LOW-POLLUTING. THE HONDA CVCC IS THE BEST AVAILABLE PRODUCTION ENGINE IN BOTH CATEGORIES, AND CAN BE USED IN THE RSV BECAUSE OF THE LOW VEHICLE WEIGHT.

ENERGY REQUIREMENTS

(VEHICLES WITH SIMILAR INTERIOR VOLUME)

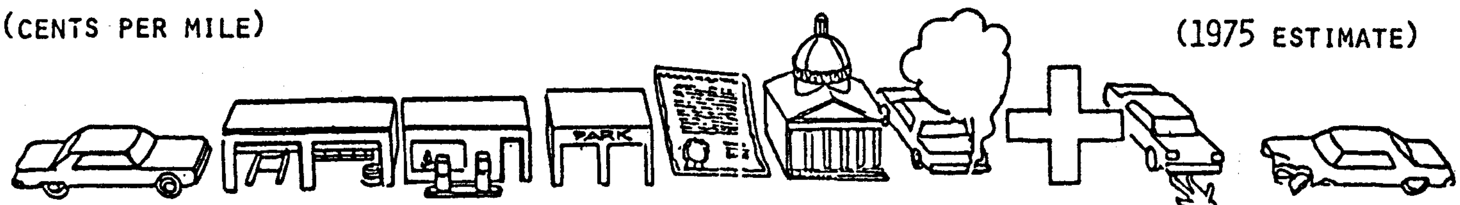
	MANUFACTURING ENERGY (MILLION BTU'S)	LIFETIME ENERGY (MILLION BTU'S)	TOTAL
PLYMOUTH VALIANT	61	263	324
RSV	38	144	182
SAVINGS	23 (38%)	119 (45%)	142 (44%)

BUT THIS IS ONLY THE "S" IN THE "S-3E" STRATEGY. ECONOMY CONSIDERATIONS DICTATE THAT THE VEHICLE BE AS LIGHT AS POSSIBLE SO AS TO GET THE BEST POSSIBLE FUEL ECONOMY. THE MINICARS RSV WILL GET 37 MPG ON THE HIGHWAY BECAUSE IT WEIGHS ONLY 1,918 POUNDS (CURB). BECAUSE OF ITS LIGHT WEIGHT, THE MINICARS RSV REQUIRES ONLY 56 PERCENT AS MUCH ENERGY AS A PLYMOUTH VALIANT, WHICH HAS ABOUT THE SAME INTERIOR VOLUME.

THE COST OF OPERATING AN AUTOMOBILE

(CENTS PER MILE)

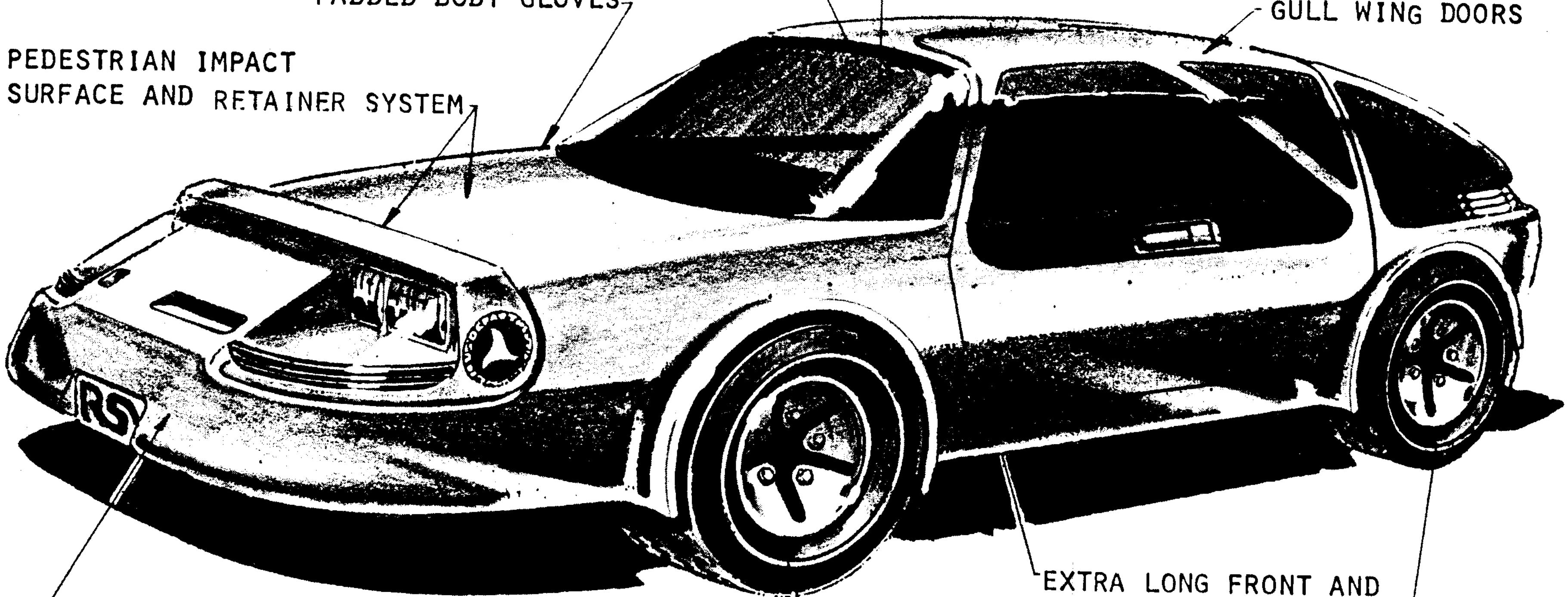
(1975 ESTIMATE)



	ORIGINAL VEHICLE COST DEPRECIATED	MAINTENANCE, ACCESSORIES, PARTS & TIRES	GAS & OIL (EXCLUDING TAXES)	GARAGE, PARKING, & TOLLS	INSURANCE	STATE & FEDERAL TAXES	EMISSIONS	OCCUPANT CASUALTIES	PEDESTRIAN CASUALTIES	PROPERTY DAMAGE	TOTAL
STANDARD	4.8	3.4	3.3	2.0	1.8	1.7	.8	1.6	.5	.8	20.7
COMPACT	3.8	2.9	2.8	2.0	1.7	1.3	.6	1.8	.5	.8	18.2
SUBCOMPACT	3.1	2.7	2.2	2.0	1.6	1.0	.4	2.1	.5	.8	16.4
RSV	2.7	2.5	1.6	2.0	1.0	.9	.1	.7	.3	.3	12.1

CONSIDERING ALL CONTRIBUTORS TO VEHICLE COST, THE RSV COSTS ONLY 12.1 CENTS PER MILE, COMPARED TO 18.2 CENTS FOR A CAR OF COMPARABLE INTERIOR ACCOMMODATIONS

RSV CONFIGURATION



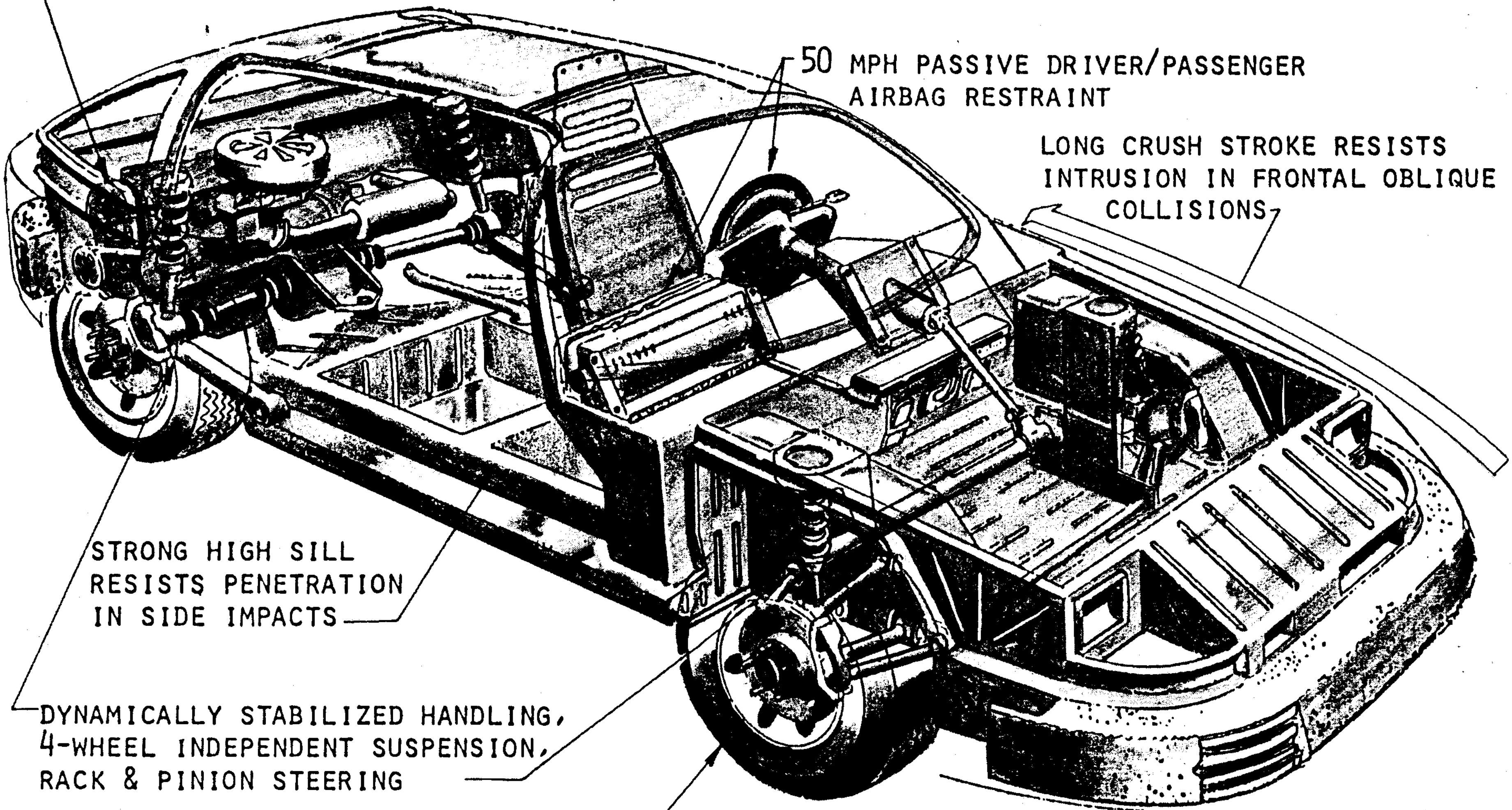
OMNI DIRECTIONAL ENERGY ABSORBING STRUCTURE

PASSIVE REAR SEAT AIRBELTS

STRUCTURE AND RESTRAINTS PROTECT TO 50 MPH

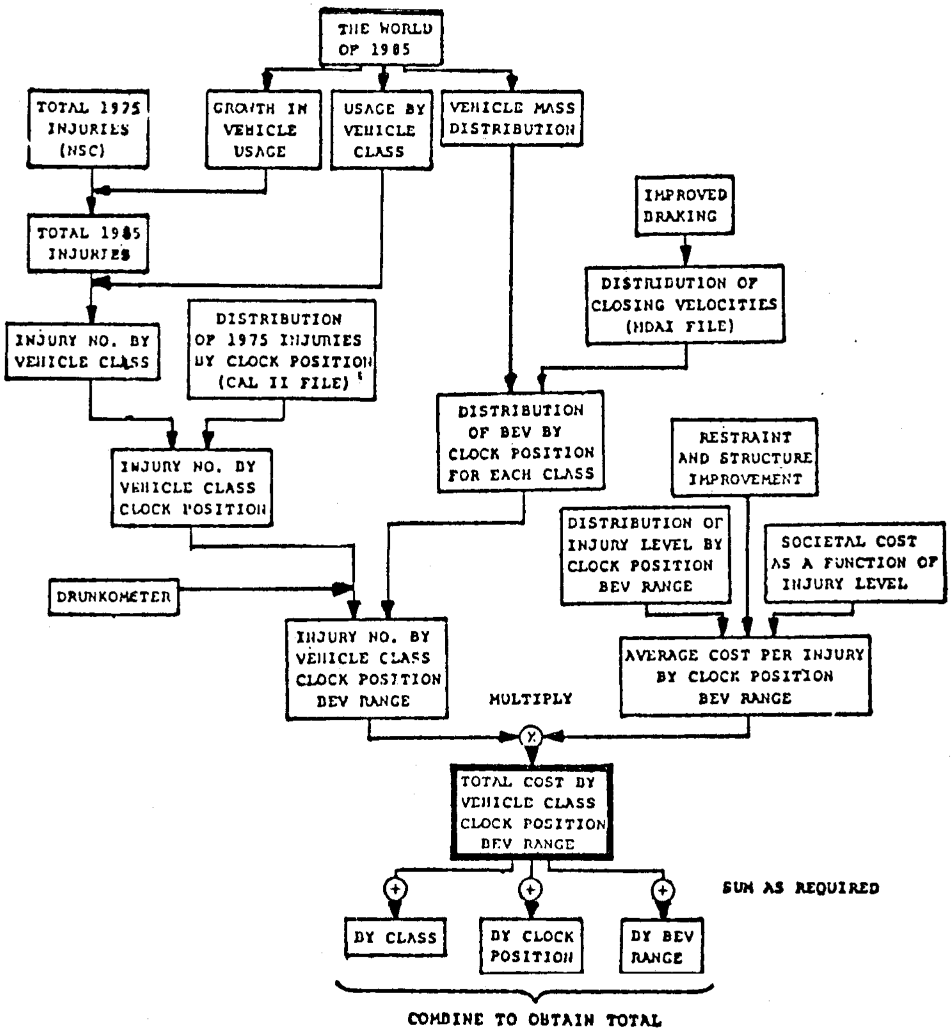
EXTERIOR SURFACES CONSIST OF A BODY GLOVE MADE FROM SELF-SKINNING FOAM. METAL SURFACES DO NOT HAVE TO BE SMOOTH AND HIGHLY FINISHED, MAKING THEM SIMPLER AND LIGHTER. DAMAGED BODY GLOVES MAY BE EASILY REPAIRED OR REPLACED.

RSV CONFIGURATION

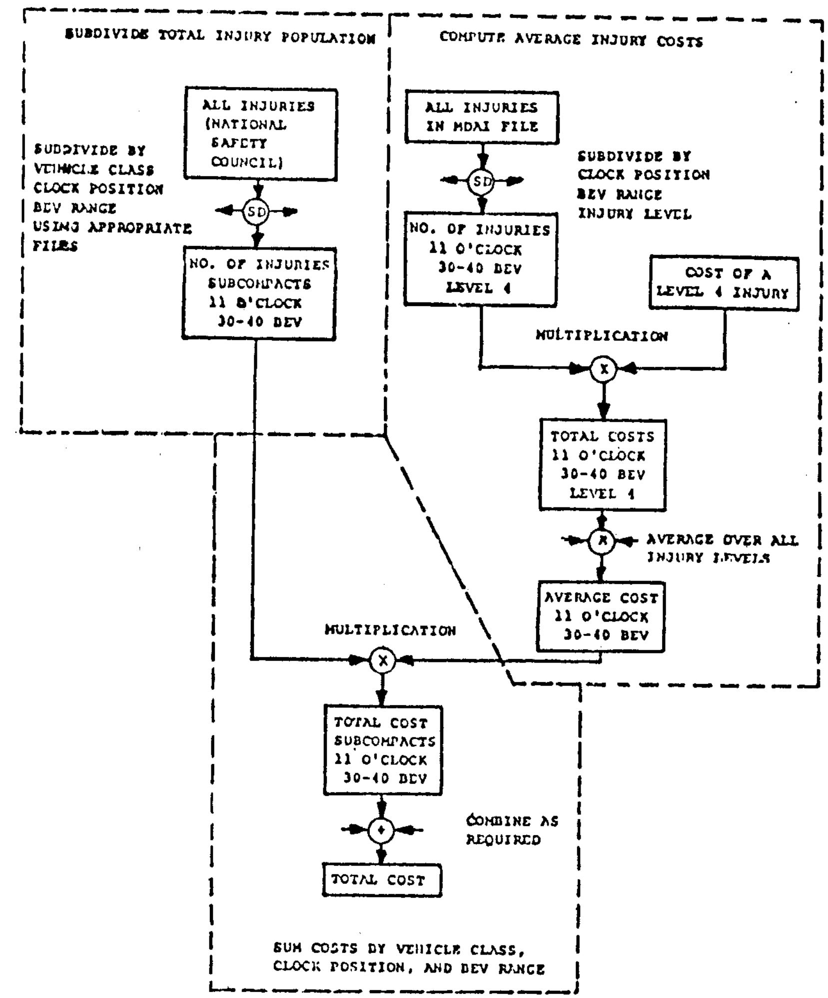


THE REAR ENGINE CONFIGURATION RESULTS IN HIGH VELOCITY CRASHWORTHINESS PERFORMANCE AT LOW FORCE LEVELS AND LOW WEIGHT, BECAUSE IT GETS THE TROUBLESOME HARD MASSES OUT OF THE WAY. ENGINE WEIGHT IS MINIMAL, RESULTING IN A FRONT/REAR WEIGHT DISTRIBUTION OF 48/52 PERCENT SO AS TO KEEP HANDLING AND BRAKING PERFORMANCE IN THE OPTIMAL RANGE

SOCIETAL COST METHODOLOGY

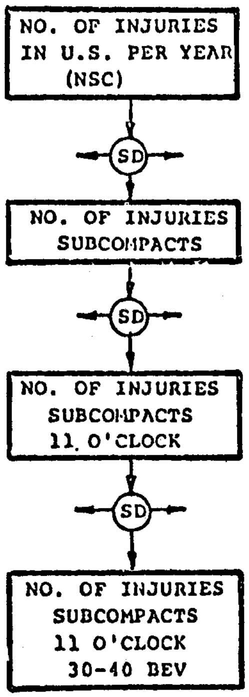


NOW FOR MORE DETAILS ON THE BENEFIT/COST METHODOLOGY. NOTE THAT THE MAJOR INPUTS ARE: (A) FUTURE AUTOMOTIVE PROJECTIONS (ACCIDENT EXPOSURE AND VEHICLE MASSES); (B) TOTAL NUMBER OF INJURIES, BY VEHICLE CLASS, CLOCK POSITION, AND VELOCITY; (C) DISTRIBUTION OF CLOSING VELOCITIES; AND (D) THE EFFECTS OF VEHICLE IMPROVEMENTS ON THESE QUANTITIES.

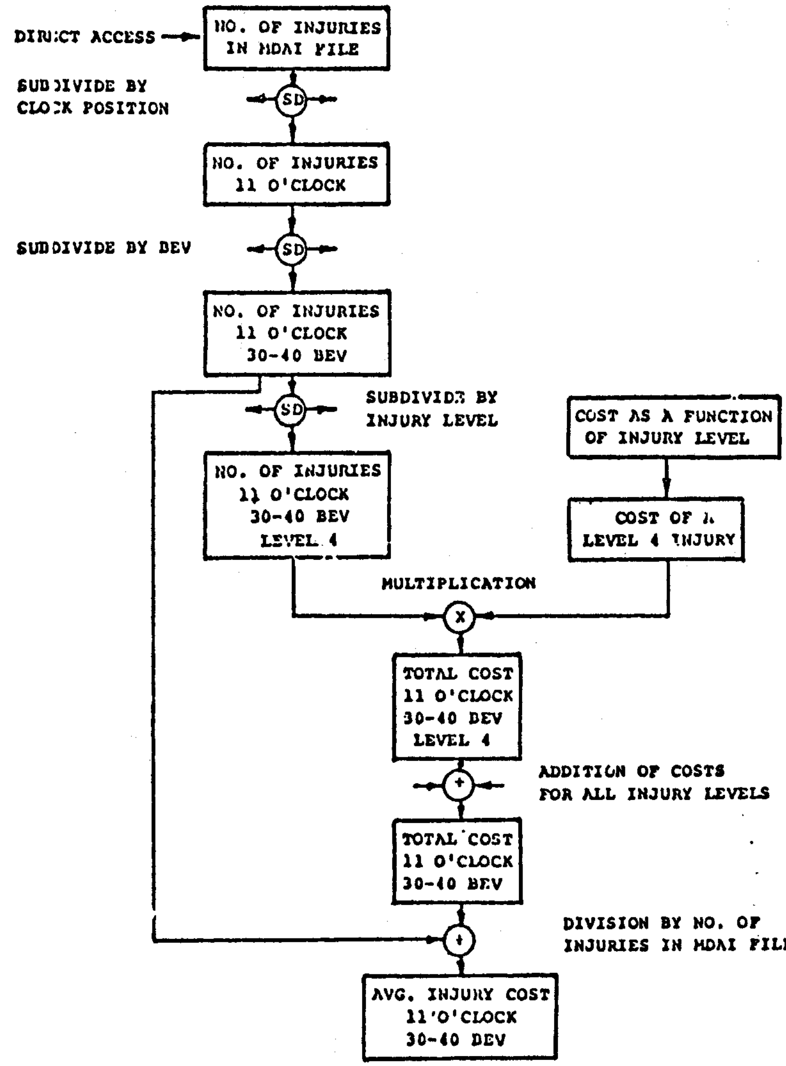


THE BASIC METHODOLOGY HAS THREE PARTS: FIRST, THE INJURY POPULATION IS SUBDIVIDED; SECOND, THE AVERAGE INJURY COST IS COMPUTED IN EACH STATISTICAL CELL; AND THIRD, THE FREQUENCY AND SEVERITY ARE MULTIPLIED FOR EACH CELL, AND THE RESULTS ARE COMBINED AS REQUIRED.

SUBDIVISION OF TOTAL INJURY POPULATION

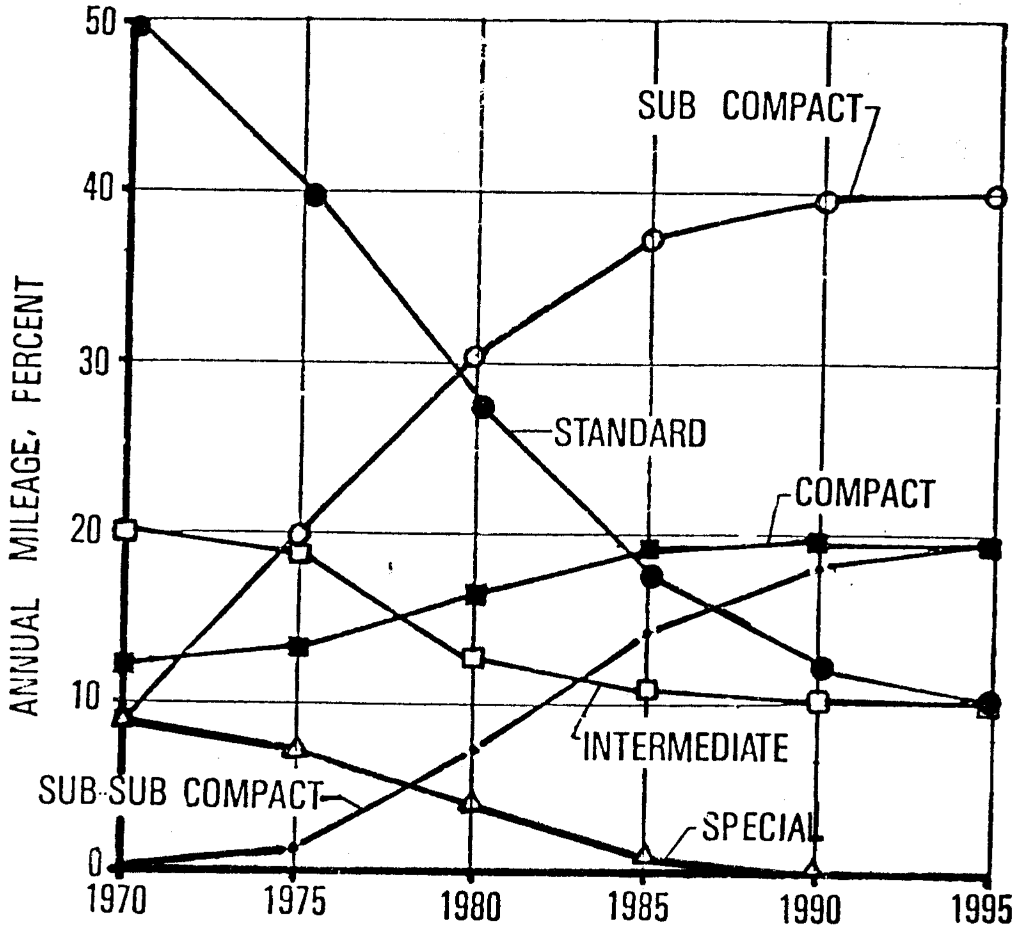


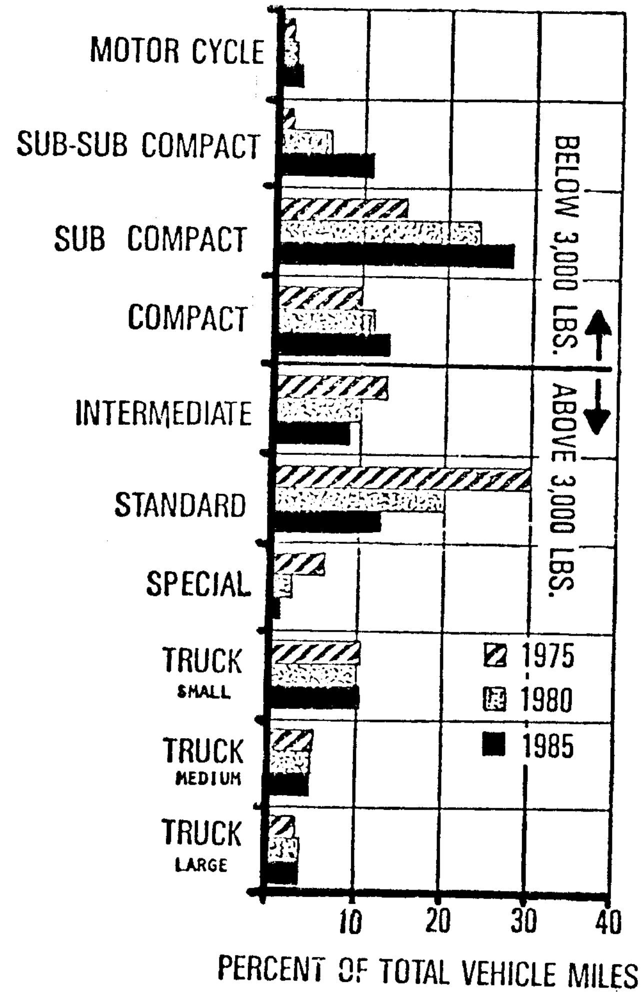
SUBDIVISION OF THE INJURY POPULATION INVOLVES DIFFERENT ACCIDENT FILES, ACCORDING TO THEIR SIZE AND DETAIL. BIASES IN THE MDAI FILE ARE CORRECTED SO THAT THE APPROPRIATE DISTRIBUTION OF SEVERE AND MILD INJURIES IS PRESENT IN EACH VELOCITY RANGE AND CLOCK POSITION.



THE CALCULATION OF AVERAGE INJURY COST IS BASED ON EXAMINING EACH VELOCITY RANGE-CLOCK POSITION CELL, AND SUBDIVIDING IT ACCORDING TO INJURY SEVERITY, AS MEASURED BY THE AMA INJURY LEVEL. COSTS ARE ASSIGNED TO EACH INJURY LEVEL, SO THE AVERAGE COST DEPENDS ON THE DISTRIBUTION OF INJURY LEVELS IN EACH CELL.

AUTO USAGE BY CLASS

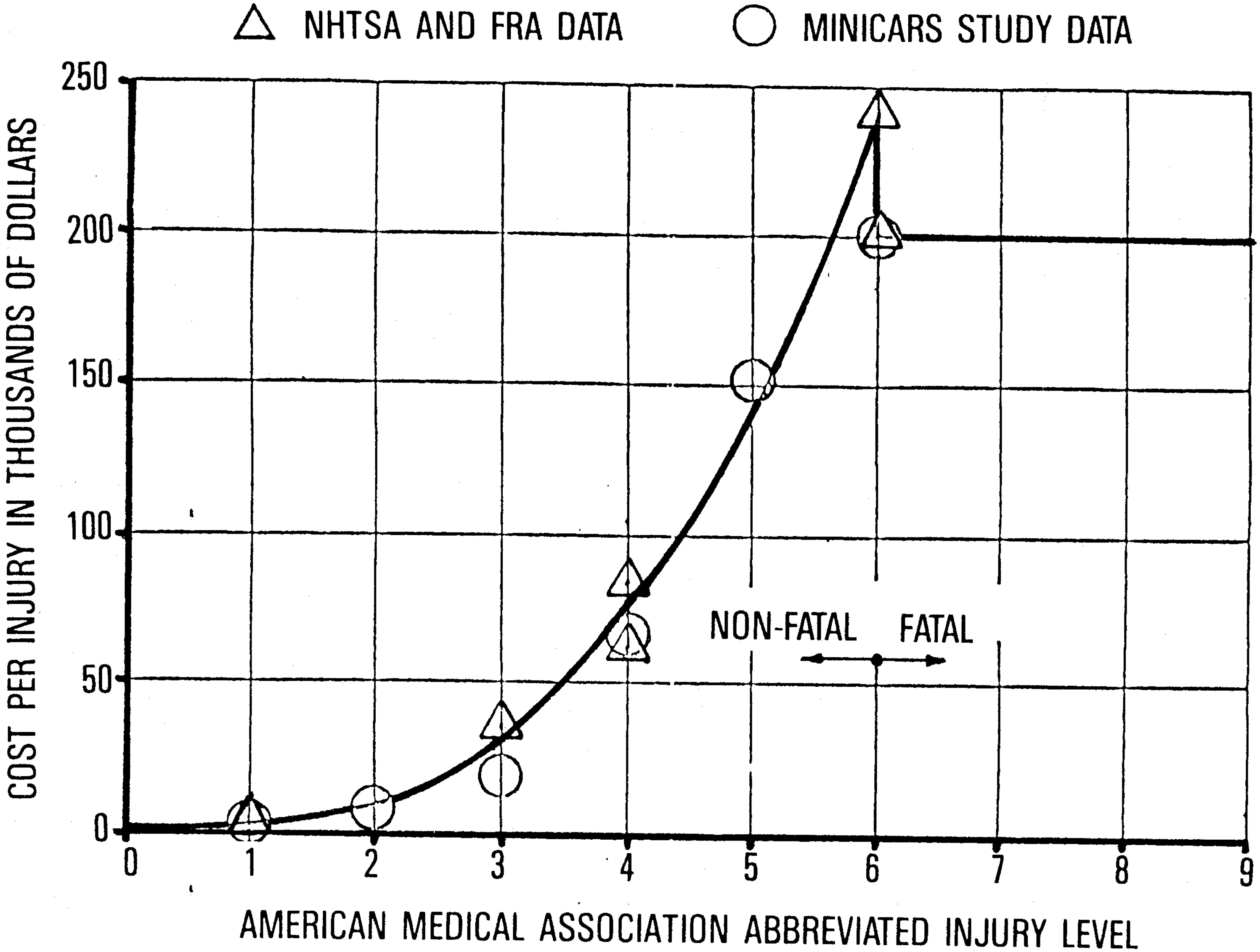




IN EACH VEHICLE CLASS, THE NUMBER OF INJURIES DEPENDS STRONGLY ON THE NUMBER OF VEHICLES. THIS IS CALCULATED FROM YEARLY SALES PROJECTIONS AND SCRAPPAGE RATES.

ACCIDENT EXPOSURE IS PROPORTIONAL TO VEHICLE USAGE, IN VEHICLE-MILES PER YEAR. USAGE TRENDS DIFFER SLIGHTLY FROM CAR POPULATION TRENDS BECAUSE NEW CARS ARE DRIVEN MORE THAN OLD ONES. IN 1985, SUBCOMPACTS WILL COMPRISE 36 PERCENT OF THE POPULATION, BUT WILL PRODUCE 38 PERCENT OF THE INJURIES. COMPARED TO HEAVIER CARS, THESE INJURIES WILL TEND TO BE MORE SEVERE, AND THE COSTS

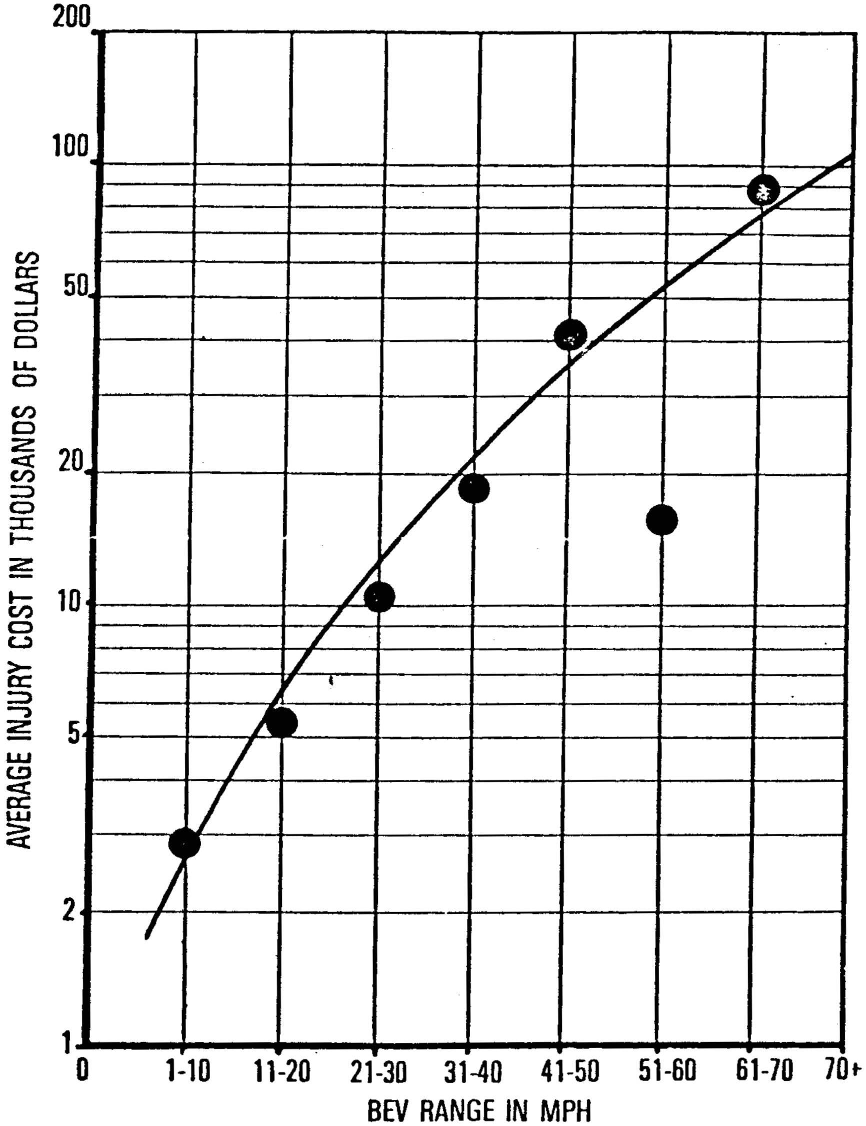
SOCIETAL COST VERSUS AMA INJURY SCALE



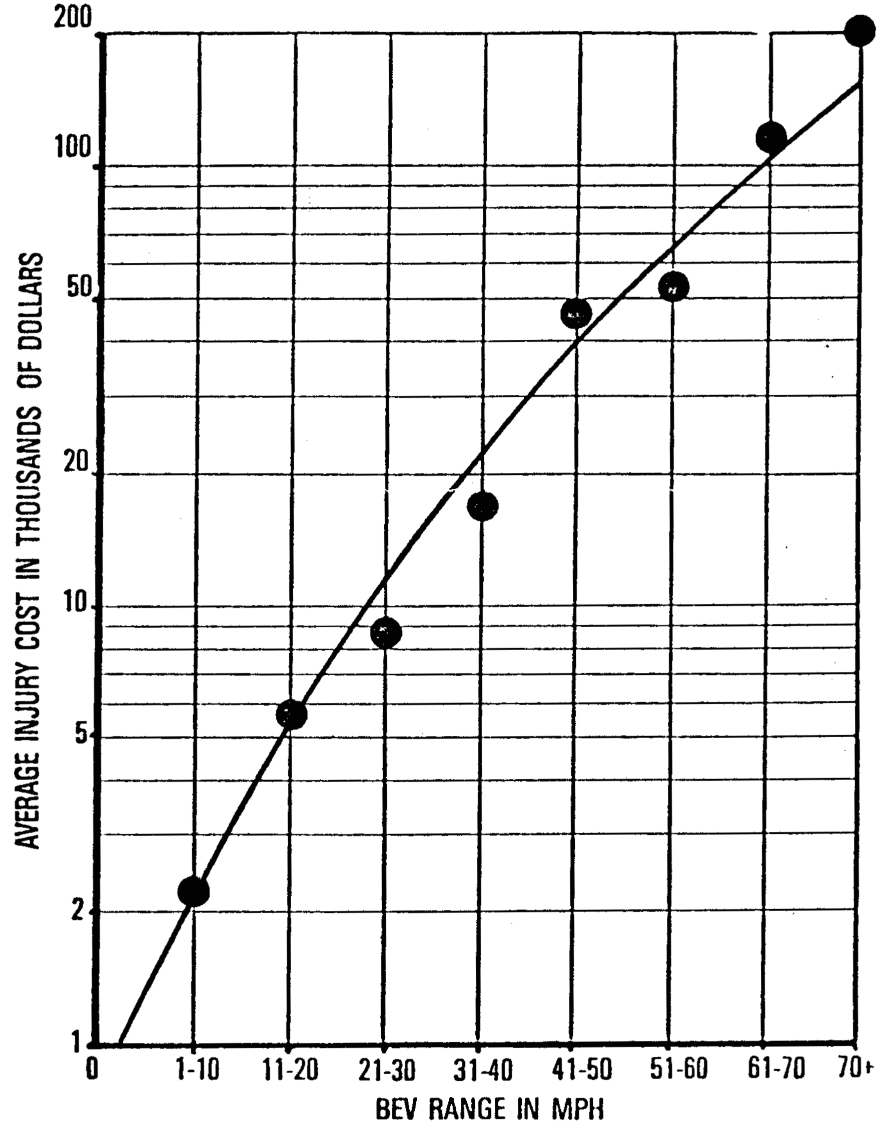
COSTS ARE CALCULATED FOR EACH INJURY LEVEL ON THE AMA ABBREVIATED INJURY SCALE, IN WHICH 1 THROUGH 6 ARE INJURIES OF INCREASING

AVERAGE INJURY COST IN A GIVEN STATISTICAL CELL DEPENDS ON THE DISTRIBUTION OF THESE INJURY LEVELS IN THE CELL.

VEHICLE TO VEHICLE FULL FRONTAL IMPACTS

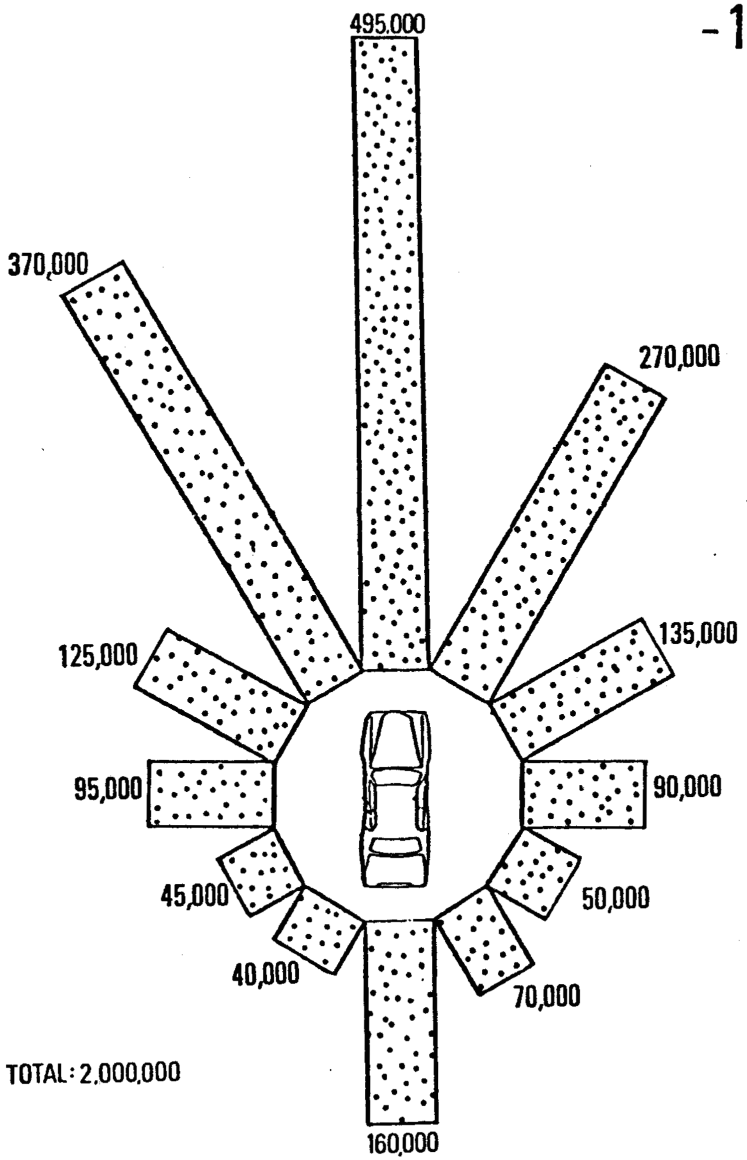


FIXED OBJECT FRONTAL IMPACTS



AVERAGE INJURY COST IS A FUNCTION OF VELOCITY AND ACCIDENT MODE (CODED BY CLOCK POSITION, FOR VEHICLE-TO-VEHICLE AND FIXED-OBJECT CRASHES). A MONOTONIC RELATIONSHIP WITH VELOCITY IS EXPECTED, THOUGH SMALL SAMPLE SIZES AT THE HIGHER VELOCITIES CAUSE SOME SCATTER. THE SAME COST CURVES ARE USED FOR ALL CLASSES, BUT SMALL CARS TEND TO GET INTO HIGHER-VELOCITY ACCIDENTS, DUE TO THEIR MOMENTUM DISADVANTAGE. SMALL CAR COSTS THUS TEND TO BE HIGHER.

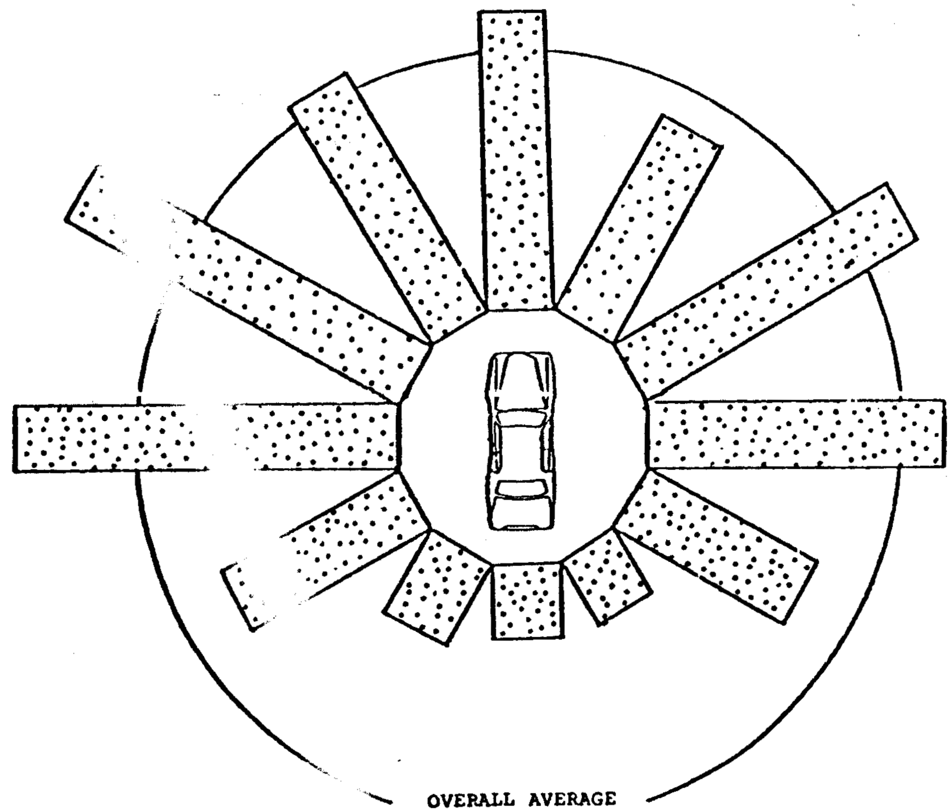
NUMBER OF INJURIES BY CLOCK POSITION--1975



TOTAL: 2,000,000

TOTAL SOCIETAL COSTS DEPEND ON BOTH THE FREQUENCY (NUMBER OF INJURIES) AND THE SEVERITY (AVERAGE INJURY COST). EACH CLOCK POSITION DENOTES AN AREA OF DAMAGE WHICH DESCRIBES THE ACCIDENT MODE.

RELATIVE SEVERITY BY CLOCK POSITION

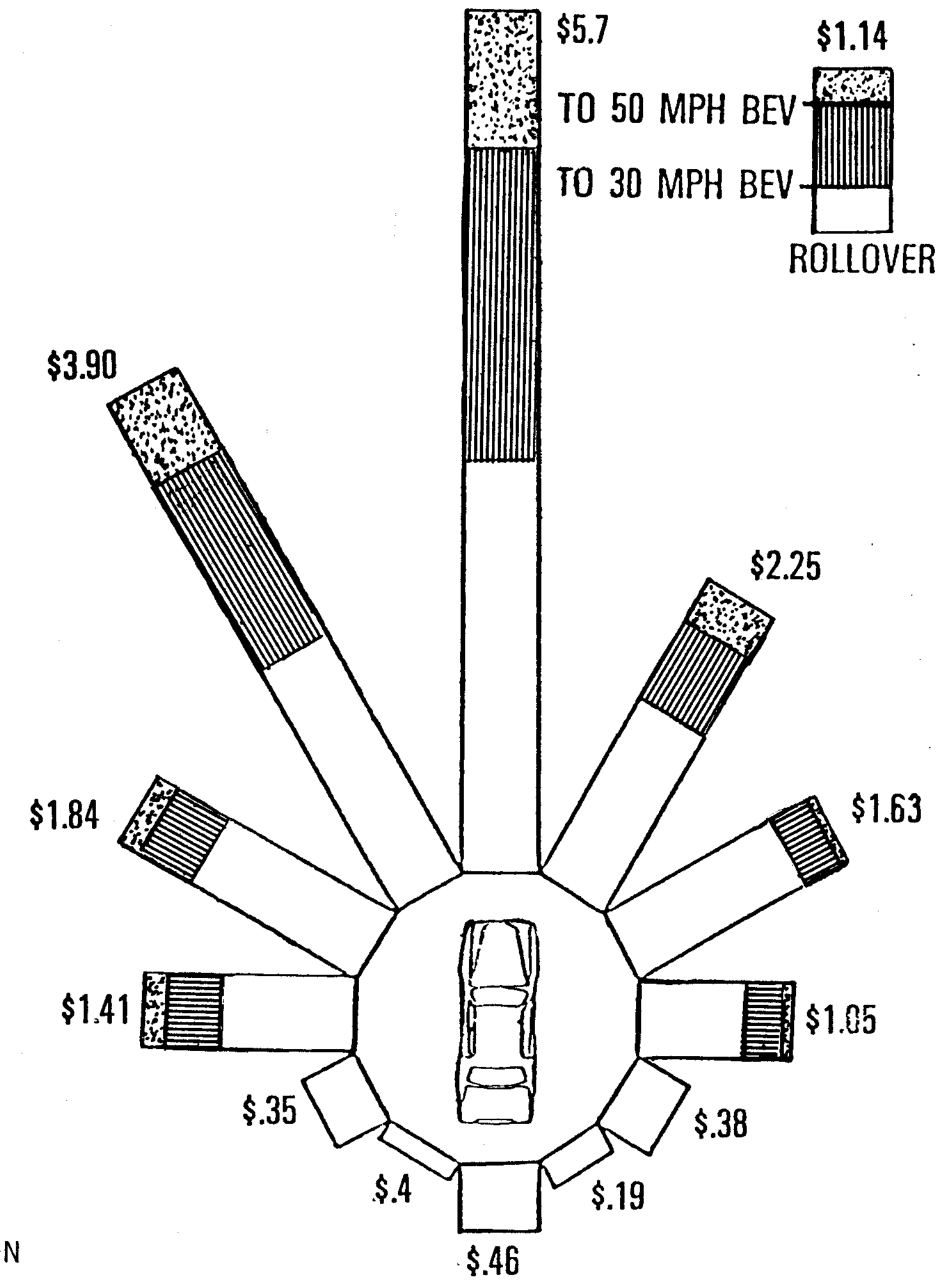


ROLLO[illegible]R: 1.52 TIMES AVERAGE

NOTE THE DIFFERENCES BETWEEN FREQUENCY AND SEVERITY FOR THE VARIOUS MODES. THE PRODUCT OF THE TWO IS THE SOCIETAL COST. THESE CLOCK POSITION CHARTS ARE SUMMED OVER ALL VEHICLE CLASSES AND ALL VELOCITY RANGES.

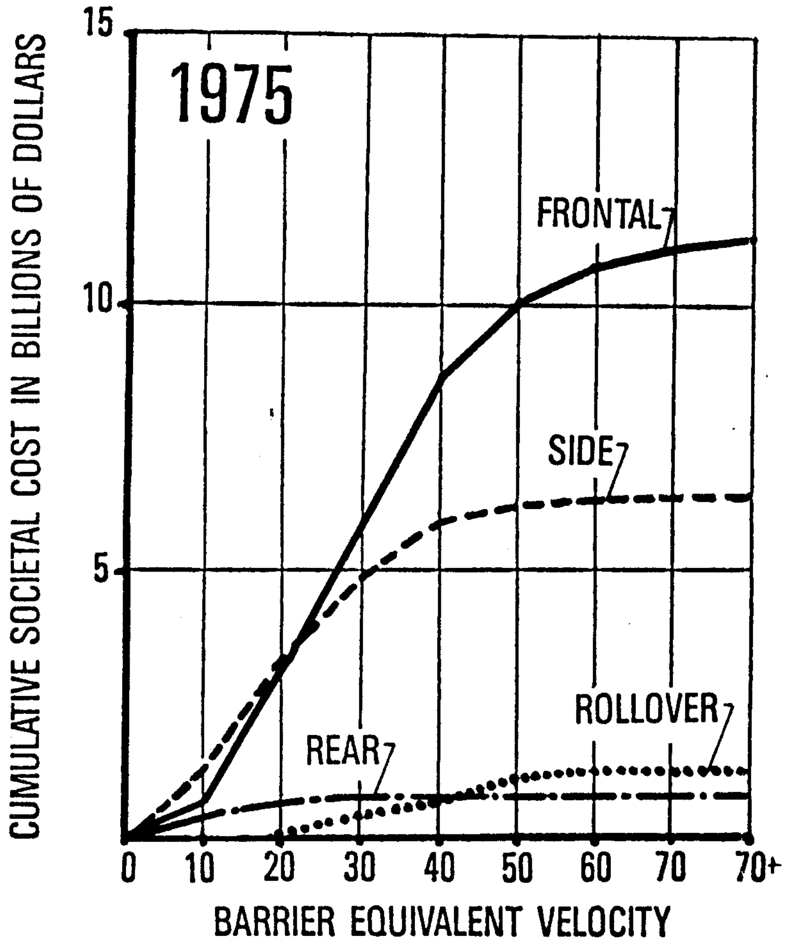
SOCIETAL COST BY CLOCK POSITION – 1975

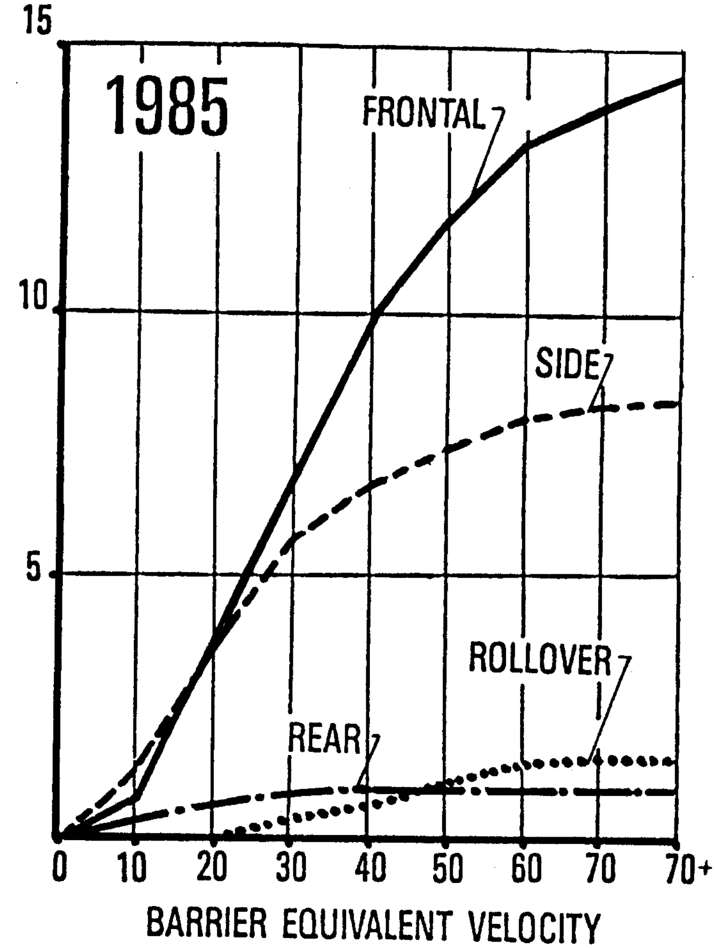
COST IN BILLIONS OF DOLLARS



TOTAL SOCIETAL COST, FOR ALL VEHICLE CLASSES, IS SHOWN AS A FUNCTION OF CLOCK POSITION AND VELOCITY. THIS COST IS DUE TO OCCUPANT INJURIES ONLY; YET THE TOTAL IS $20.44 BILLION ANNUALLY.

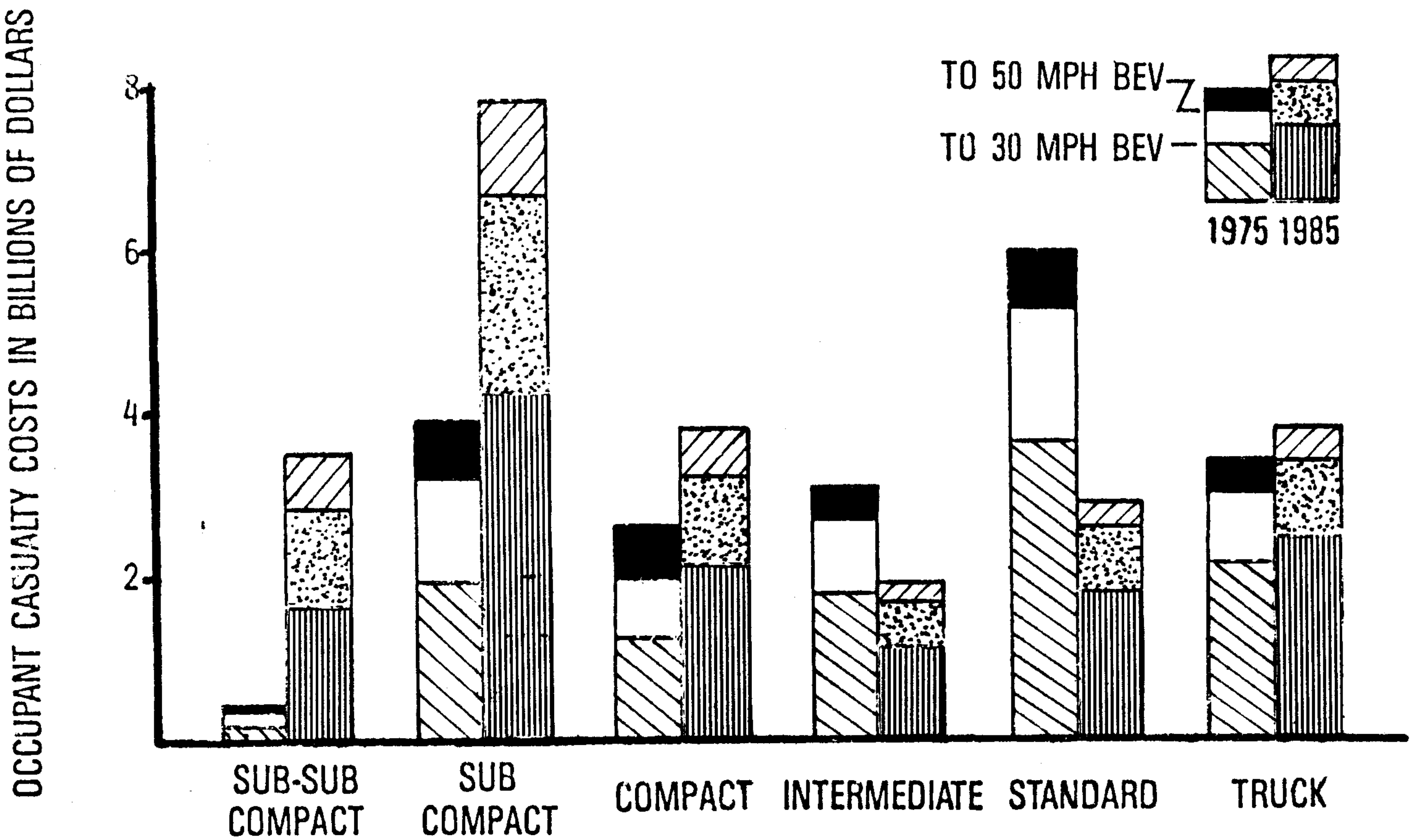
CUMULATIVE SOCIETAL COST BY VELOCITY FOR EACH ACCIDENT MODE





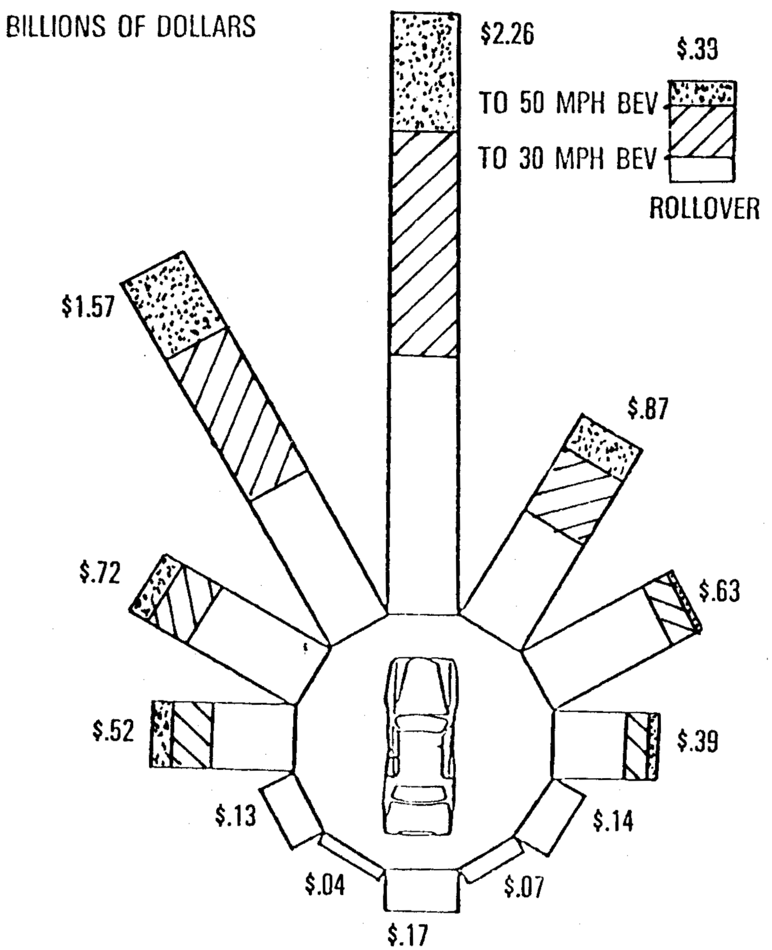
VELOCITY DISTRIBUTIONS AID IN ESTABLISHING VELOCITY PERFORMANCE GOALS. IF COSTS ARE TO BE REDUCED SUBSTANTIALLY, 50 MPH FRONTAL PERFORMANCE AND 30 MPH SIDE PERFORMANCE ARE WARRANTED, ESPECIALLY IN 1985. BETWEEN NOW AND THEN, THE COST OF OCCUPANT INJURIES WILL INCREASE BY 21 PERCENT.

SOCIETAL COST OF ACCIDENT INJURIES BY CAR CLASS, 1975-1985



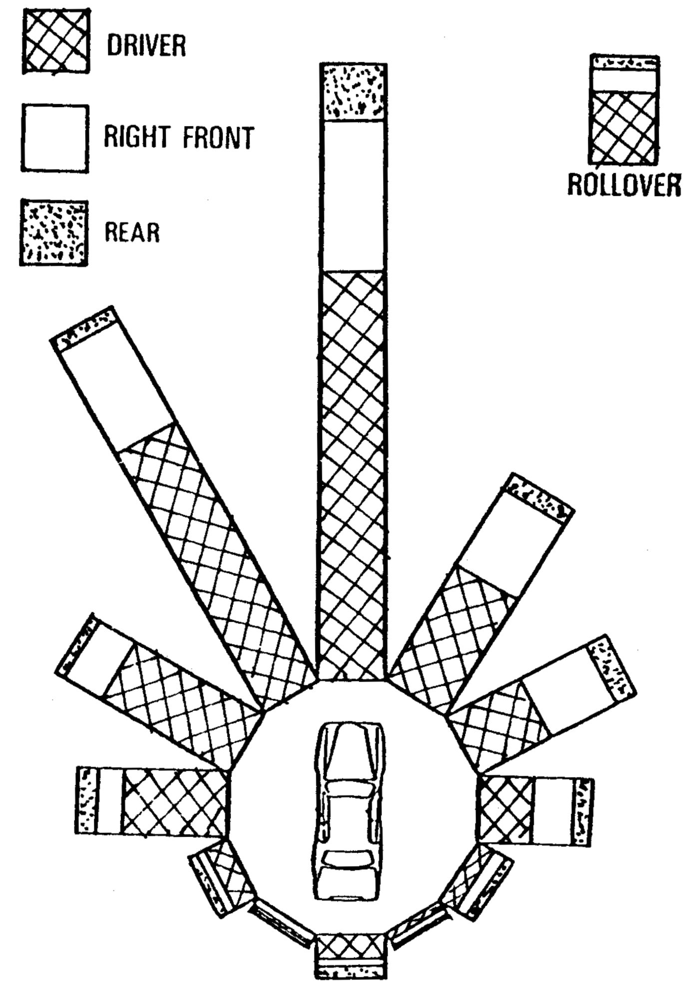
THE BRUNT OF THIS INCREASE TO $24.74 BILLION ANNUALLY WILL BE CARRIED BY SMALL CARS. THEIR SHARE WILL GROW FROM 35 TO 61 PERCENT, WITH SUBCOMPACTS ALONE RISING FROM 19 TO 26 PERCENT. SINCE THE RSV IS DESIGNED FOR THE GREATEST PUBLIC GOOD, IT IS AIMED AT THE SUBCOMPACT CLASS, AS A MINIMUM. NOTE ALSO THE LARGER PORTION OF COSTS ABOVE 50 MPH FOR SMALL CARS, WHICH JUSTIFIES HIGHER SPEED PERFORMANCE FOR THOSE VEHICLES.

SOCIETAL COST BY CLOCK POSITION – 1985 SUBCOMPACT CLASS ONLY

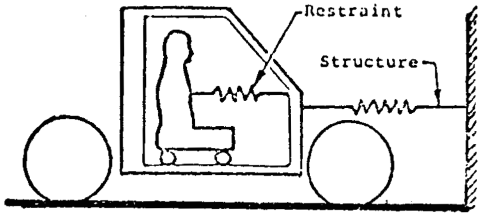


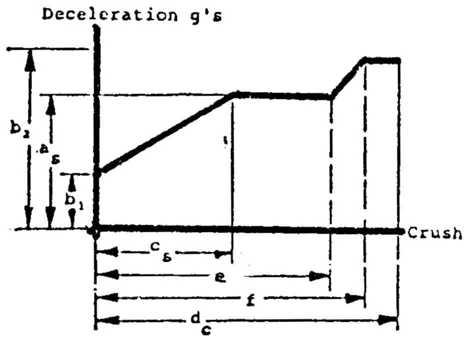
THESE ARE THE COSTS THAT ARE AMENABLE TO REDUCTION BY IMPROVEMENTS IN 1985 SUB-COMPACTS. 30 MPH PERFORMANCE WILL BE ADEQUATE IN THE SIDE, BUT CERTAINLY NOT

SOCIETAL COST BY SEAT POSITION

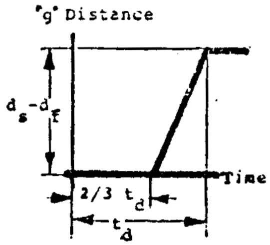


NOTE THE PREPONDERANCE OF COSTS FOR THE DRIVER COMPARED TO OTHER SEATING POSITIONS (DUE TO OCCUPANCY, PRIMARILY). DIFFERENT RESTRAINT PERFORMANCE AND COST

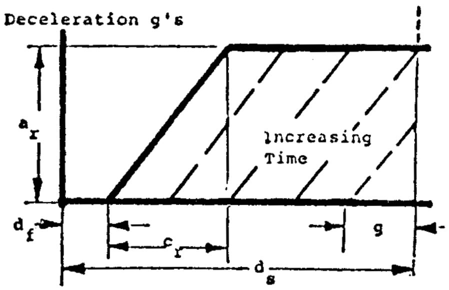




Structure Characteristic

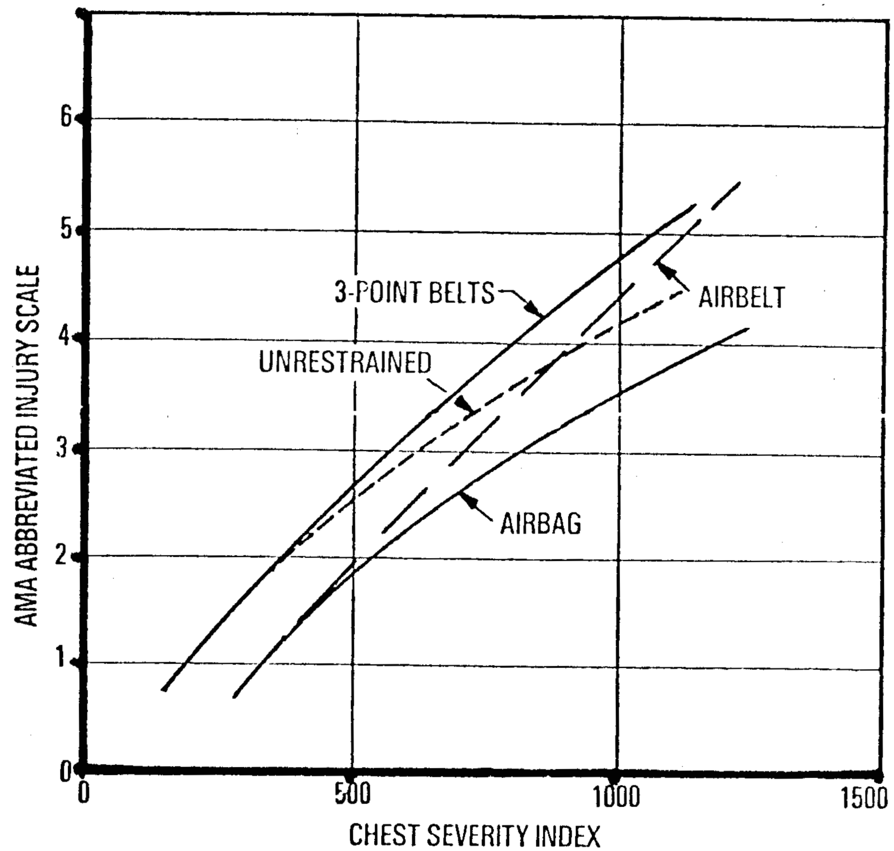


Restraint Deployment Characteristic



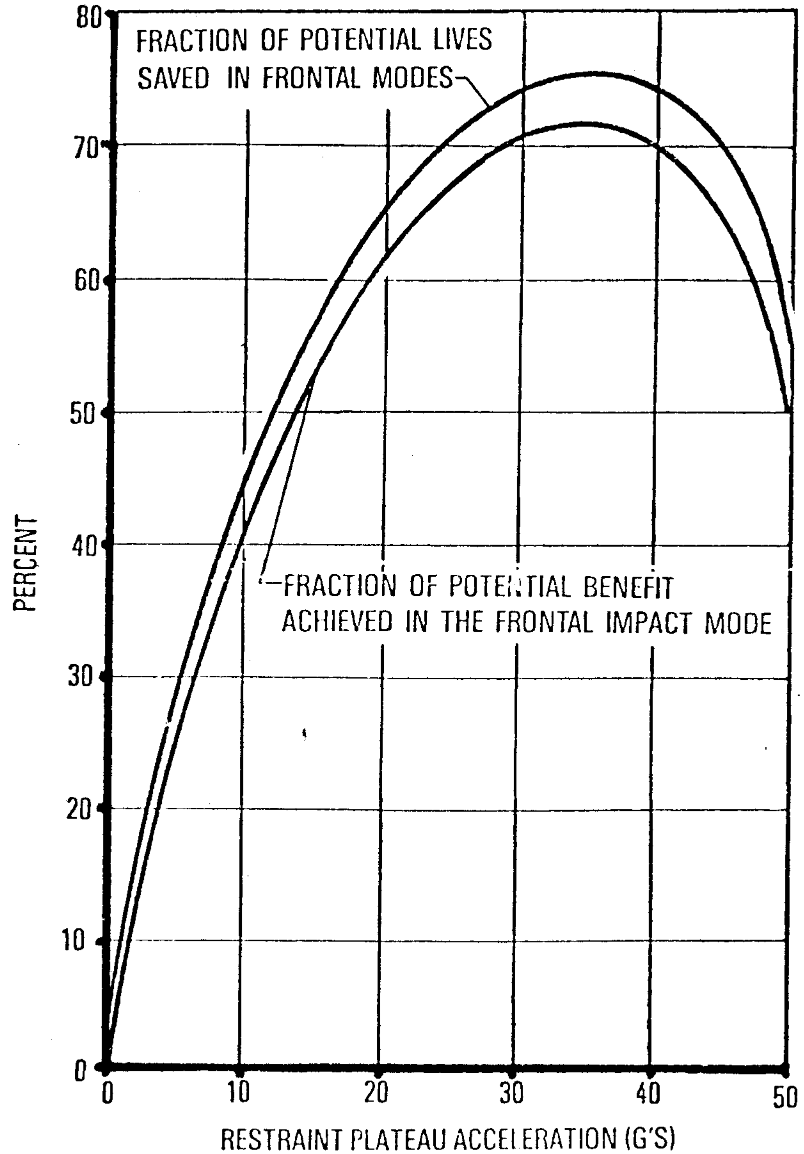
BENEFITS OF STRUCTURE AND RESTRAINT IMPROVEMENTS ARE CALCULATED BY RUNNING A SIMPLE COMPUTER SIMULATION IN 1 MPH INCREMENTS FROM 1 THROUGH 80 MPH, AND CALCULATING THE RESULTING CHEST SEVERITY INDEX (CSI) IN EACH CRASH. OBLIQUE AND CAR-TO-CAR IMPACTS ARE SIMULATED BY ADJUSTING THE STRUCTURAL FORCE-DEFLECTION CURVE APPROPRIATELY. RESTRAINT FORCE IS A FUNCTION OF BOTH TIME AND OCCUPANT STROKE.

AIS VS CSI



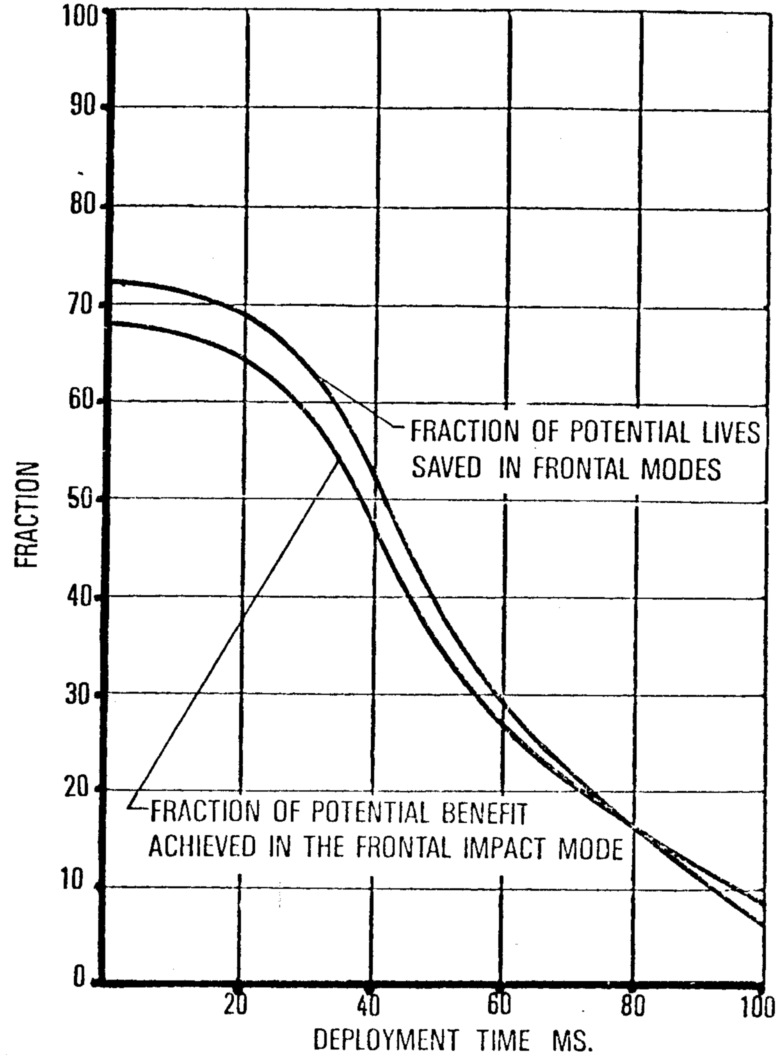
THESE CURVES ALLOW THE CONVERSION FROM TEST PARAMETERS (CSI) TO REAL-WORLD PARAMETERS (AMA INJURY LEVEL), AND THENCE TO SOCIETAL COST. DIFFERENCES IN THE CURVES ARE DUE TO LOAD DISTRIBUTION; AN AIRBELT DOES NOT DISTRIBUTE LOADS AS WELL AS AN AIRBAG, BUT TENDS TO PRODUCE LOWER CSI'S BECAUSE OF SUPERIOR DEPLOYMENT TIME.

RESTRAINT PERFORMANCE IN FRONTAL MODE



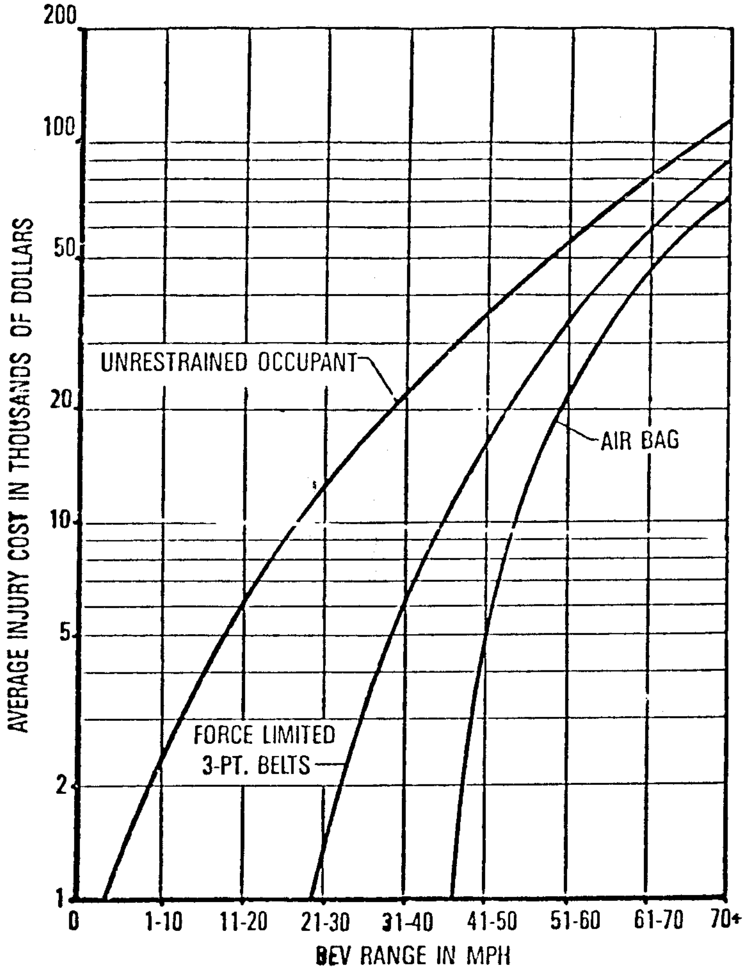
THE METHODOLOGY PERMITS PARAMETRIC STUDIES TO BE MADE. WE FIND, FOR EXAMPLE, THAT A 35G RESTRAINT (FOR A 50TH PERCENTILE MALE) IS NEARLY OPTIMAL OVER THE FULL ANTHROPO-

RESTRAINT PERFORMANCE VS. DEPLOYMENT TIME



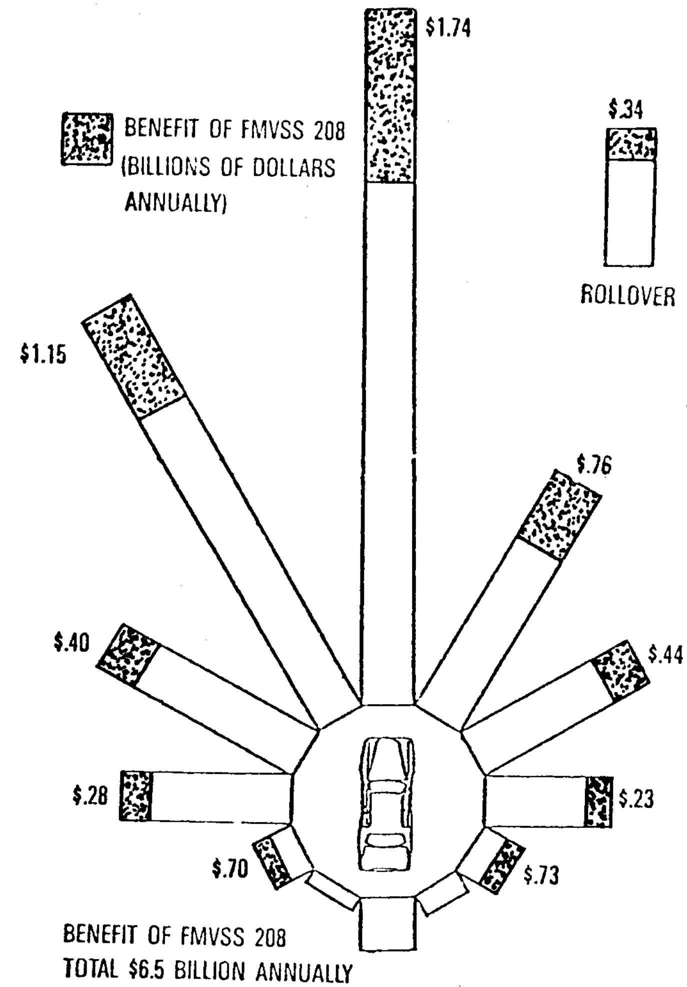
FURTHERMORE, RAPID DEPLOYMENT IS CRUCIAL TO THE REDUCTION OF BOTH FATALITIES AND SOCIETAL COST IN THE FRONTAL MODES.

AVERAGE COST PER INJURY
3-PT VS. AIRBAG



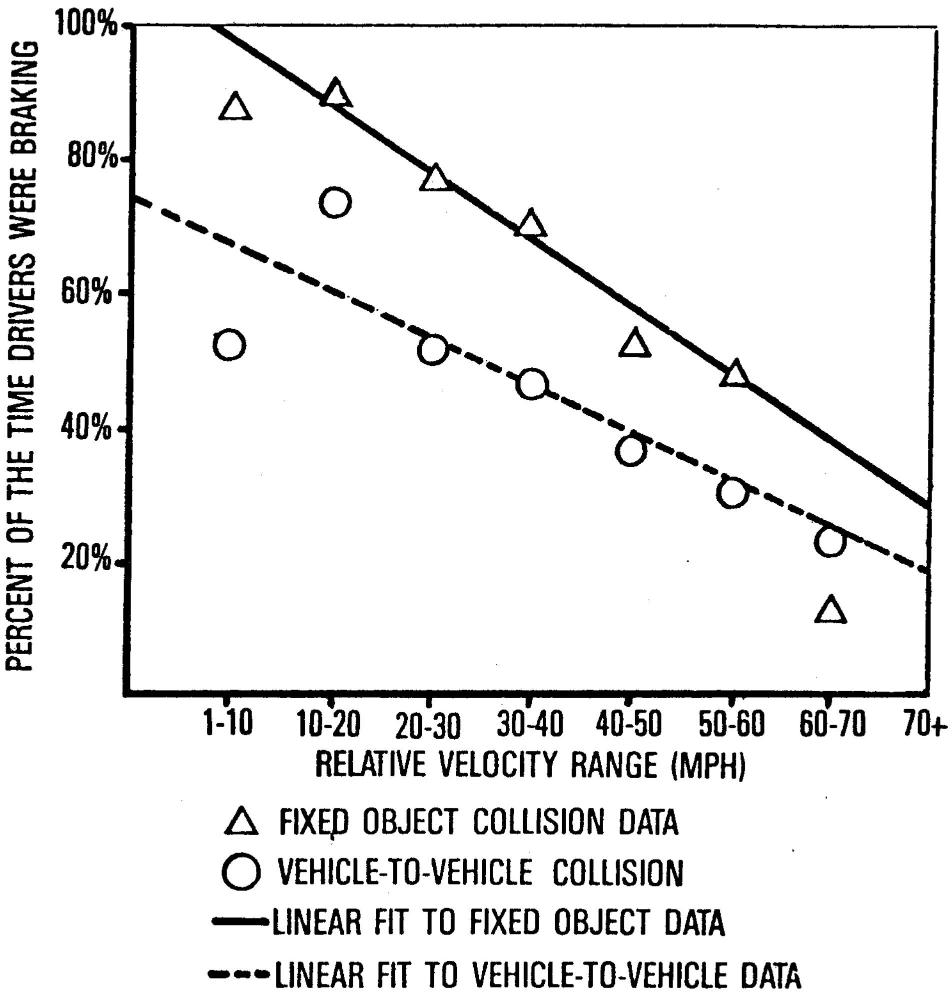
THE METHODOLOGY ENABLES A CALCULATION (NOT AN ESTIMATE) OF CRASHWORTHINESS BENEFITS IN EVERY VELOCITY RANGE, BY COMPARING AVERAGE INJURY COSTS, "BEFORE" AND "AFTER." TOTAL BENEFIT IS THE PRODUCT OF AVERAGE BENEFIT AND THE NUMBER OF INJURIES IN THE PARTICULAR SEATING POSITION, REDUCED ACCORDING TO RESTRAINT SYSTEM USAGE.

EFFECT OF FMVSS 208

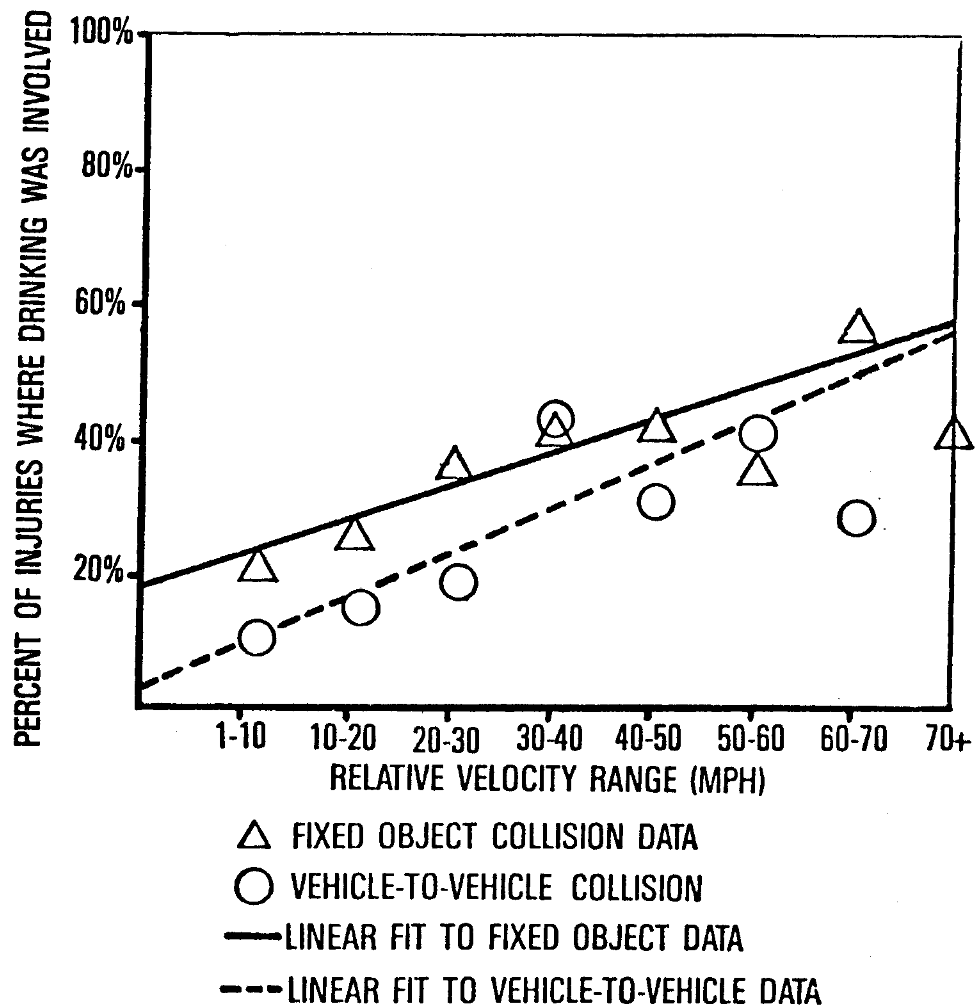


THE ABILITY TO CALCULATE CRASHWORTHINESS BENEFITS PERMITS THE INCLUSION OF THE EFFECTS OF FMVSS 208. WHAT REMAINS IN 1985 IS THE COST AMENABLE TO REDUCTION BY THE RSV, I.E., THE POTENTIAL RSV BENEFITS. THIS ASSUMES THE REPLACEMENT OF ALL 1985 SUBCOMPACTS BY RSV'S, AND IGNORES THE PENETRATION OF THE RSV INTO THE SUB-SUB-

PRE-IMPACT BRAKING

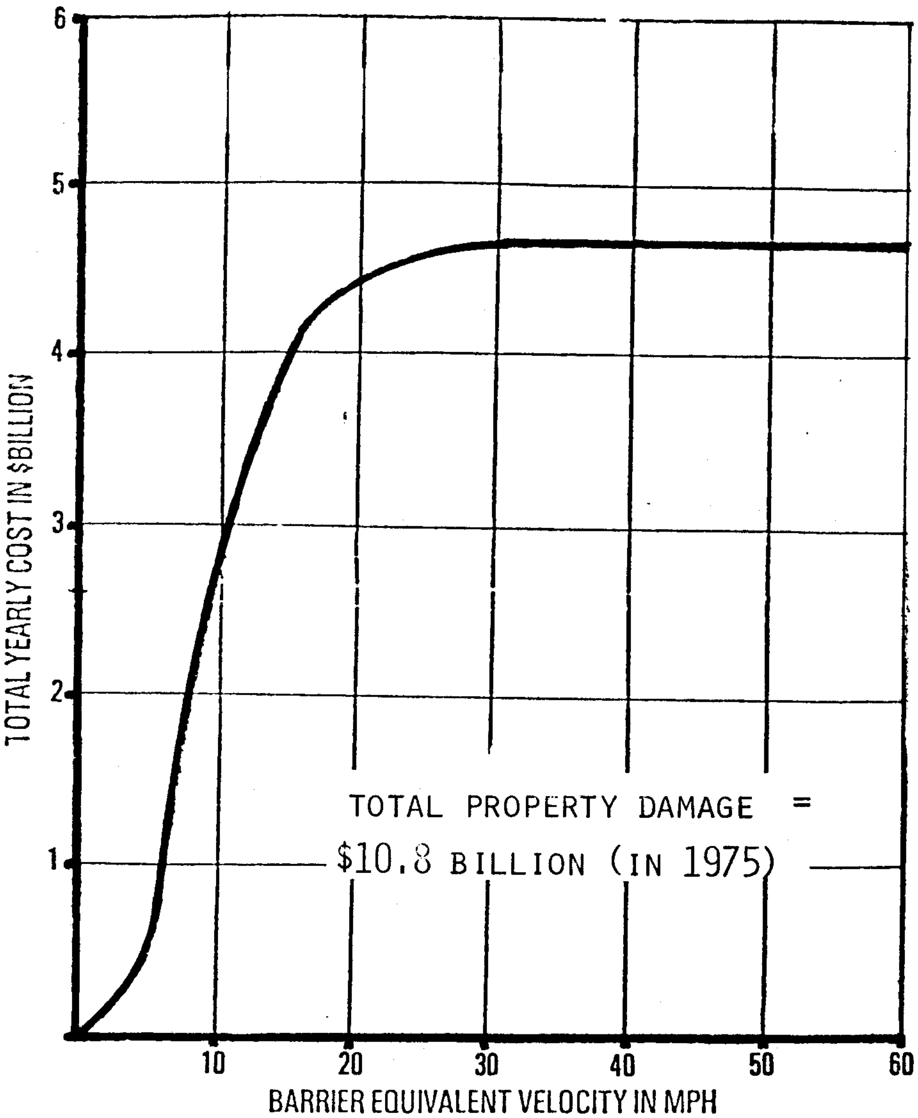


DRIVER IMPAIRMENT

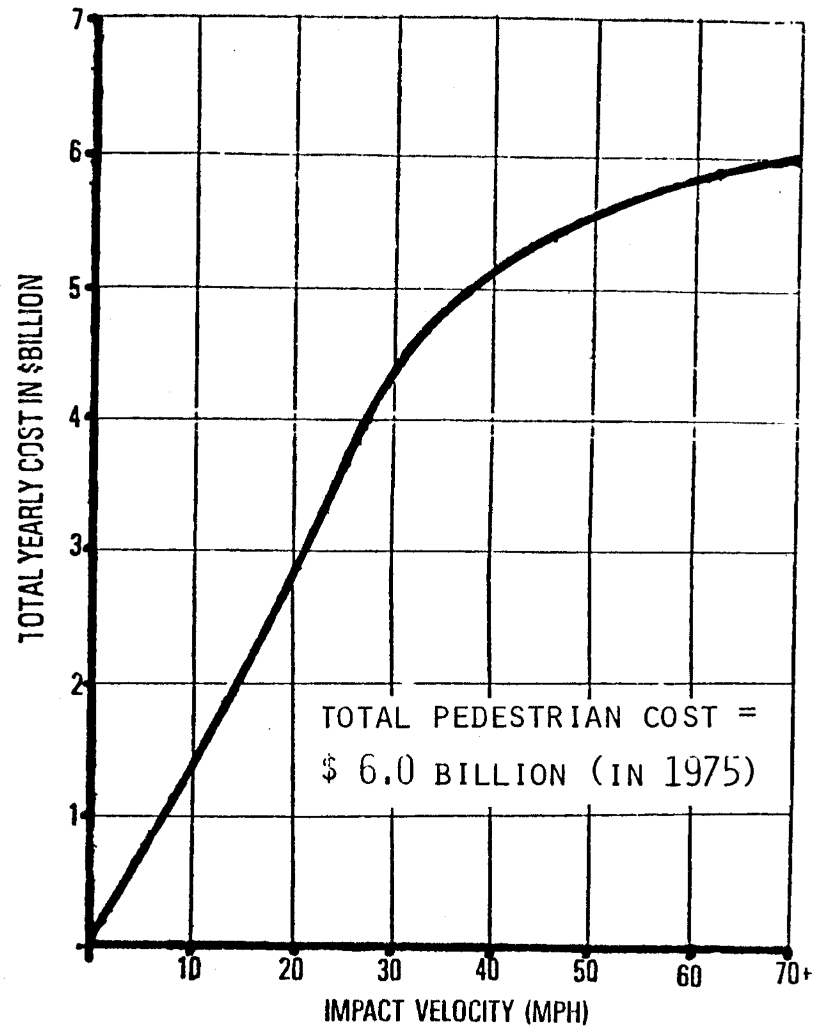


BRAKING AND DRIVER IMPAIRMENT ARE TWO OTHER QUANTIFIABLE FACTORS IN THE PRODUCTION (AND THE REDUCTION) OF SOCIETAL COSTS. THE BRAKING FRACTIONS CAN BE BOOSTED TOWARD 100 PERCENT BY SEMI-AUTOMATIC BRAKE APPLICATION (WITH THE AID OF RADAR), AND IMPACT VELOCITIES CAN BE FURTHER REDUCED BY BETTER BRAKING PERFORMANCE. DRIVER IMPAIRMENT IS OVER-REPRESENTED AT THE HIGHER VELOCITIES, WHICH CREATES POTENTIAL BENEFIT FOR A DRIVER IMPAIRMENT DETECTOR.

FRONTAL PROPERTY DAMAGE COSTS



PEDESTRIAN CASUALTY COSTS

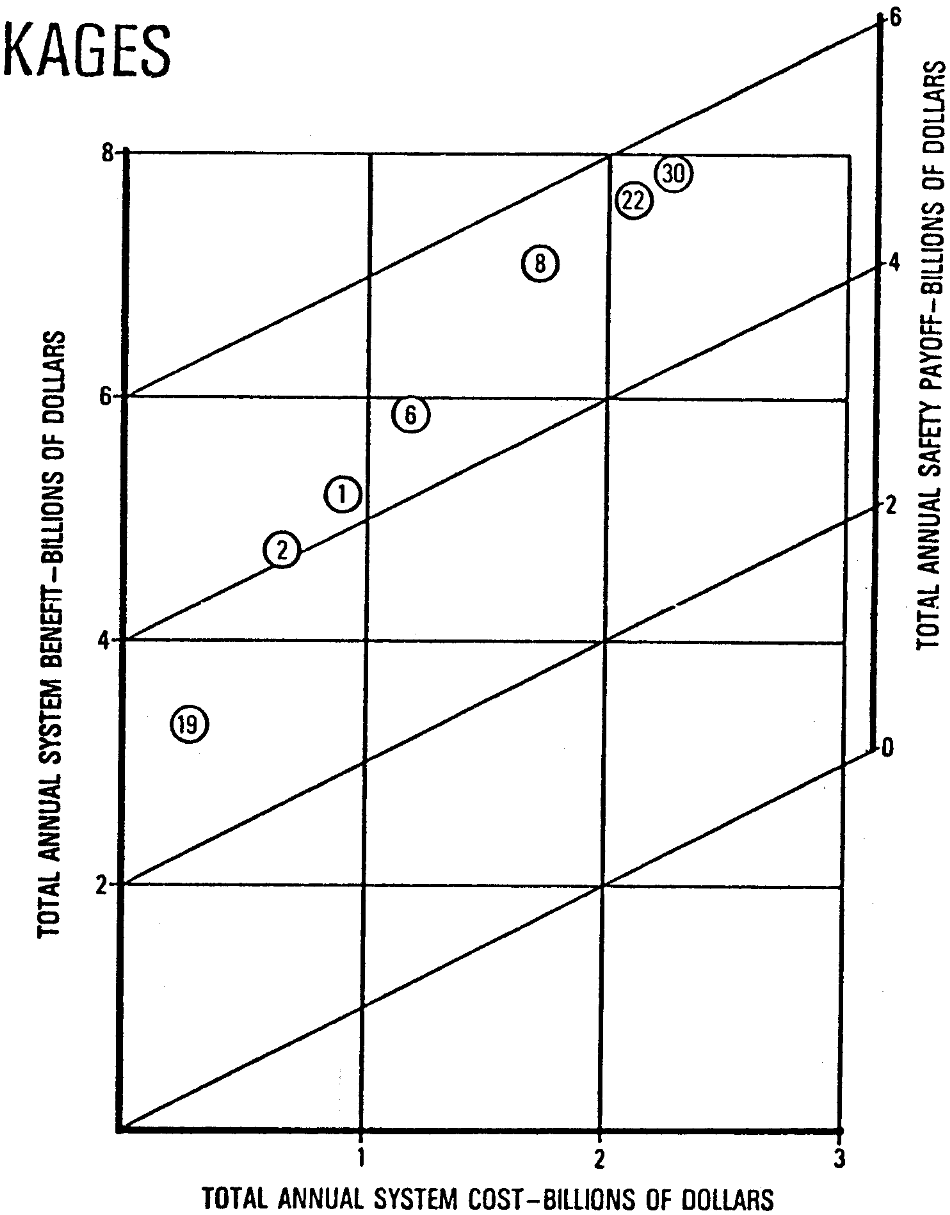


IMPROVED BRAKING, IN CONJUNCTION WITH A LOW-DAMAGE BODY GLOVE AND IMPROVED BUMPERS, RESULTS IN REDUCED DAMAGEABILITY. IMPROVED

NOT IN A WAY THAT IS PRESENTLY QUANTIFI-ABLE. POTENTIAL BENEFITS FOR BOTH PROPERTY DAMAGE AND PEDESTRIAN PROTECTION SYSTEMS

BENEFITS AND COSTS OF SAFETY PACKAGES

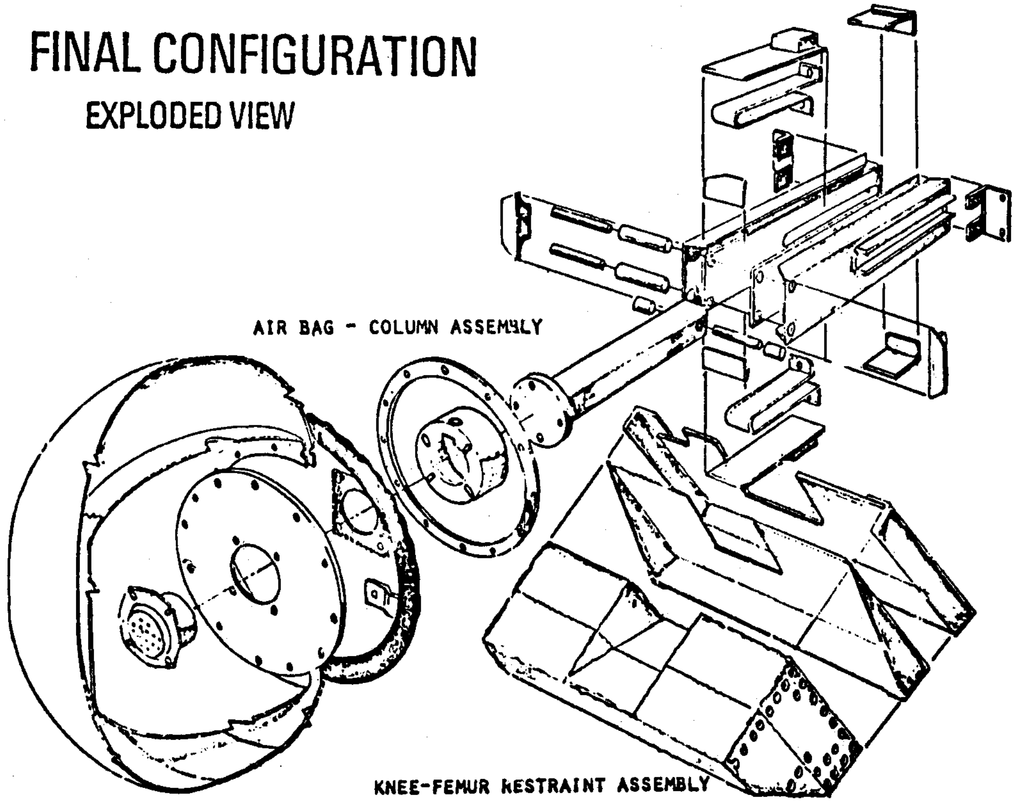
SYSTEM NO.	DRIVER RESTRAINT	FRONT PASSENGER RESTRAINT	REAR PASSENGER RESTRAINT	AVOIDANCE SYSTEM	IMPAIRED PERFORMANCE DETECTOR
1	AIRBAG	AIRBAG	LAP BELTS	NONE	NONE
2	AIRBAG	AIRBELT	LAP BELTS	NONE	NONE
6	AIRBAG	AIRBAG	LAP BELTS	NONE	IPD-50%
8	AIRBAG	AIRBAG	LAP BELTS	RADAR-1.2G	NONE
19	FL 3-PT	FL 3-PT	LAP BELTS	NONE	NONE
22	AIRBAG	AIRBAG	LAP BELTS	RADAR-1.2G	IPD-50%
30	AIRBAG	AIRBAG	AIRBELTS	RADAR-1.2G	IPD-50%

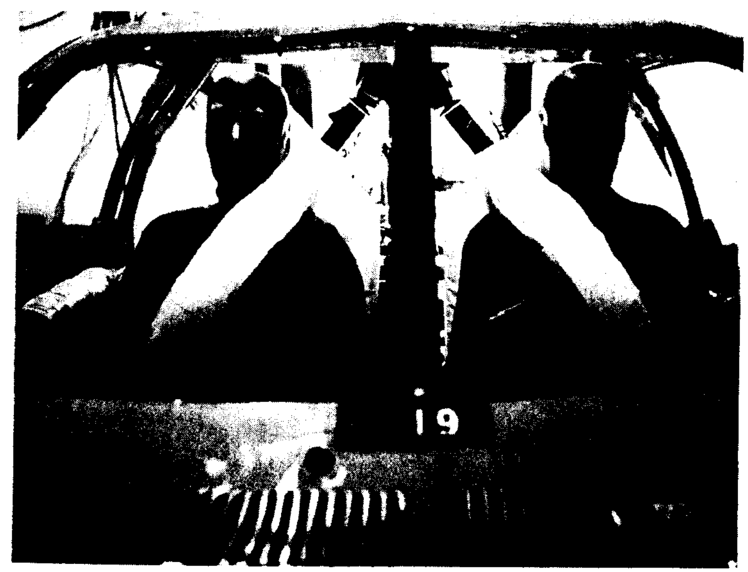


WHEN PROPERTY DAMAGE BENEFITS ARE INCLUDED WITH OCCUPANT INJURY BENEFITS, THIS CURVE RESULTS. FOR CLARITY, ONLY SEVEN DIFFERENT COMBINATIONS OF SAFETY SYSTEMS ARE SHOWN. NOTE THAT INCLUSION OF PROPERTY DAMAGE CAUSES THE RADAR BRAKING TO BE COST-EFFECTIVE. NOTE ALSO THAT EACH SAFETY SYSTEM COMPETES WITH ALL OTHERS FOR THE AVAILABLE BENEFIT (I.E., THE BENEFIT ACCRUED BY A GIVEN SYSTEM DEPENDS ON WHAT OTHER SYSTEMS ARE ALREADY IN THE CAR, ACCRUING BENEFITS OF THEIR OWN).

FINAL CONFIGURATION

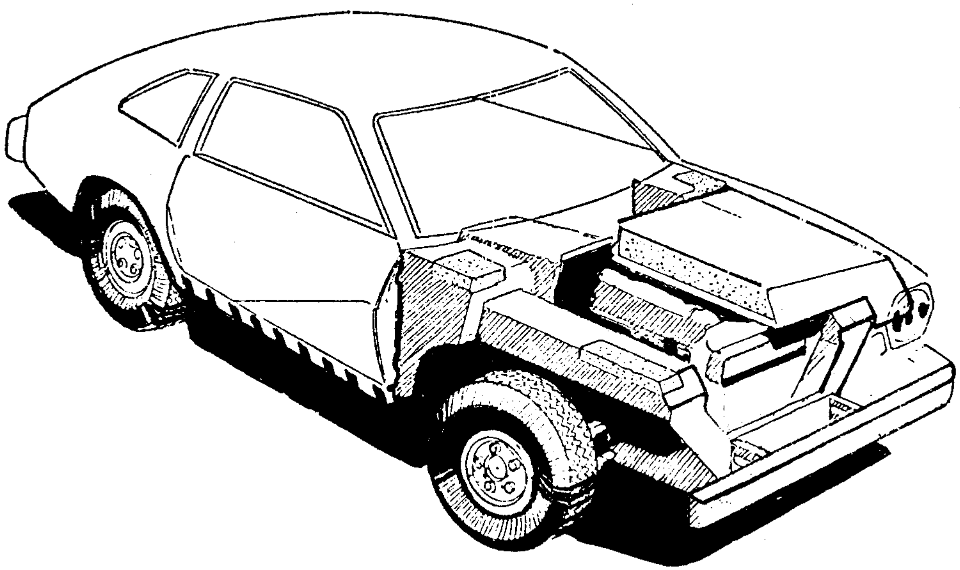
EXPLODED VIEW





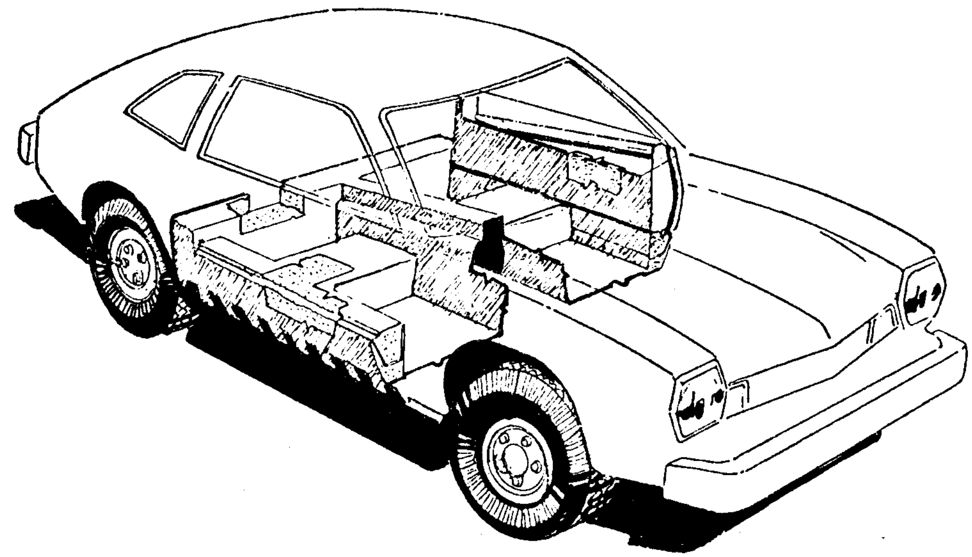
BENEFITS AND COSTS FOR RSV RESTRAINTS CAN BE CALCULATED ACCURATELY BECAUSE TWO OF THEM ARE LARGELY DEVELOPED ALREADY. THE DRIVER AIRBAG AND INFLATABLE BELT RESTRAINTS HAVE ALREADY DEMONSTRATED 50 MPH PERFORMANCE IN SUBCOMPACT CARS, WITH AMPLIFICATION FACTORS AS LOW AS 0.71 IN 80 MPH IMPACTS WITH 4,500-POUND CARS. THESE ARE BOTH QUICK-ACTING, FORCE-LIMITED SYSTEMS, IN WHICH OCCUPANT KINEMATICS ARE CAREFULLY CONTROLLED, AND IN WHICH THE INFLATABLE PORTION IS MORE OF A LOAD-DISTRIBUTOR THAN A LOAD-LIMITER.

FRONT END MODIFICATIONS



BENEFITS AND COSTS FOR THE RSV STRUCTURE CAN BE CALCULATED ACCURATELY BECAUSE OF OUR EXPERIENCE WITH RSV-LIKE STRUCTURES IN OTHER PROGRAMS. PERFORMANCE OF THE FORD PINTO WAS RAISED TO 50 MPH IN BOTH FRONTAL AND FRONTAL OBLIQUE MODES BY A SLIGHT RECONFIGURATION, AND BY USING FOAM-FILLED SHEET

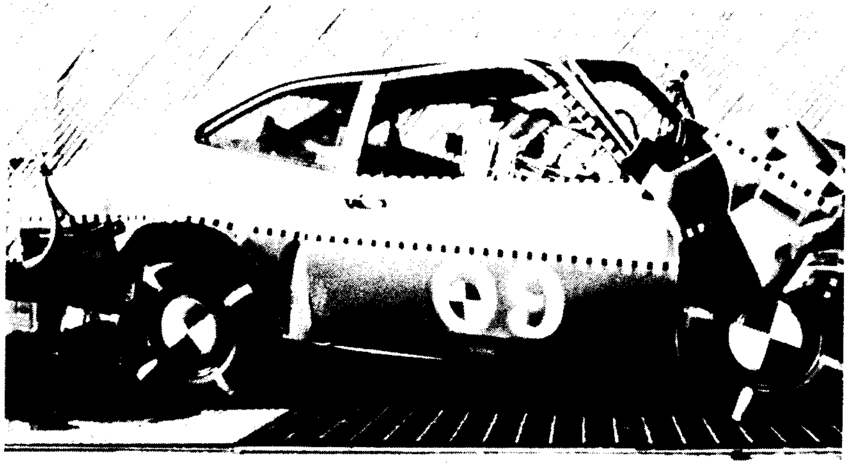
COMPARTMENT MODIFICATIONS



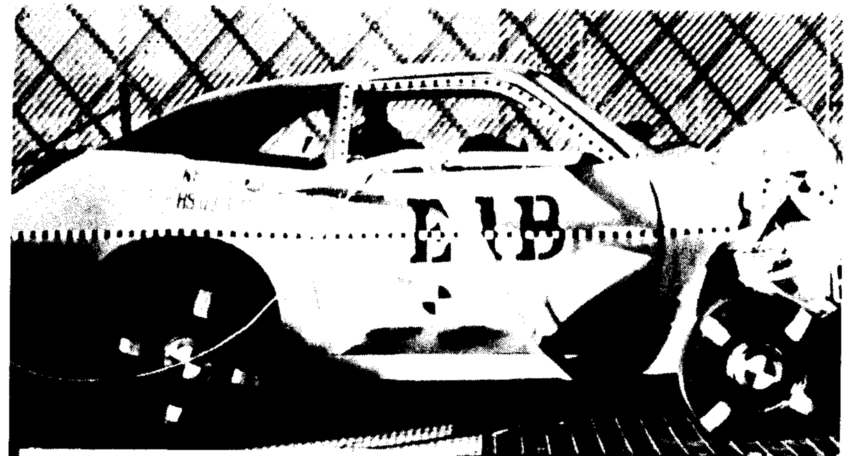
METAL FOR ENERGY ABSORPTION. NOTE THE FOAM FILLING IN THE HOOD, THE INNER FENDER PANELS, THE LOWER DOOR VOLUMES, THE SILL (WHICH IS RAISED), AND THE COMPARTMENT CROSS MEMBERS. WEIGHT GROWTH WAS ONLY 80 POUNDS FOR THE STRUCTURE

TEST COMPARISONS

OF THE FOAM-FILLED SHEET METAL AS DEVELOPED IN DOT-HS-113-3-746

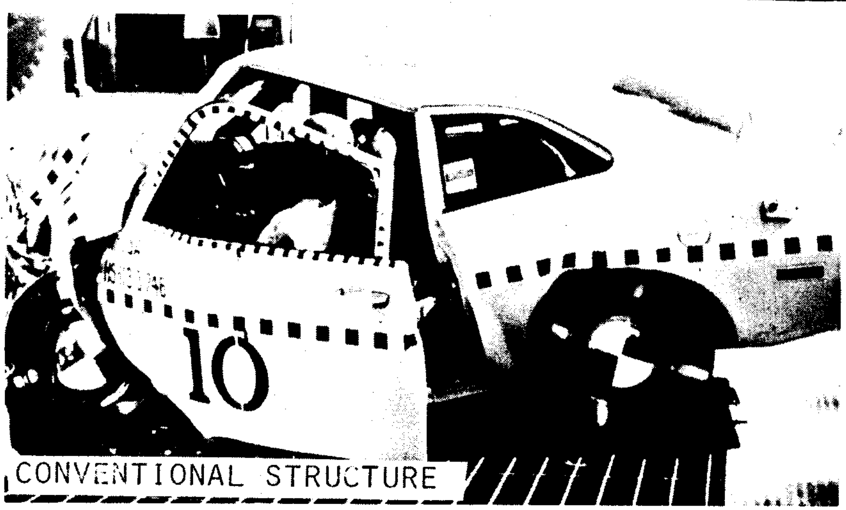


CONVENTIONAL STRUCTURE

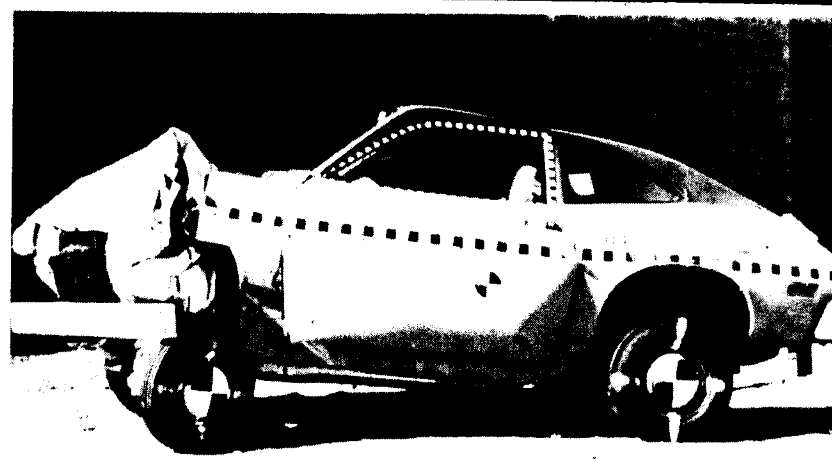


FOAM-FILLED STRUCTURE

FRONTAL BARRIER IMPACTS AT 50 MPH



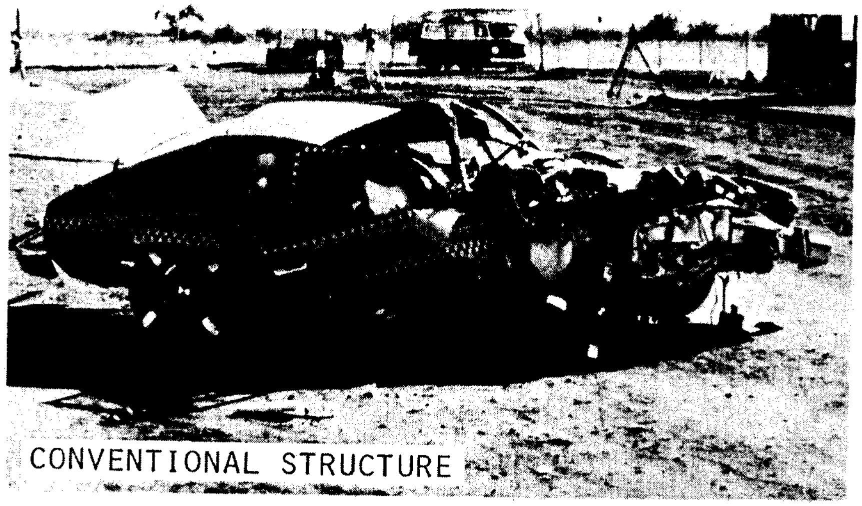
CONVENTIONAL STRUCTURE



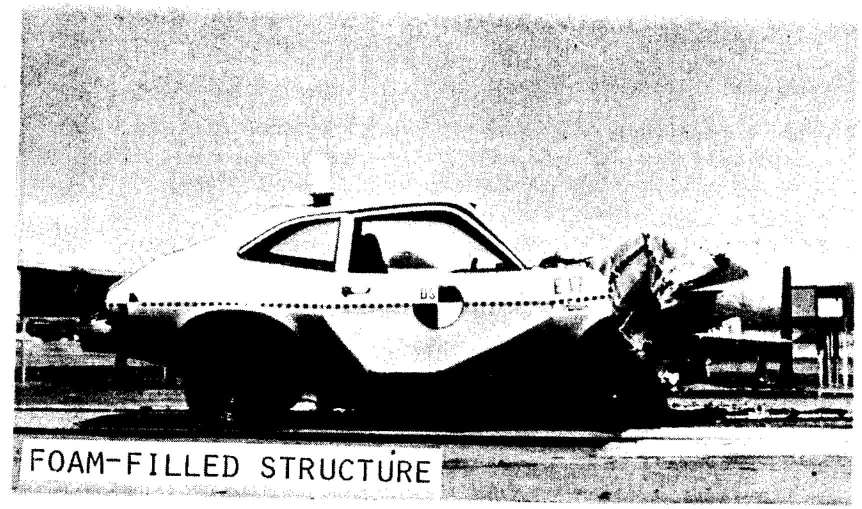
FOAM-FILLED STRUCTURE

ANGULAR BARRIER IMPACTS AT 50 MPH

THE EFFECTS OF THESE STRUCTURAL MODIFICATIONS ARE MOST APPARENT IN FRONTAL OBLIQUE AND SIDE IMPACTS. DOOR INTEGRITY IS MAINTAINED; EJECTION HAZARDS ARE REDUCED.

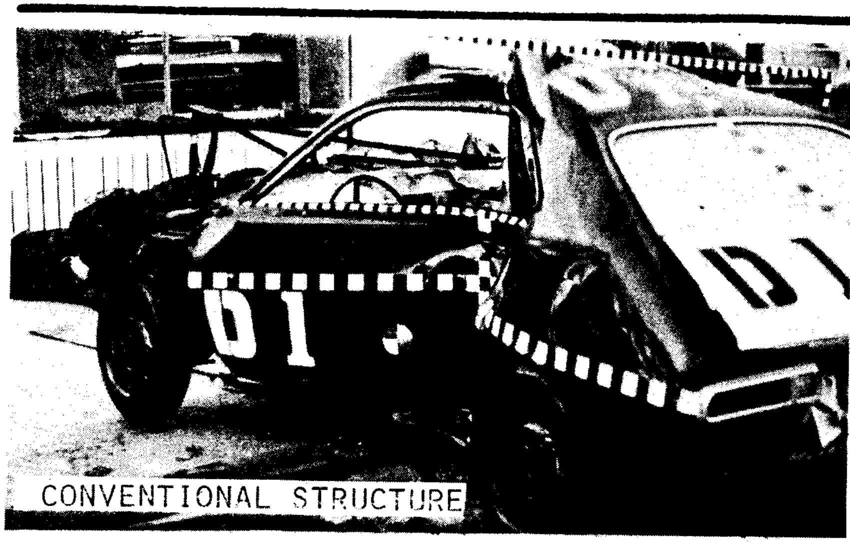


CONVENTIONAL STRUCTURE

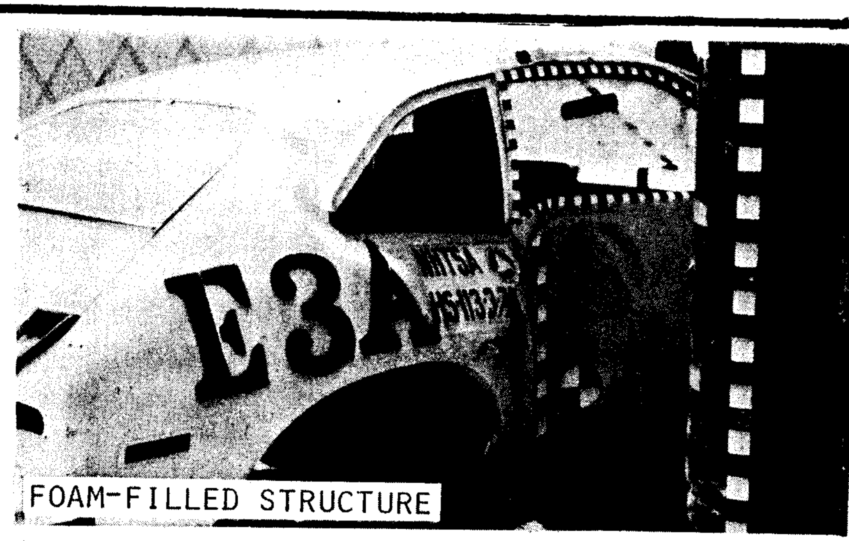


FOAM-FILLED STRUCTURE

LARGE CAR/SMALL CAR OFFSET IMPACT AT 70 MPH



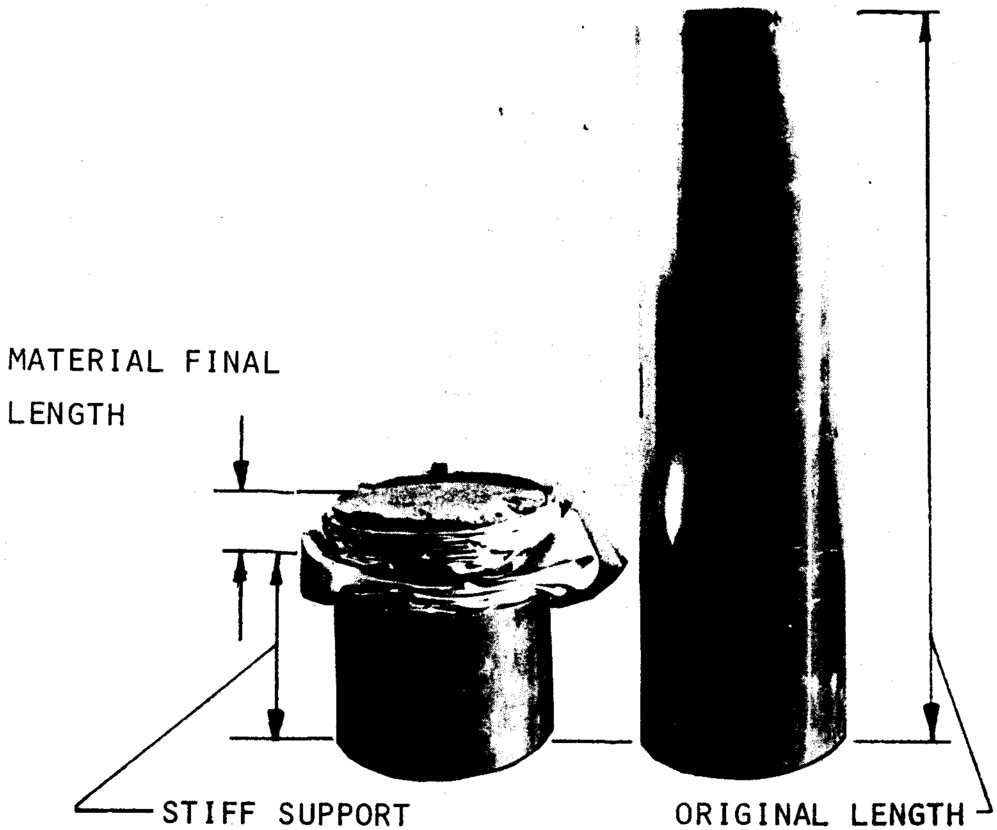
CONVENTIONAL STRUCTURE



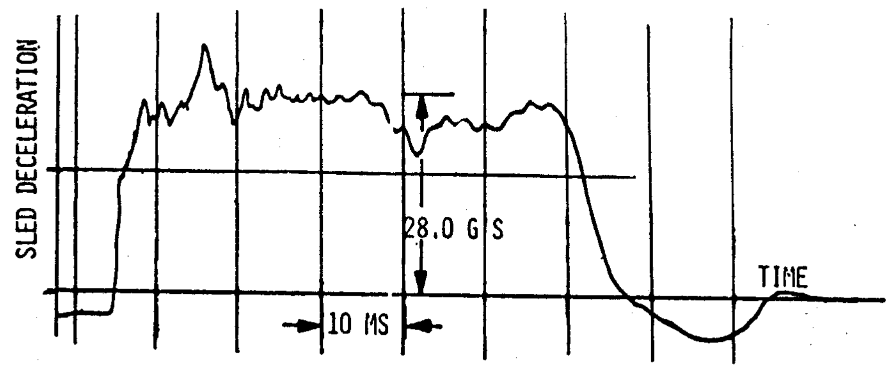
FOAM-FILLED STRUCTURE

POLE SIDE IMPACT AT 20 MPH

DEFORMATION IS CONTROLLED, AND THE RESTRAINTS ARE ALLOWED
TO FUNCTION PROPERLY -- ALL WITH NEGLIGIBLE WEIGHT INCRE



TEST NO. 3 - RSV MATERIALS
FOAM DENSITY: 2.14 LB/FT^3
CONTAINER: .032 INCH ALUMINUM SHEET
GEOMETRY: 8-INCH DIAMETER CYLINDER × 36"
IMPACT VELOCITY: 34.8 MPH

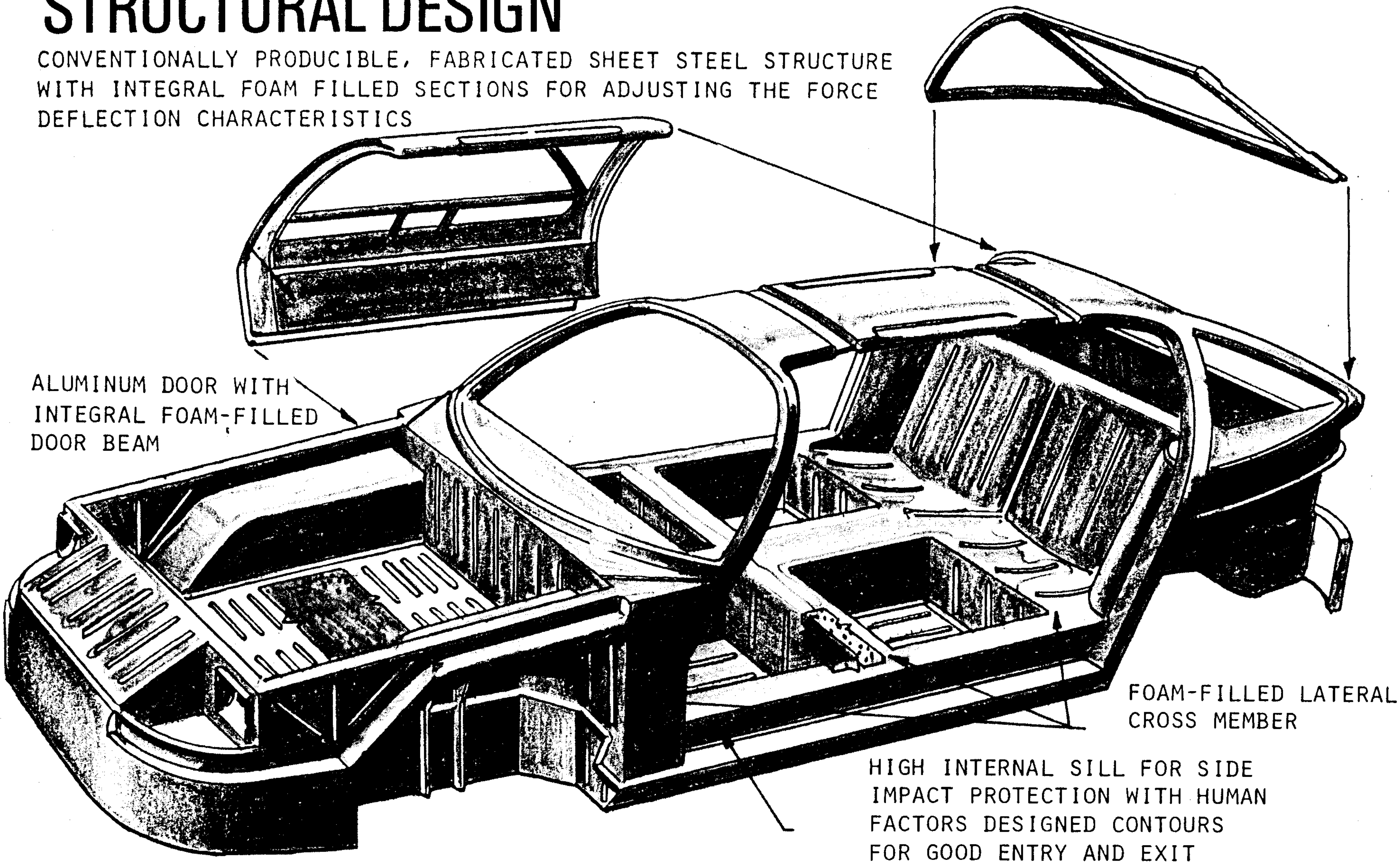


RESULTS OF DYNAMIC TEST OF FOAM/SHEETMETAL SPECIMEN

THIS PERFORMANCE IS MADE POSSIBLE BY THE OMNI-DIRECTIONAL NATURE OF THE ENERGY ABSORBING MATERIAL, ITS LIGHT WEIGHT, AND ITS HIGH STROKE EFFICIENCY. THIS DYNAMIC TEST SHOWED A CRUSH UP TO 90 PERCENT OF THE SPECIMEN ORIGINAL LENGTH BEFORE "BOTTOMING OUT," WITH A REMARKABLY SQUARE DECELERATION PULSE. BUT FRONT-ENGINE CARS CANNOT REALIZE NEARLY AS HIGH A STROKE EFFICIENCY, NOR AS SMOOTH A CRASH PULSE, BECAUSE OF THE HARD ENGINE AND CROSS MEMBER MASSES. SO WE LOCATE THE ENGINE IN THE REAR. IN ORDER TO MINIMIZE WEIGHT, COST, AND AGGRESSIVITY TO OTHER CARS, WHILE MAXIMIZING RSV CRASHWORTHINESS PERFORMANCE.

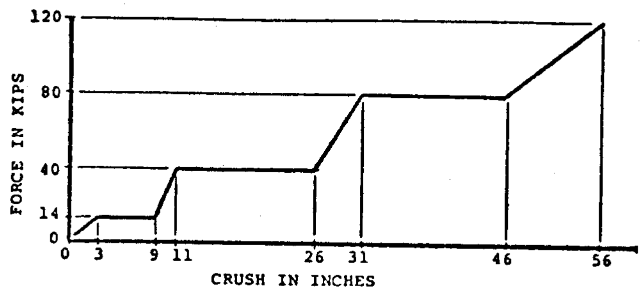
STRUCTURAL DESIGN

CONVENTIONALLY PRODUCIBLE, FABRICATED SHEET STEEL STRUCTURE WITH INTEGRAL FOAM FILLED SECTIONS FOR ADJUSTING THE FORCE DEFLECTION CHARACTERISTICS

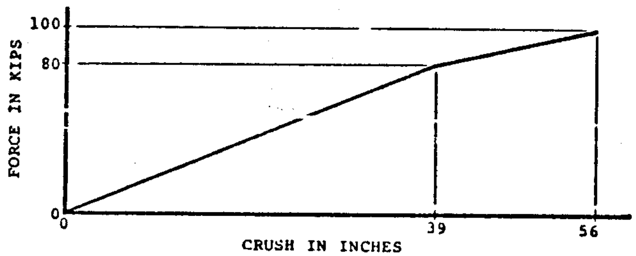


THE MAIN BODY SHELL IS FABRICATED OF AUTOMOTIVE SHEET STEEL THROUGHOUT, EXCEPT FOR THE SIDE SILLS, THE BUMPER BACKING PLATES, AND THE REAR ENGINE MOUNT AND BUMPER ATTACHMENT CAGE. THE DOORS ARE ALUMINUM. STANDARD HIGH-VOLUME PRODUCTION TECHNIQUES ARE USED EXCLUSIVELY, EXCEPT FOR THE ADDED FOAM-FILLING OPERATION. SHEET METAL GAUGES ARE REDUCED RELATIVE TO CURRENT CARS, IN ORDER TO SAVE WEIGHT. CRASHWORTHINESS PERFORMANCE IS "TUNED" BY ADJUSTING THE FOAM DENSITIES.

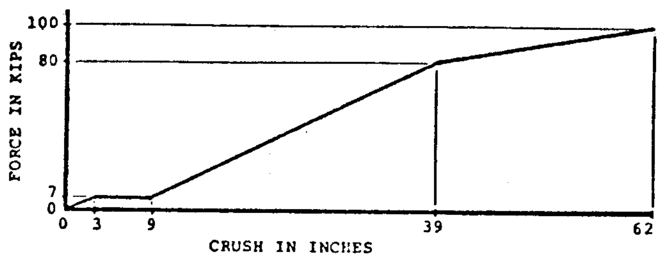
WIDE OBJECT FRONTAL



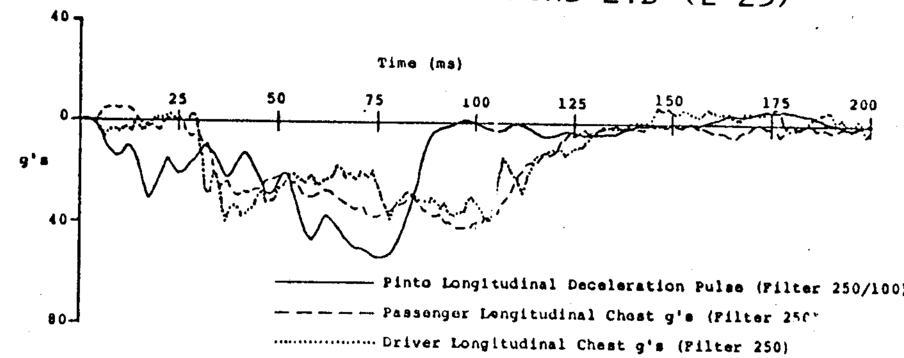
NARROW OBJECT FRONTAL



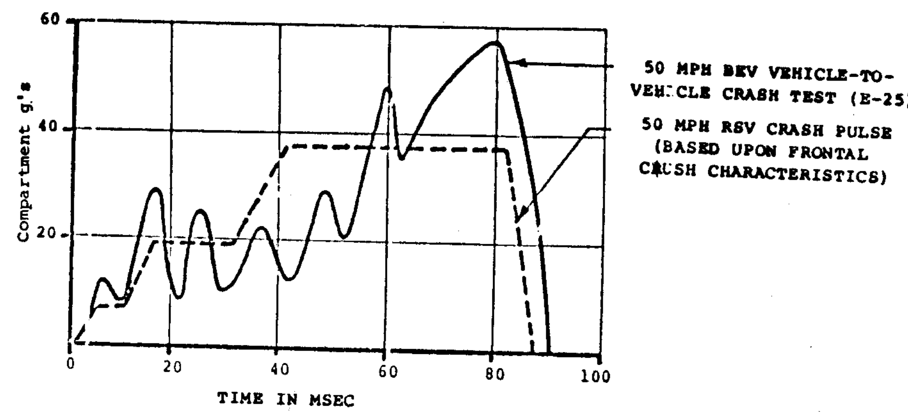
WIDE OBJECT FRONTAL OBLIQUE



TEST RESULTS FROM 80 MPH IMPACT - MODIFIED PINTO INTO 1974 FORD LTD (E-25).

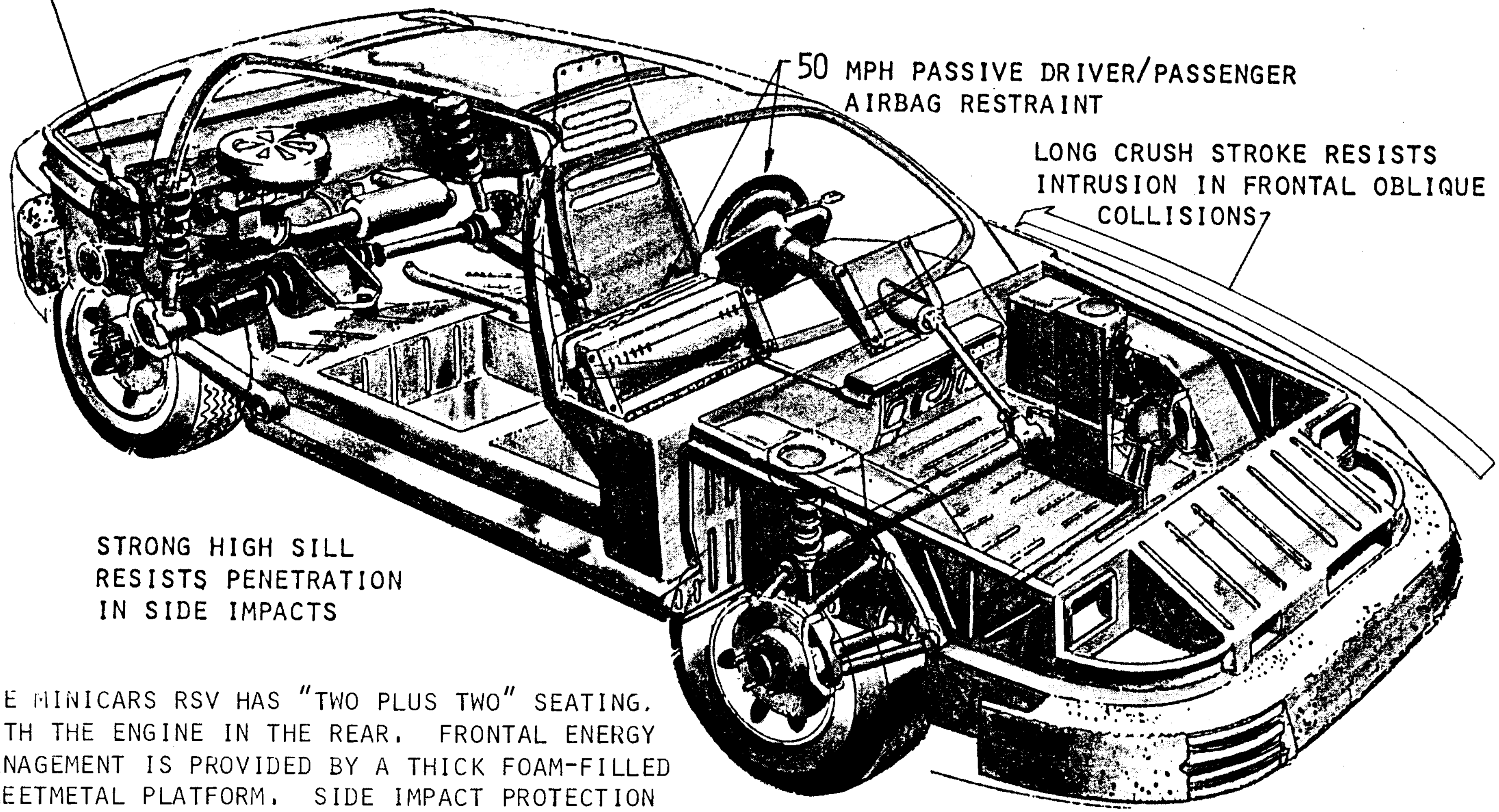


COMPARISON OF RSV AND MODIFIED PINTO CRASH PULSES



THESE ARE THE DESIGN CRUSH CHARACTERISTICS. THE LOW FRONTAL FORCES ARE DESIGNED FOR MINIMAL AGGRESSIVITY IN SIDE IMPACTS. ACTUAL CRUSH CHARACTERISTICS WILL DEPEND ON THE OBJECT STRUCK, BUT TEST RESULTS PROVE THAT PEAK-SHAVING RESTRAINTS CAN HANDLE AN INEFFICIENT CRASH PULSE, WITH AMPLIFICATION FACTORS LESS THAN ONE. THIS COMPARISON OF CRASH PULSES FOR THE RSV, AND FOR A MODIFIED SUBCOMPACT CAR HITTING A FULL-SIZE CAR AT 80 MPH, SHOWS THAT THE RESTRAINTS WILL WORK IN THE RSV STRUCTURE.

RSV CONFIGURATION

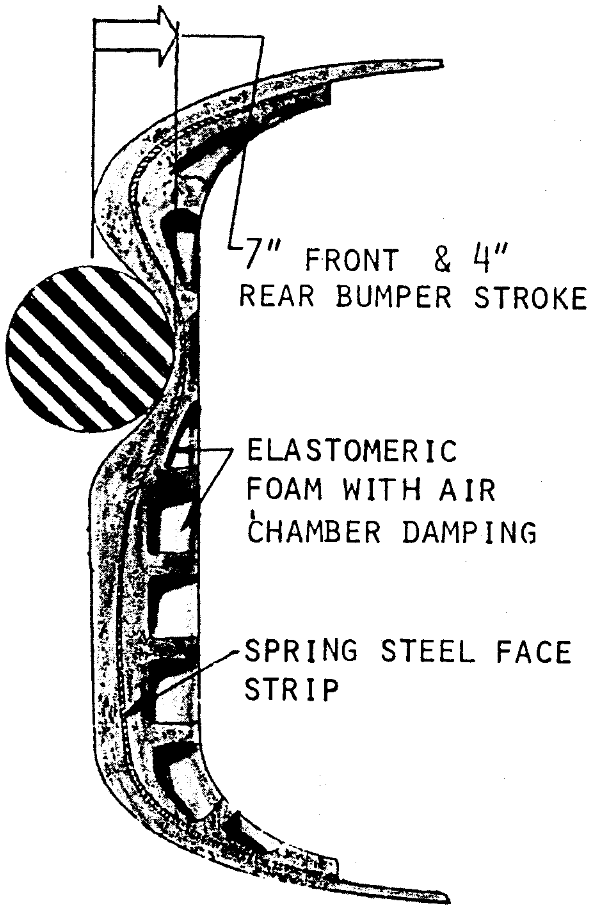


THE MINICARS RSV HAS "TWO PLUS TWO" SEATING, WITH THE ENGINE IN THE REAR. FRONTAL ENERGY MANAGEMENT IS PROVIDED BY A THICK FOAM-FILLED SHEETMETAL PLATFORM. SIDE IMPACT PROTECTION COMES FROM A MASSIVE FOAM-FILLED SILL STRUCTURE THAT RUNS THE LENGTH OF THE VEHICLE (WITH REDUCED GAUGES FORWARD OF THE FRONT SUSPENSION ATTACH POINTS), AND IS SUPPORTED LATERALLY BY FOAM-FILLED CROSS MEMBERS. THE POWERPLANT IS A FUEL-EFFICIENT, LOW-POLLUTING HONDA CVCC STRATIFIED-CHARGE ENGINE.

PROPERTY DAMAGE - PROTECTION

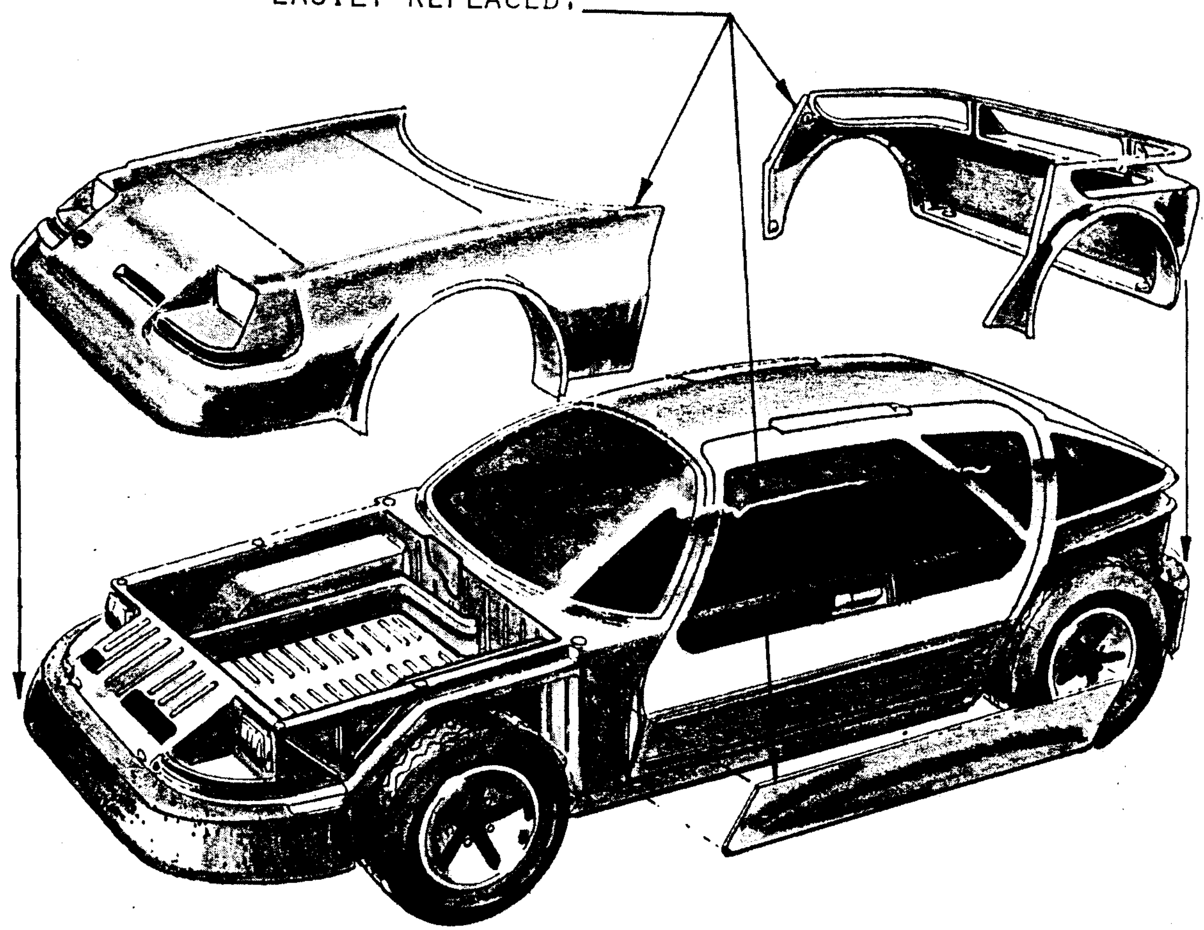
THE RSV BUMPER SYSTEM

ALLOWS 10 MPH FRONTAL AND 5 MPH REAR IMPACTS WITH NO DAMAGE



THE BODY GLOVE CONCEPT

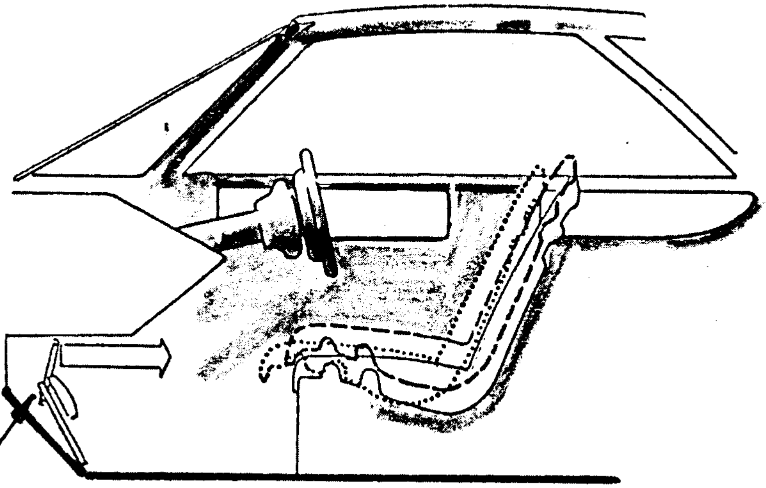
- THE EXTERIOR SURFACES OF THE RSV CONSIST OF SOFT FOAM BACKED COMPONENTS, WHICH IF HEAVILY DAMAGED CAN BE EASILY REPLACED.



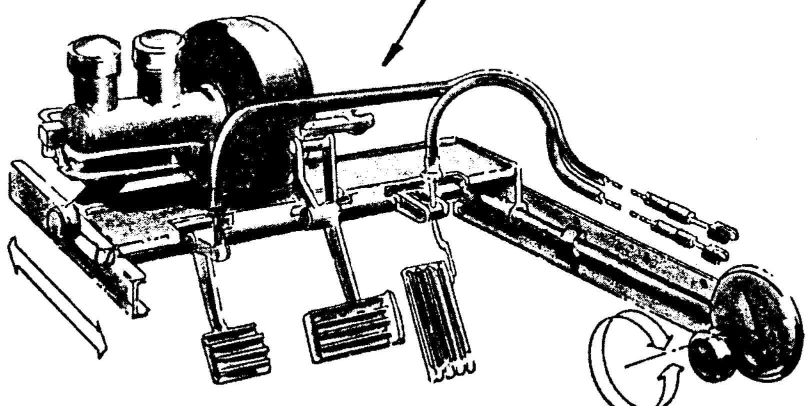
BUMPERS ARE MADE OF ELASTOMERIC FOAM WITH AIR CHAMBERS TO PROVIDE REBOUND DAMPING. THE RESULT IS LIGHTWEIGHT COMPONENTS THAT PROVIDE 10 MPH PERFORMANCE IN THE FRONT, AND 5 MPH IN THE REAR. ELSEWHERE, DAMAGEABILITY IS IMPROVED VIA THE BODY GLOVE, WHICH IS EASILY REPAIRED OR REPLACED.

DRIVER ACCOMMODATION

ADJUSTABLE DRIVER'S SEAT AND PADDING
FOR SPECIAL DRIVER PREFERENCES

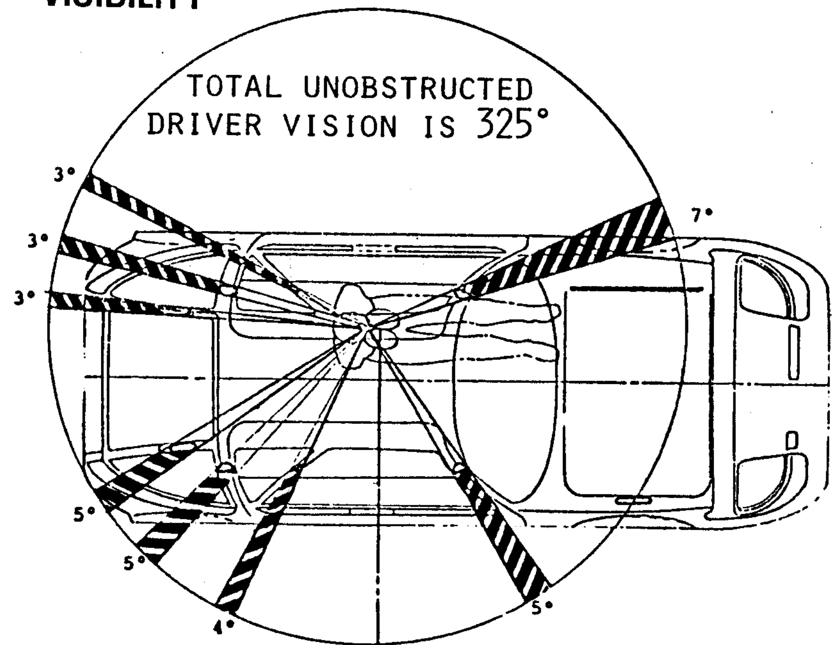


MOVABLE PEDAL ASSEMBLY

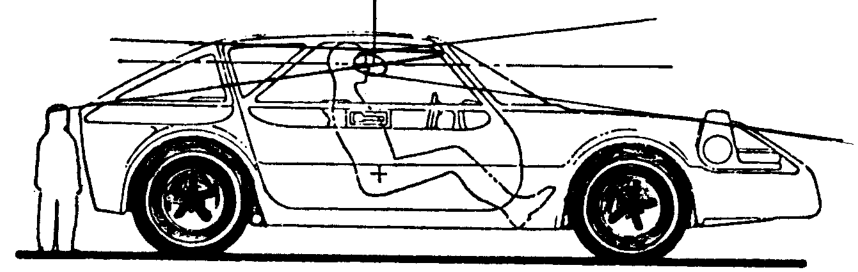


TOTAL ADJUSTMENT (FORE AND AFT) IS 8.5"
CONVENTIONAL CARS OFFER ONLY 5" MAXIMUM

VISIBILITY



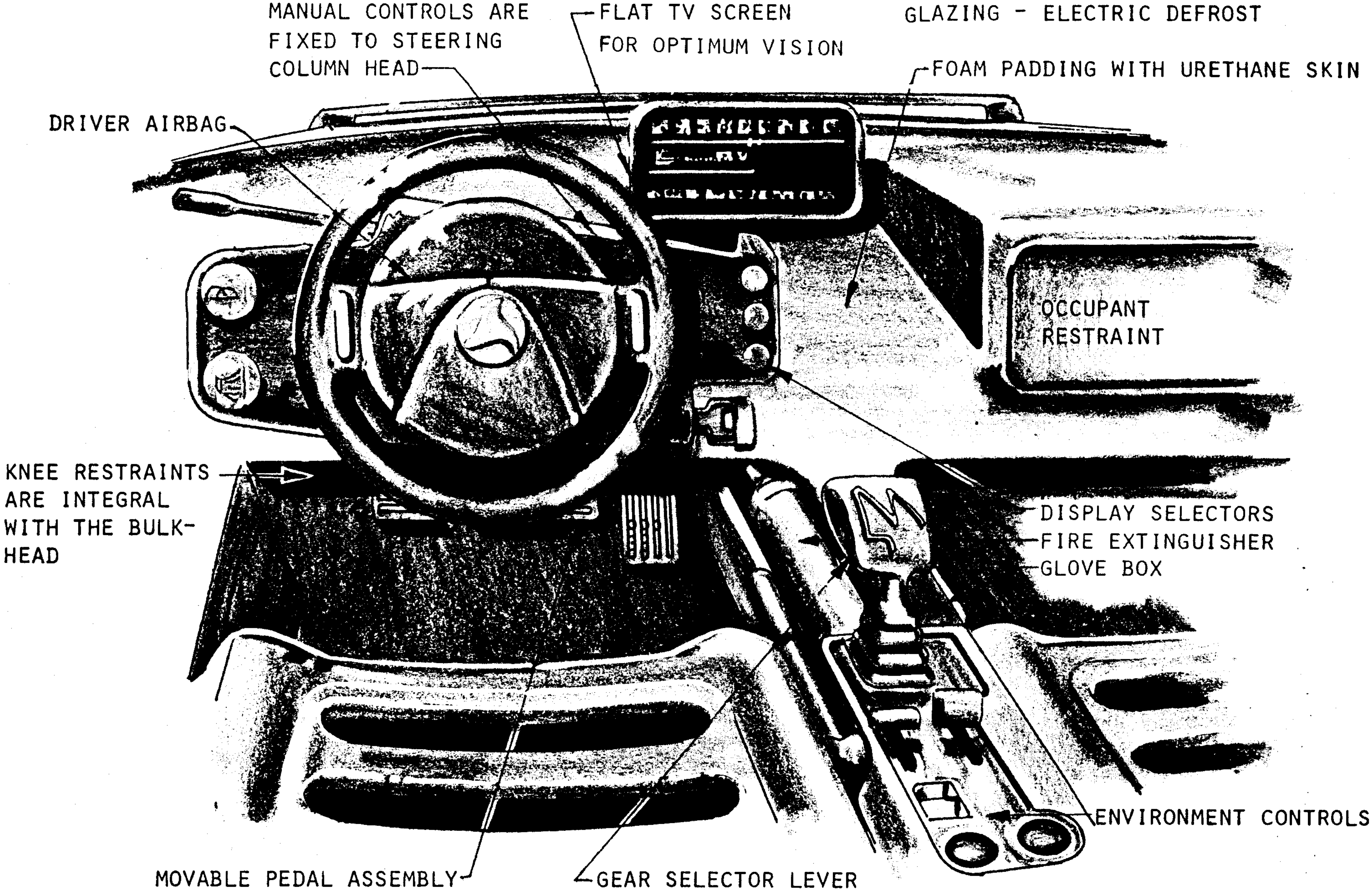
MANY NARROW STRUTS PROVIDE SUPERIOR ALL AROUND VISION TO A FEW WIDE STRUTS



3 YEAR OLD CHILD CAN BE SEEN
STANDING AT THE REAR BUMPER

SUPERIOR DRIVER ACCOMMODATIONS ARE PROVIDED FOR THE FULL ANTHROPOMETRIC RANGE VIA A MOVABLE PEDAL ASSEMBLY. SEAT POSITION AND PADDING THICKNESSES CAN BE EASILY CUSTOMIZED FOR SPECIAL DRIVER PREFERENCES. VISION IS OUTSTANDING.

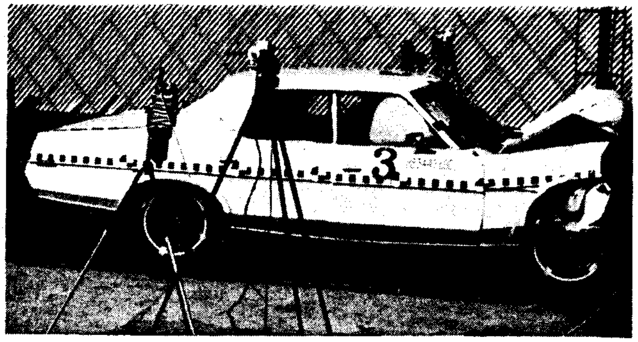
DRIVER CONTROLS AND DISPLAYS



DRIVER CONTROLS ARE GENERALLY CONVENTIONAL. THE DISPLAY IS A FLEXIBLE-FORMAT FLAT TV SCREEN (TO BE ALL-SOLID STATE BY 1985) THAT IS OPERATED BY AN ONBOARD MICROPROCESSOR.

DRIVER RESTRAINT SYSTEM

THE CONCEPT OF THE STROKING ENERGY-ABSORBING COLUMN AND THE DUAL AIRBAG WAS DEVELOPED BY MINICARS FOR FULL-SIZED AND SUBCOMPACT CARS UNDER CONTRACTS DOT-HS-113-2-441 AND DOT-HS-113-3-742

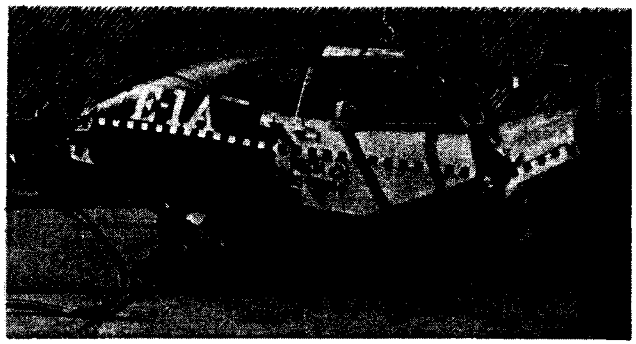


UNMODIFIED FULLSIZE CAR

45 MPH FRONTAL BARRIER

TYPICAL DRIVER RESTRAINT PERFORMANCE

HIC	450
CSI	350
CPG	43 G'S
FL.	1300



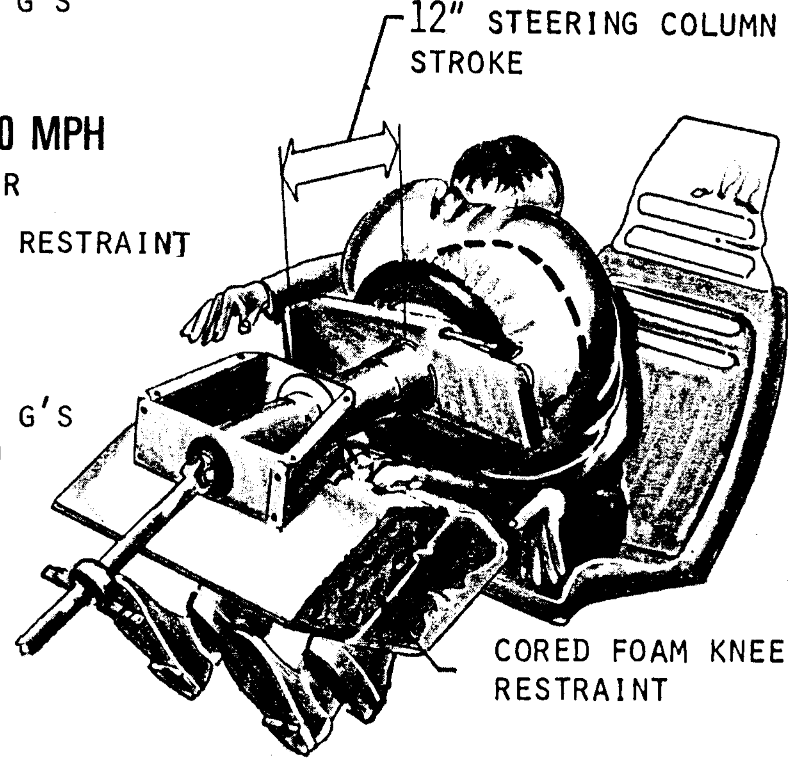
SUBCOMPACT 50 MPH

FRONTAL BARRIER

TYPICAL DRIVER RESTRAINT PERFORMANCE

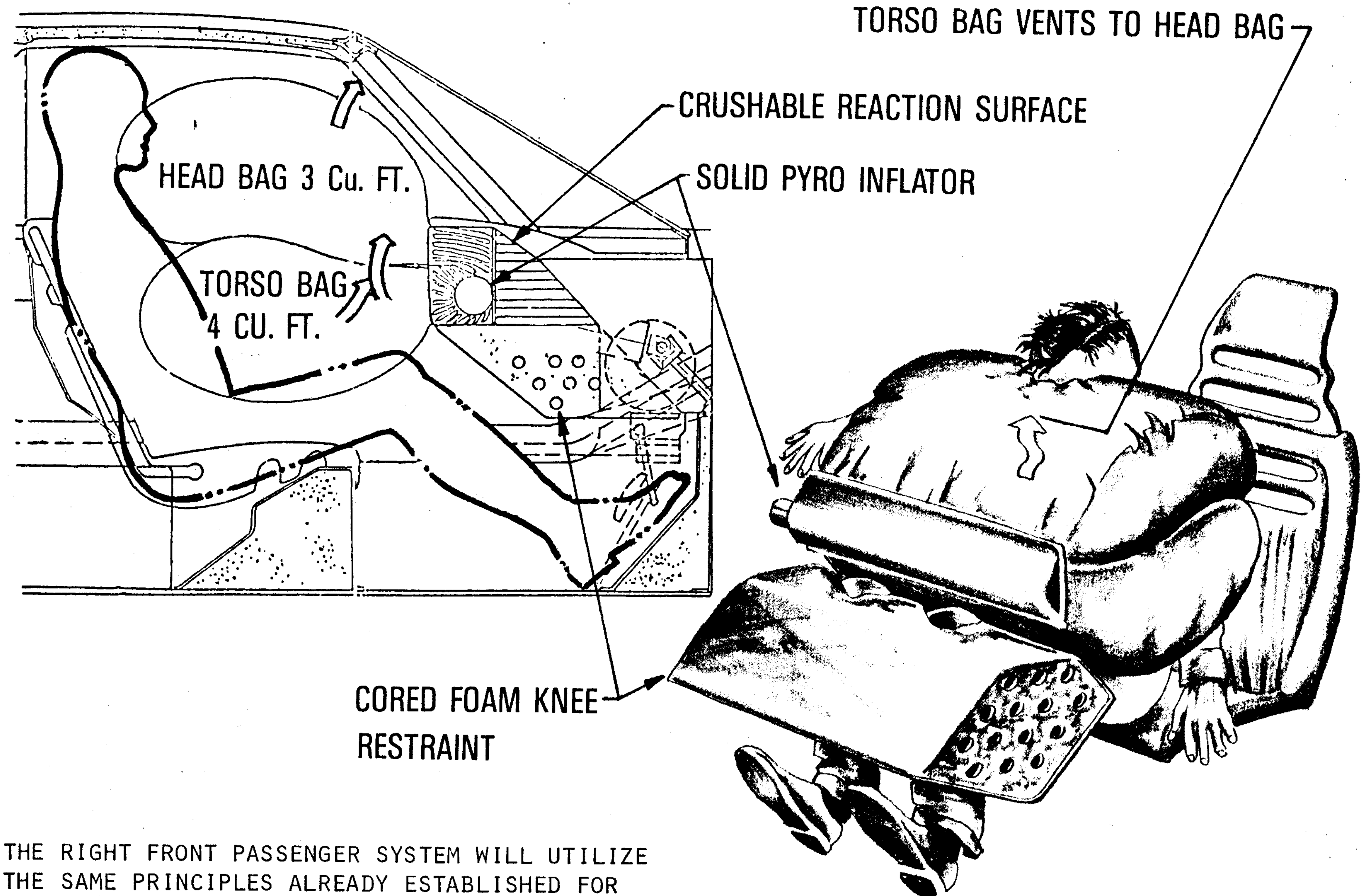
HIC	550
CSI	400
CPG	42 G'S
FL.	1300

DUAL AIRBAG SYSTEM SMALL "HARD" INNER BAG FOR TORSO DECELERATION - SOFT OUTER BAG FOR HEAD DECELERATION



THE DRIVER RESTRAINT IS A MORE FINELY-TUNED PRODUCTION VERSION OF THE MINICARS AIRBAG SYSTEM THAT HAS ALREADY DEMONSTRATED 50 MPH PERFORMANCE IN SUBCOMPACT CARS. IT IS A TWO-BAG SYSTEM (HEAD AND TORSO), WITH A CRUSHABLE KNEE RESTRAINT AND SOLID PYROTECHNIC INFLATOR.

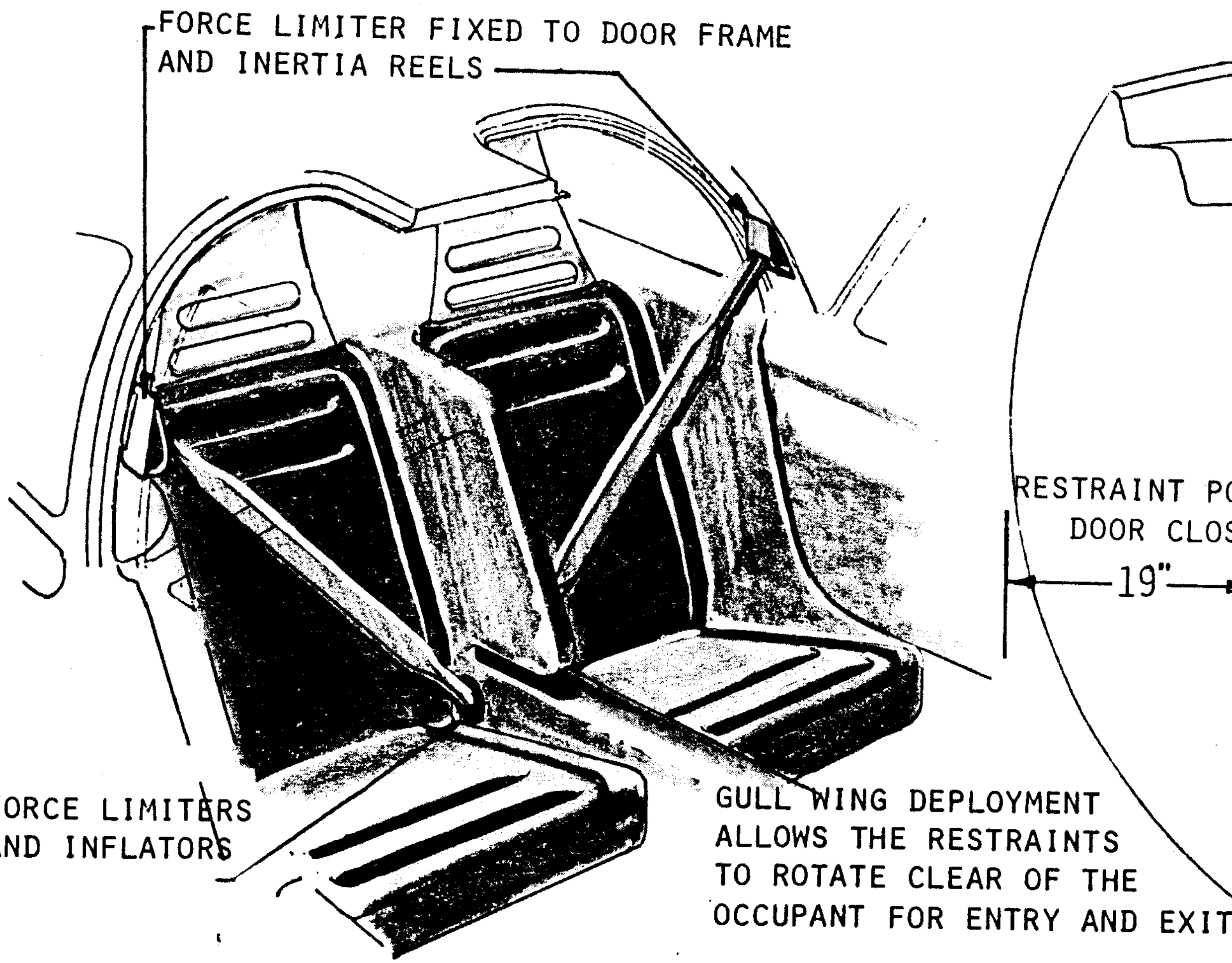
PASSENGER RESTRAINT SYSTEM

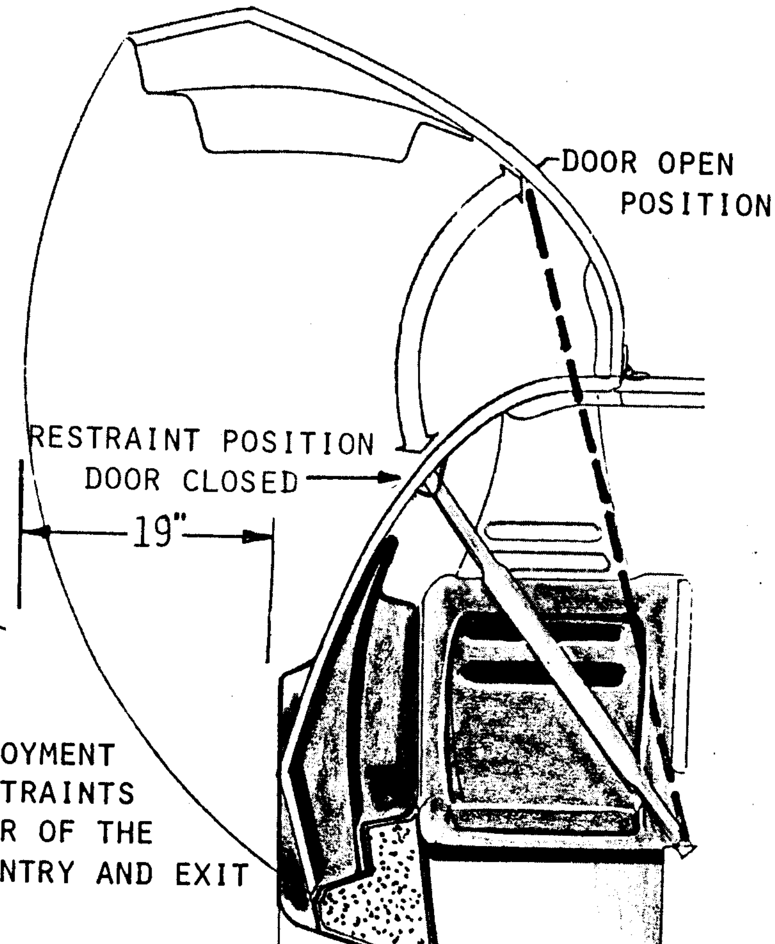


THE RIGHT FRONT PASSENGER SYSTEM WILL UTILIZE THE SAME PRINCIPLES ALREADY ESTABLISHED FOR THE DRIVER RESTRAINT (I.E., A SMALL, QUICK-ACTING DOUBLE BAG SYSTEM THAT IS FORCE-LIMITED). THE INFLATOR WILL BE A SPECIALLY DESIGNED SOLID PYROTECHNIC SYSTEM.

REAR SEAT RESTRAINT SYSTEM

BECAUSE OF THE INFREQUENT USE OF THE REAR SEAT, THE EFFECT OF OTHER SAFETY SYSTEMS, AND LOW BELT USAGE, A HARNESS WAS FOUND TO BE TOO EXPENSIVE. BUT THE EASE OF GULL WING DOOR DEPLOYMENT AND THE RESEARCH OBJECTIVES OF THE PROGRAM WARRANT INCORPORATING THE INFLATABELTS DEVELOPED UNDER DOT-HS-4-00917.

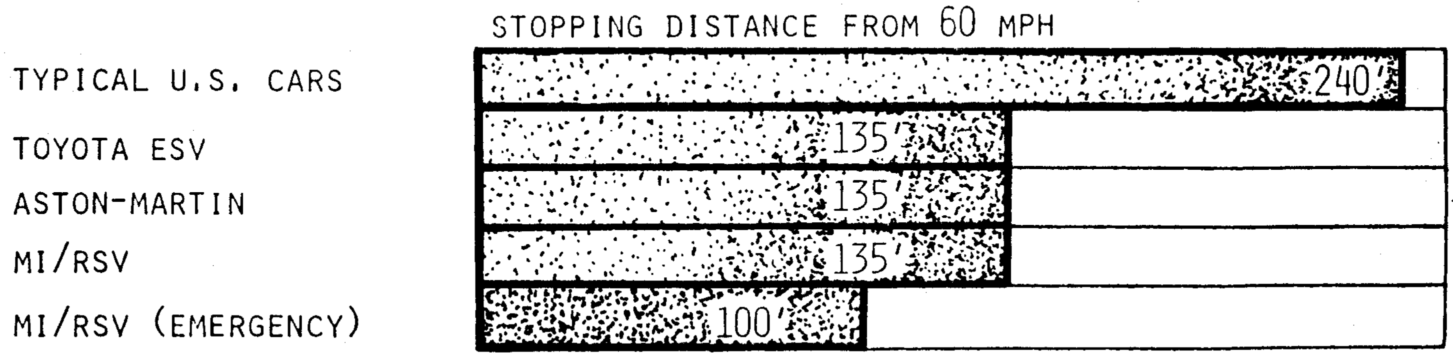


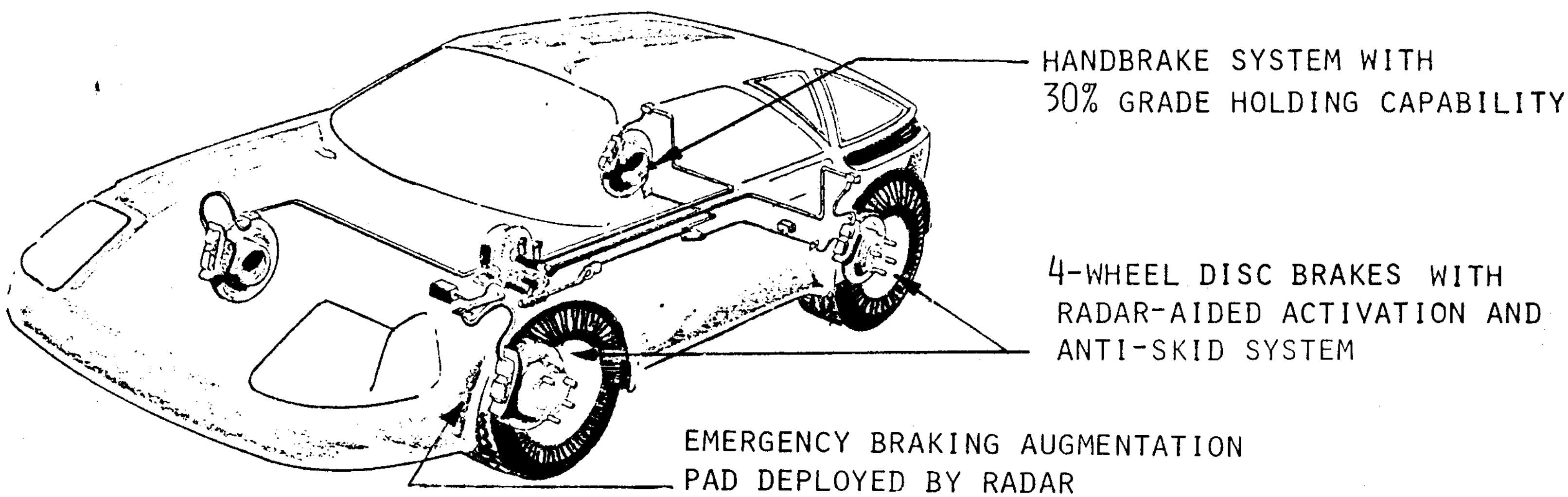


THE REAR RESTRAINTS ARE A MORE FINELY-TUNED PRODUCTION VERSION OF THE MINICARS INFLATABLE BELT SYSTEM THAT HAS DEMONSTRATED THE HIGHEST PERFORMANCE EVER SEEN, EVEN IN A SUBCOMPACT CAR. IT IS A FORCE-LIMITED, QUICK-ACTING SYSTEM, WITH A CRUSHABLE KNEE RESTRAINT (NO LAP BELT) AND A SOLID PYROTECHNIC INFLATOR. IT WILL BE DEPLOYED PASSIVELY VIA THE GULL WING DOORS

RSV BRAKE SYSTEM

THE RSV CARRIES BOTH A 4-WHEEL ANTI-SKID SYSTEM AND
A RADAR-ACTIVATED EMERGENCY BRAKING SYSTEM

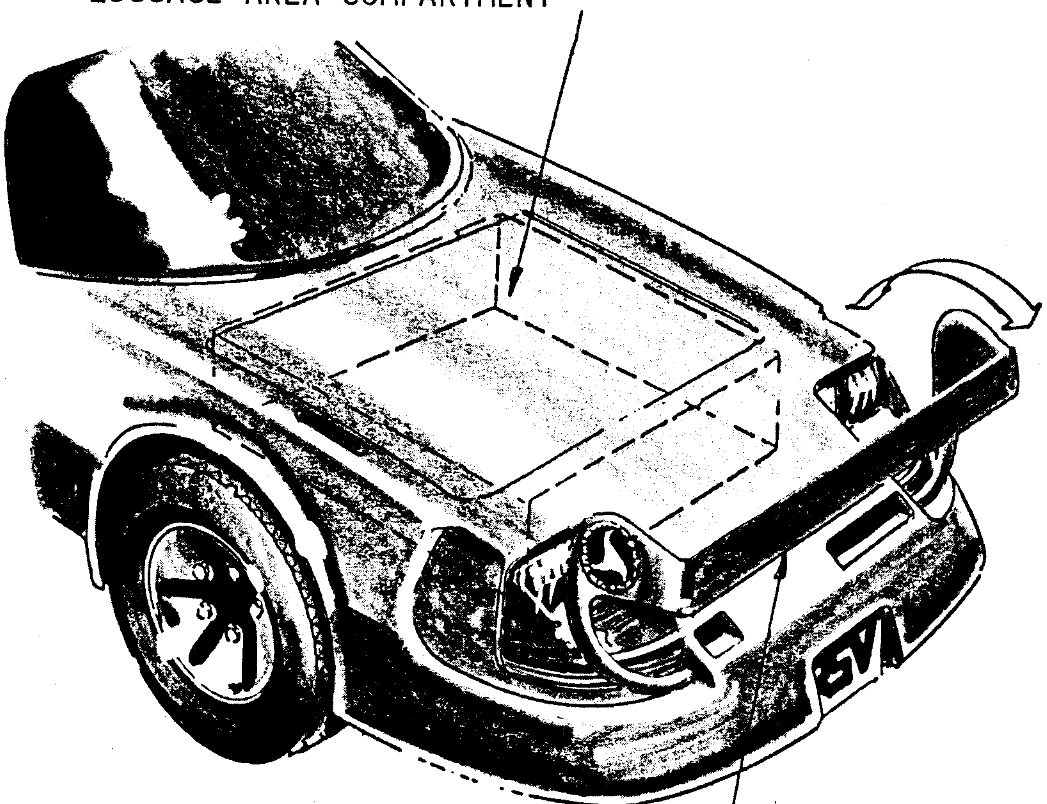




THE MINICARS RSV WILL HAVE DUAL-MODE BRAKING, WITH THE "NORMAL" MODE EMPLOYING FOUR-WHEEL DISC BRAKES, THE MOST ADVANCED FOUR-WHEEL ANTI-SKID SYSTEM AVAILABLE, AND TWO-WAY BRAKE PROPORTIONING. PERFORMANCE WILL BE ON A PAR WITH THE TOYOTA ESV. THE "EMERGENCY" MODE WILL BE TARGETED FOR 1.2G CAPABILITY, EITHER MODE MAY BE RADAR-ACTIVATED, DEPENDING ON THE DEGREE OF DANGER DEDUCED BY THE MICROPROCESSOR. THE CAR WILL HAVE FOUR-WHEEL INDEPENDENT SUSPENSION THAT IS SPECIALLY DESIGNED FOR OPTIMAL DRIVER/VEHICLE RESPONSE.

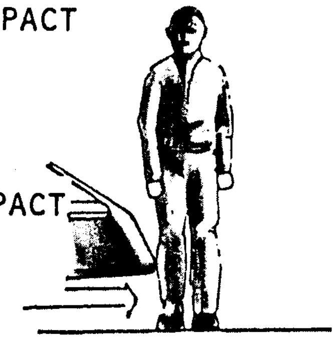
PEDESTRIAN RETAINER SYSTEM

THE SOFT FOAM-BACKED BODY GLOVE ALLOWS DEEP PENETRATION IN THE LUGGAGE AREA COMPARTMENT

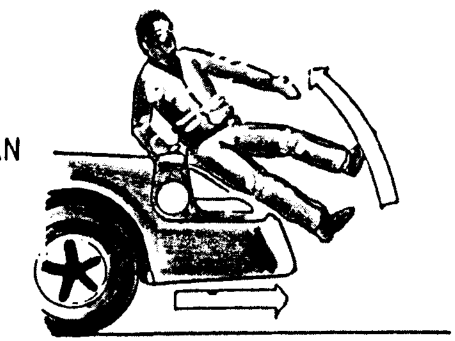


FLEXIBLE RETAINER BAR ROTATES FORWARD AFTER INITIAL IMPACT AS THE CAR DECELERATES

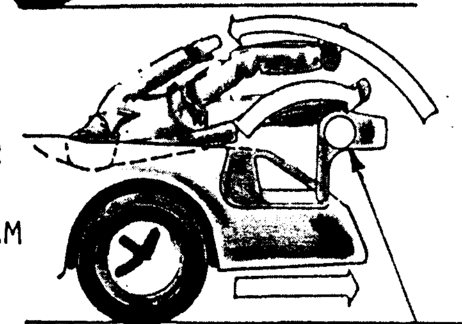
TYPICAL IMPACT SEQUENCE



1. INITIAL IMPACT BELOW THE PATELLA

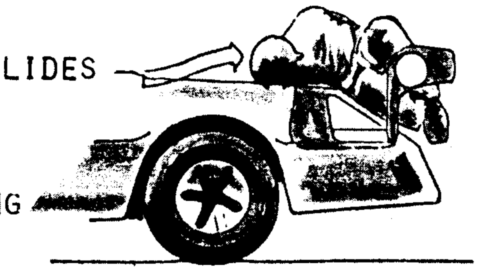


2. PEDESTRIAN BEGINS ROTATION



3. PEDESTRIAN REACHES CAR VELOCITY CRUSHES FOAM HOOD

AT.5 G THE RETAINER DEPLOYS

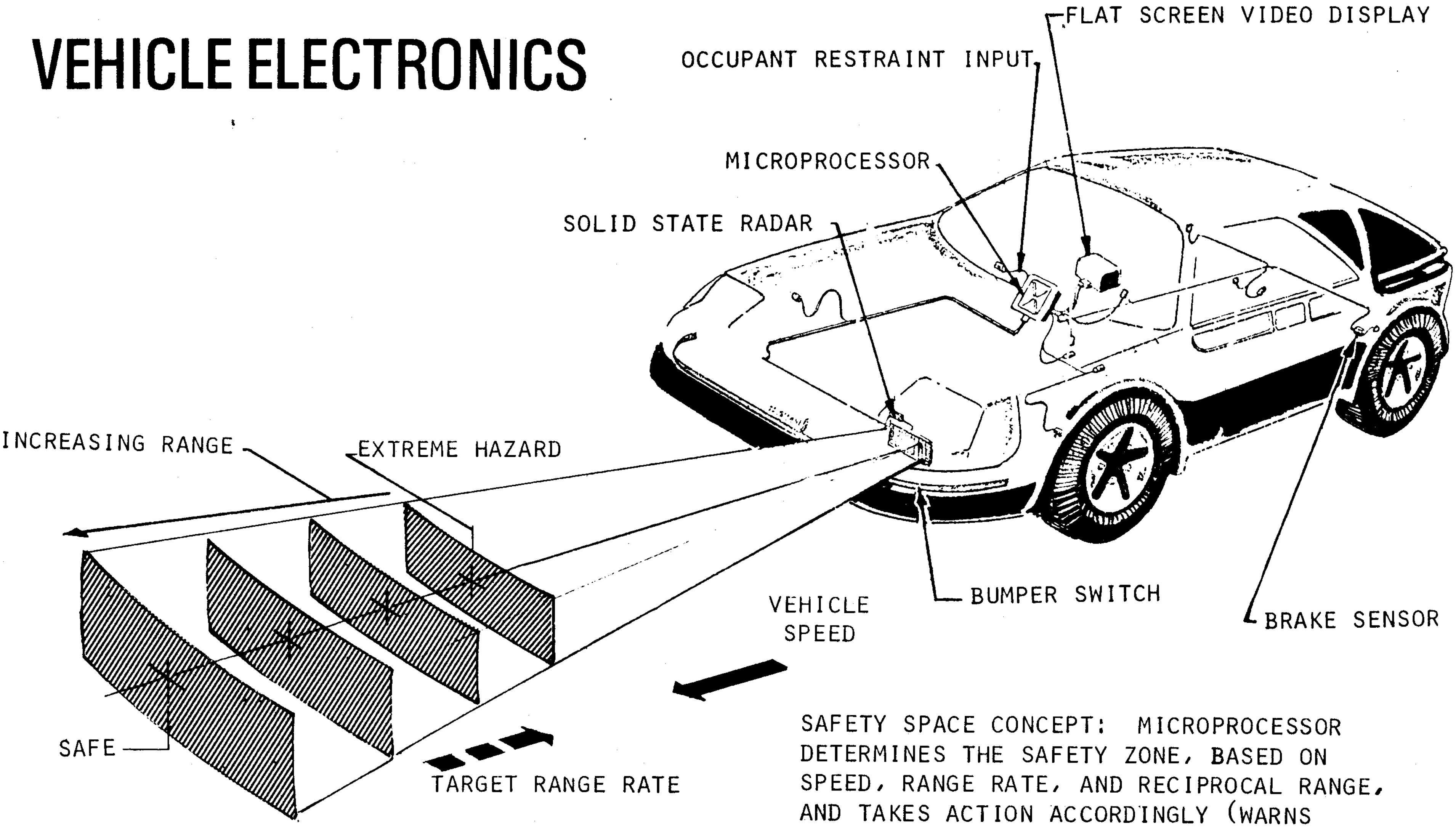


4. PEDESTRIAN SLIDES FORWARD INTO THE RETAINER

CAR DECELERATING

PEDESTRIAN IMPACT PROTECTION IS PROVIDED BY THE EXTERIOR GEOMETRY AND BY THE IMPACT PADDING PROVIDED. ADDITIONALLY, A RETAINER WILL BE DEPLOYED AUTOMATICALLY BY INERTIA FORCES, TO KEEP THE PEDESTRIAN FROM STRIKING THE ROAD IN LOW-SPEED IMPACTS.

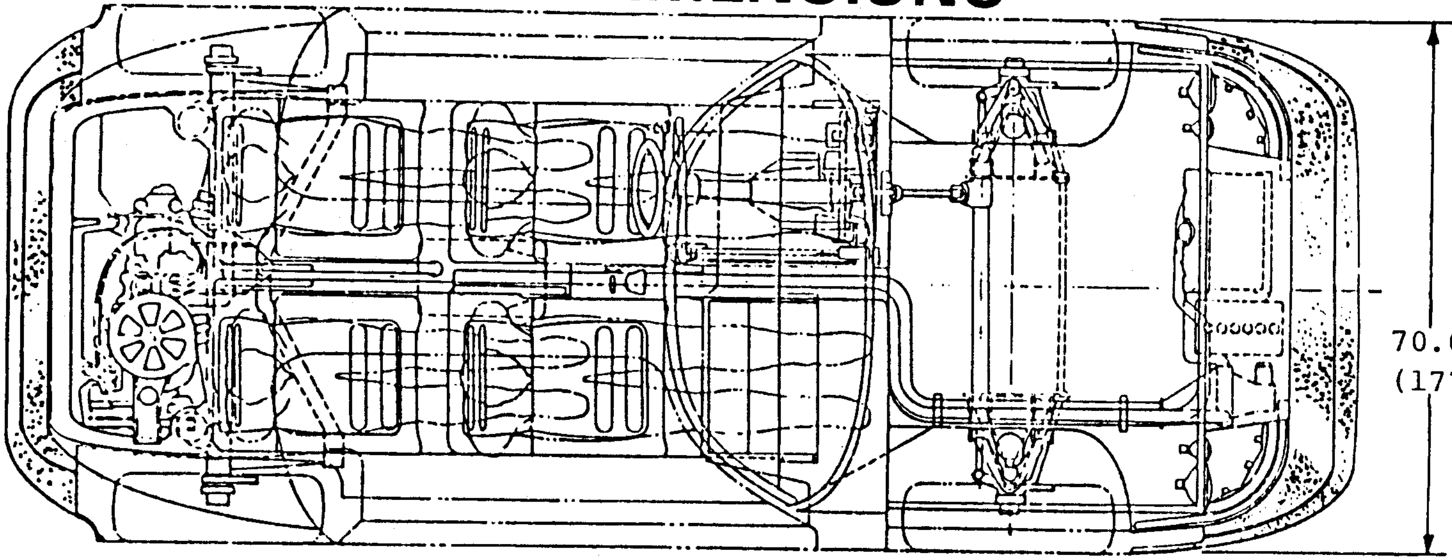
VEHICLE ELECTRONICS



SAFETY SPACE CONCEPT: MICROPROCESSOR DETERMINES THE SAFETY ZONE, BASED ON SPEED, RANGE RATE, AND RECIPROCAL RANGE, AND TAKES ACTION ACCORDINGLY (WARNS DRIVER, APPLIES BRAKES, DEPLOYS AIRBAGS, ETC.).

THE VEHICLE CARRIES AN ONBOARD MICROPROCESSOR AND RADAR SYSTEM. THE RADAR IS DESIGNED PRIMARILY FOR AUTOMATIC BRAKING AND COLLISION WARNING; PRE-IMPACT DEPLOYMENT IS DESIRABLE FOR THE RIGHT FRONT RESTRAINT, BUT NOT STRICTLY NECESSARY. A FLAT TV DISPLAY PRODUCES DIAGNOSTIC WARNINGS AND SERVES AS A DRIVER AID.

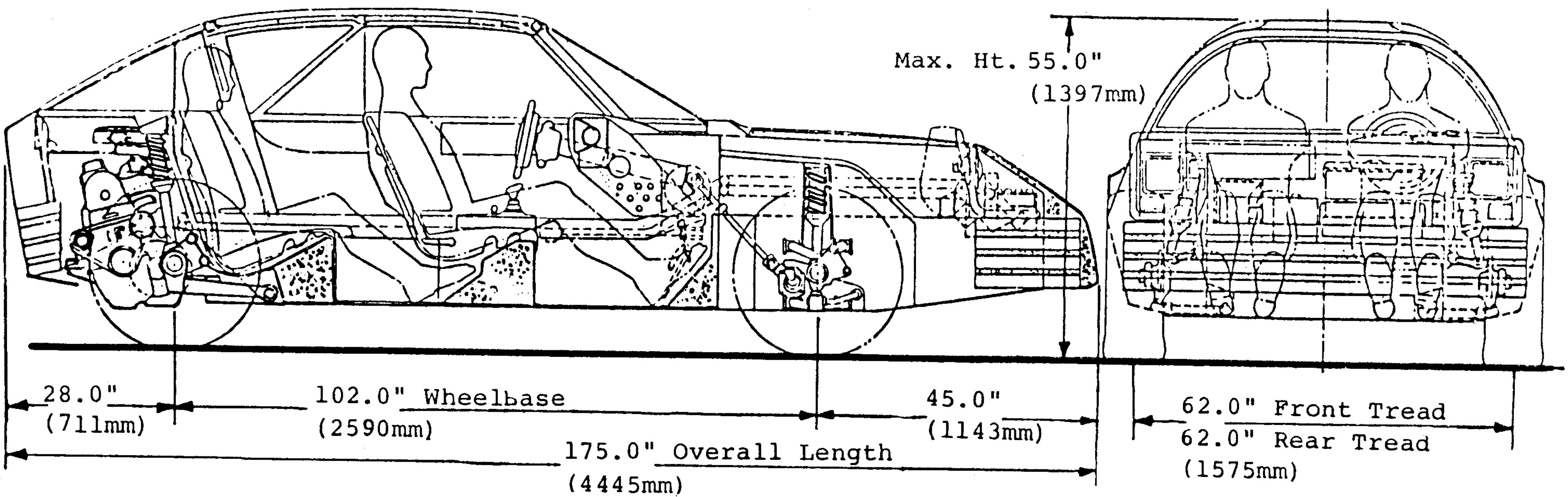
BASIC VEHICLE DIMENSIONS



SEATING CAPACITY
2 95TH PERCENTILE
MALES-FRONT SEAT

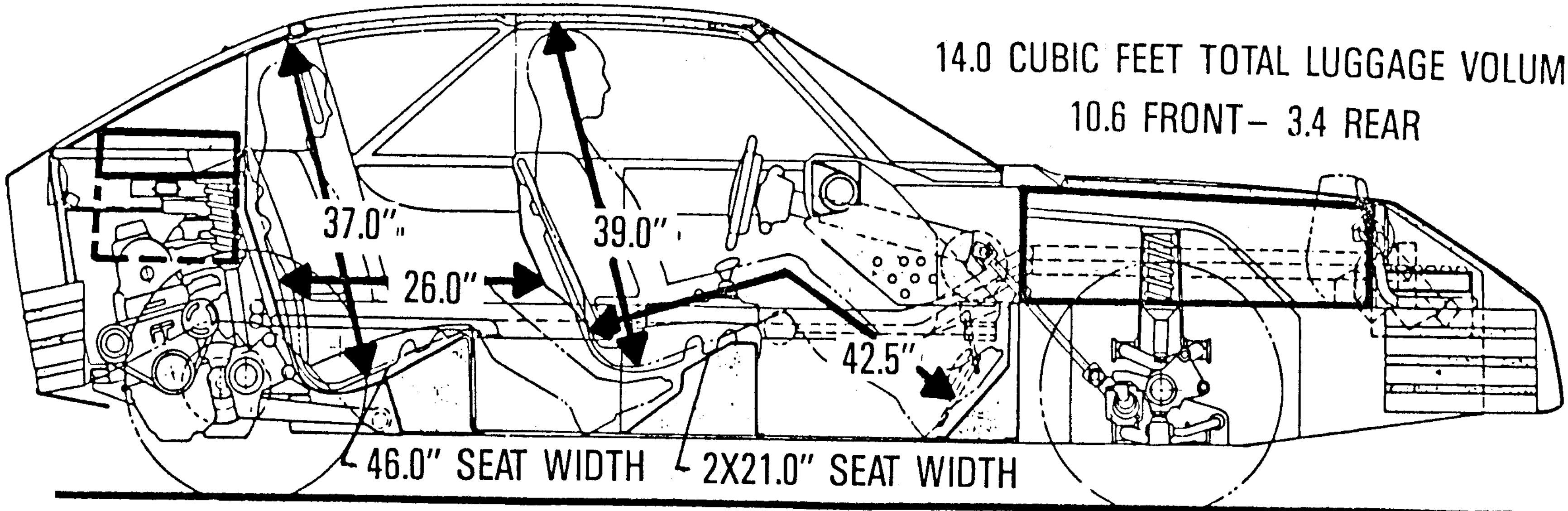
2 50TH PERCENTILE
MALES-REAR SEATS

CURB WEIGHT 1,917.5 LBS
871 KG



THE MINICARS RSV HAS THE COMPARTMENT SIZE OF A COMPACT CAR BUT THE WEIGHT OF A SUB-SUB-COMPACT.

SPACE EFFICIENCY



	Seating Dimensions, in. Front Width/Headroom/ Legroom	Rear Width/Headroom/ Kneeroom	Usable Space, cu ft Seating	Trunk	Total	Road Area, sq ft	Space * Efficiency Factor	Weight ** Efficiency Factor
RSV	2X21/39/42.5	46/37/26	65.6	14.0	79.6	85.0	0.94	83.0
FORD MAVERICK	48.5/36.0/38.0	52.5/37.0/27.5	69.3	12.2	81.5	94.9	0.86	60.6
BMW BAVARIA	2X22.6/38.0/39.3	55.0/36.0/25.1	67.8	15.3	83.1	93.3	0.89	49.2
AUDI FOX	2X20.5/36.5/38.5	53.3/35.5/23.7	59.3	12.6	71.9	75.6	0.95	68.2
HONDA CIVIC	2X20.5/36.2/40.0	49.5/33.6/22.5	56.0	6.9	62.9	60.5	1.04	73.2
VEGA	2X20.2/35.5/38.5	2X18.0/36.0/23.5	49.6	10.4	60.0	79.7	.74	46.8

THE MINICARS RSV HAS INTERIOR ACCOMMODATIONS COMPARABLE TO THOSE OF A BMW BAVARIA, BUT HAS A LOWER WEIGHT (AND A HIGHER FUEL ECONOMY) THAN ANY AMERICAN SUBCOMPACT NOW ON THE ROAD

* USABLE SPACE / ROAD AREA

** USABLE SPACE / WEIGHT (TONS)

RSV SUBSYSTEM BENEFITS IF SUBSTITUTED FOR SMALL CARS

	INITIAL & OPERATING COSTS*	1985 SAVINGS NO. OF INJURIES**	NO. OF FATALITIES	$ BENEFIT BILLIONS
OCCUPANT PROTECTION				
RSV STRUCTURE	($2.39)	156,000	7,540	3.08
ADVANCED DRIVER RESTRAINT	.54	197,000	10,700	4.24
ADVANCED PASSENGER RESTRAINT	.32	71,500	3,570	1.46
REAR SEAT RESTRAINTS	.21	7,600	370	.15
HIGH-G BRAKING WITH RADAR	.276	56,700	2,980	1.22
IMPAIRED DRIVER DET	.442	19,500	3,300	1.17
PROPERTY DAMAGE PROTECTION				
10 MPH BUMPER	(.39)			2.56
RADAR BRAKING	.553			4.33
PEDESTRIAN IMPACT PROTECTION	.415	39,900	3,490	1.61
NON-QUANTIFIABLE SUBSYSTEMS				
TOTAL INJURIES AND FATALITIES		567,700	33,010	
TOTAL PROPERTY DAMAGE				$6.89
DOLLAR EQUIVALENT	($0.02)	← $19.82 BILLION →		

*IN $ BILLIONS ADDED OR SUBTRACTED (-) TO SUBSTITUTE THESE SUBSYSTEMS ON THE 5.53 MILLION SMALL CARS PRODUCED IN 1985.

**REDUCED TO BELOW AMA ABBREVIATED INJURY SCALE - LEVEL 1.

OUR DETAILED METHODOLOGY SHOWS THE RSV TO SAVE 568,000 INJURIES AND 33,000 LIVES, WITH A DOLLAR EQUIVALENT OF ALMOST $20 BILLION, WITH A NET TOTAL COST TO THE CONSUMER OF NOTHING.

MINICARS, INC., AN INDEPENDENT RESEARCH AND DEVELOPMENT COMPANY SPECIALIZING IN TRANSPORTATION DESIGN, SAFETY, AND TESTING FOR BOTH GOVERNMENT AND INDUSTRY, WAS FOUNDED IN 1968. THE COMPANY'S FIRST CONTRACT WAS WITH THE URBAN MASS TRANSPORTATION ADMINISTRATION FOR THE DESIGN AND FABRICATION OF A SAFE, LOW EMISSION URBAN CAR TO BE USED IN THE MINICAR TRANSIT SYSTEM. SINCE THE SUCCESSFUL COMPLETION OF THAT PROJECT, THE COMPANY HAS GONE ON TO MAKE CONTRIBUTIONS IN THE AREA OF AUTOMOTIVE SAFETY THROUGH CONTRACTS TO THE NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION, SPECIFICALLY IN THE DEVELOPMENT OF ADVANCED PASSIVE RESTRAINTS FOR STANDARD, COMPACT, AND SUBCOMPACT CAR DRIVERS AND PASSENGERS, THE DEVELOPMENT OF STRUCTURAL CRASHWORTHINESS IMPROVEMENTS FOR SUBCOMPACT CARS, AS WELL AS THE RESEARCH SAFETY VEHICLE EFFORT WHICH IS THE SUBJECT OF THIS PAMPHLET.

IN ORDER TO TEST THE RESULTS OF THESE, OR ANY OTHER, AUTOMOTIVE ENGINEERING DESIGN EFFORTS, MINICARS HAS CAREFULLY PUT TOGETHER A SOPHISTICATED TEST FACILITY. IT CONSISTS OF A 2,000-POUND PAYLOAD SLED CAPABLE OF SPEEDS EXCEEDING 80 MPH AND A 600-POUND PAYLOAD SLED CAPABLE OF SPEEDS UP TO 40 MPH. A PNEUMATIC TOW MOTOR FACILITY FOR BARRIER, POLE, AND SIDE IMPACT CRASH TESTS IS ADJACENT TO THE SLEDS.

A STATIC CRUSHER IS ALSO AVAILABLE FOR DETERMINING FORCE DEFLECTION CHARACTERISTICS OF AUTOMOBILE SUB-ASSEMBLIES OR ENTIRE VEHICLES. THE DATA COLLECTED FROM THE STATIC CRUSHER IS USED BY OUR COMPUTER MODELING EXPERTS TO SIMULATE ACCIDENTS BETWEEN DIFFERENT KINDS OF AUTOMOBILES AS PART OF OUR CONTINUING EFFORTS TO DETERMINE HOW TO MAKE CARS SAFER. A TWO-CAR CRASH TEST FACILITY SHOULD BE IN OPERATION BY EARLY FALL.

IN ORDER TO GLEAN THE MOST INFORMATION FROM OUR TESTS, WHICH OFTEN ENTAILS THE CRASHING OF AN EXPENSIVE PIECE OF HARDWARE SUCH AS AN AUTOMOBILE, A COMPLETE ELECTRONIC INSTRUMENTATION FACILITY WITH THE CAPABILITY OF RECORDING 60 CHANNELS OF INFORMATION SIMULTANEOUSLY, IS AVAILABLE. THIS INFORMATION IS AUGMENTED BY MANY TIME-CODED 16 MM HIGH-SPEED CAMERAS AND SEQUENTIAL POLAROID CAMERAS. IT IS THIS ABILITY TO PERFORM A WIDE VARIETY OF DYNAMIC AND STATIC TESTS WHICH MAKES MINICARS THE MOST SOPHISTICATED TEST FACILITY ON THE WEST COAST.

THE MINICARS STAFF PROVIDES BOTH GOVERNMENT AND INDUSTRY THE TALENTS OF INNOVATIVE PROFESSIONALS WHO HAVE YEARS OF EXPERIENCE IN THE AUTOMOTIVE FIELD AND WHO ARE DEDICATED TO IMPROVING THE SOCIAL SYSTEM THROUGH CONSTRUCTIVE RESEARCH AND DEVELOPMENT.

MINICARS, INC. • 35 LA PATERA LANE • GOLETA, CALIFORNIA 93017 • PHONE (805)964-6271