AN ATTEMPT TO PLACE IN AN ORDER OF PRIORITY

THE MEASURES TO BE TAKEN TO IMPROVE ROAD SAFETY

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At the beginning of the 1970s it would have been difficult to find any document emanating from within the higher echelons of central administration of our countries which did not speak of the matter of rationalising budgetary choices and in the field of road safety. These choices were deduced from the use of cost-effectiveness studies or, better still, from cost-benefit studies. And in order to calculate possible benefits it was of course necessary to weigh up, and to evaluate the monetary quantity attributed to a human life as a function of the age of the person and of possible disabilities and handicaps that might have resulted from accidents to them (1) (2) (3).

In 1986 cost-benefit analysis still has pride of place but it is now rare that anyone is so rash as to advance a figure and even rarer to see a list of potential measures ranked in order of their capacity to forestall death and injury. There is a tendancy to limit the proposal to three or four countermeasures that are so global in nature that they collectively account for the major categories of accident patterns :

1. The generalisation of wearing of restraint systems by all front seat car passengers ;

2. The protection of pedestrians ;

3. The protection of car passengers in side impacts (4).

There are good reasons for this prudence. The complexity of the problems shows up more clearly from the results of in-depth research. Our knowledge of the effectiveness of the new countermeasures is only based on experimental data. We have learned to beware of performance measured on dummies for so long as their biofidelity continues to attract criticism. The predictive value of results obtained with cadavers is better but only on condition that their use can be made much more sophisticated so as to improve their ability to simulate living human beings (re-establishment of intra-pulmonary and intra-vascular pressure) in order to evaluate the risk of lesions to internal organs, especially the brain (5).

In the same way, the prediction of risk of injury to the skeletal structure necessitates the characterisation of the bone resistance of subjects used in experiments and its comparison with representative reference data for the living population exposed to risk (6) (7).

Besides this the reciprocal interaction of protective countermeasures introduces an additional difficulty to be overcome if one is to be able to predict expected gains. For example, the usefulness of having an anti "run-under" device at the front of a heavy truck is directly dependent upon both the behaviour of the structure of the car in asymmetrical impact conditions and the use of restraint systems by the car's passengers.
This countermeasure will be more or less effective according to the extent to which the effectiveness of the truck's anti "run under" device, of the frontal structure and of the car's restraint system has been able to be optimised for more or less high impact speeds.

Nor should we forget that the optimisation of the frontal structure of the car for this impact type may show itself to be a disaster in side impacts in which the struck car is -other things being equal- penalised in the event that the striking car is too stiff ; that is to say, too aggressive. These problems of compatibility of mass, architecture and stiffness -between cars and cars, cars and trucks, cars and pedestrians, etc...- are constantly in everybody's minds. Such problems are far from being solved. Here again great prudence is necessary !

More simply, prediction of the effectiveness of a seat belt depends on whether or not one takes into account the important variations in the tolerance of the thoracic cage that are due to age.

Should we therefore give up all hope of being able to place safety counter-measures in a rank order of priority ? We do not believe that this is the case. Simultaneous application of all the modifications that are technically possible would be an economic impossibility. It is therefore necessary to make choices.

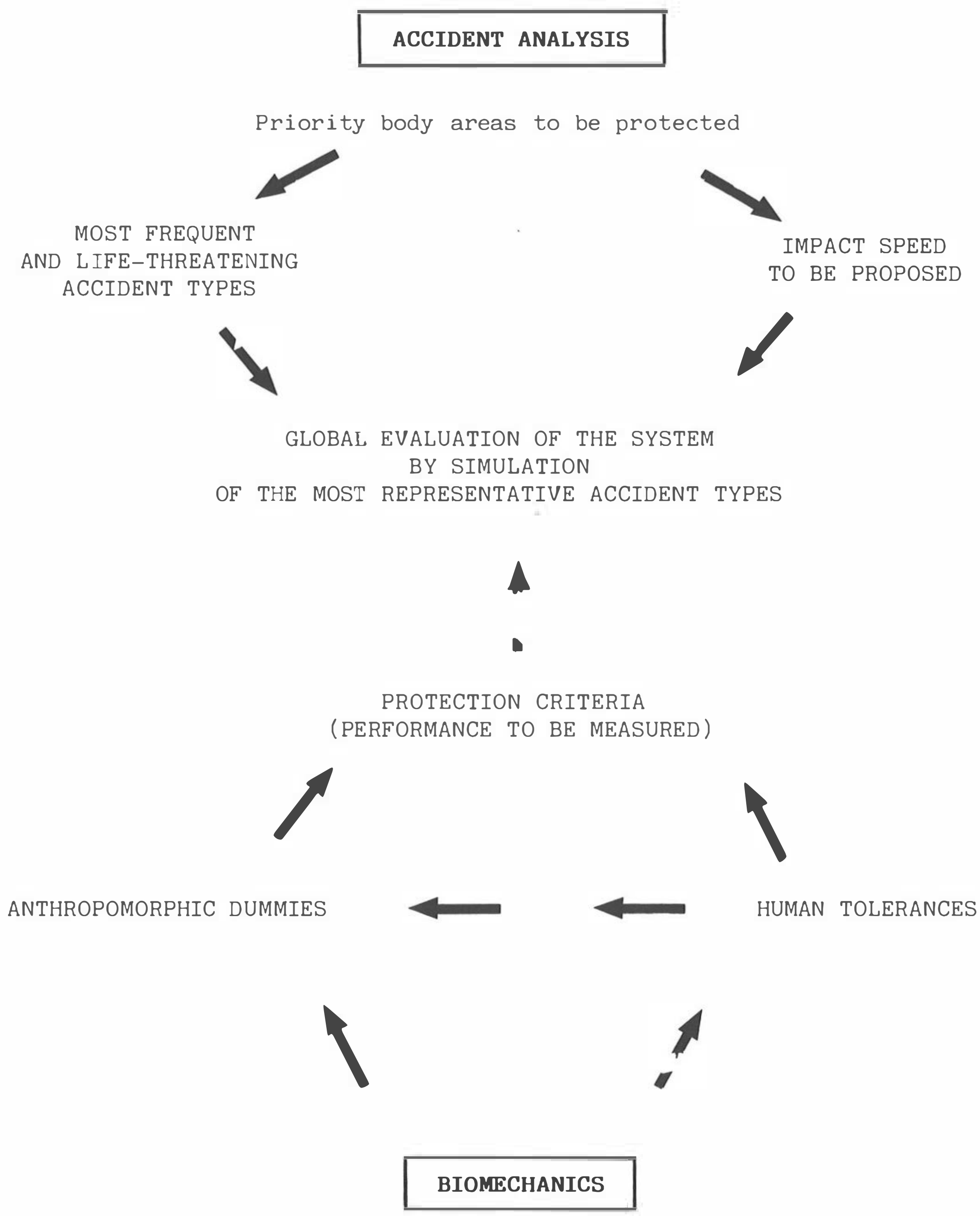
Whilst it is not for the vehicle manufacturers to set the maximum tolerable economic burden, is it not their absolute duty, when this maximum has been assessed by governments, to make available for that fixed amount those devices which will reduce to a maximum overall mortality and morbidity ?

With this aim in view, the french manufacturers have devloped a logical working method based on accident analysis, on biomechanical experiments and on structural tests (Figure).

This approach which combines observation of the real world of accidents with experimental quantitative analysis is complemented by some other essential inputs such as the annual national accident statistics published by the "SETRA" (Ministry of Transport) organisation, the data bank of the highway and national roads police and the reporting system for all fatal accidents that are available for the whole of FRANCE for different periods spread out over several months.

We have, in this paper, avoided excessively "purist" views and, accepting many approximations and wide ranges of evaluations, we have tried to group together into major categories having the same degree of priority those countermeasures that are the most often mentioned. The benefits thus quantified are based on the expected gain from countermeasures to be applied in the situation pertaining in FRANCE in 1984.

Figure


ACCIDENT ANALYSIS
Priority body areas to be protected
MOST FREQUENT
AND LIFE-THREATENING
ACCIDENT TYPES
IMPACT SPEED
TO BE PROPOSED
GLOBAL EVALUATION OF THE SYSTEM
BY SIMULATION
OF THE MOST REPRESENTATIVE ACCIDENT TYPES
PROTECTION CRITERIA
(PERFORMANCE TO BE MEASURED)
ANTHROPOMORPHIC DUMMIES
HUMAN TOLERANCES
BIOMECHANICS

The end result is a ranking in priority order that is reasonable or at least acceptable as a first basis for discussion as a function of other data bases and hypotheses that might be different. The authors are very conscious of the difficulties of their undertaking and it is therefore in all modesty that they await well-founded reactions to their proposals and remain ready to change such and such a classification (see also (8)).

To make it possible to appraise the "mechanism" of evaluation, an example is given (in an Annex) describing the benefits derived from a given counter-measure.

PRIORITY 1

Expected gain of 1000 to 2100 deaths and 3000 to 8000 seriously injured persons for each of the three following measures :

- a major thrust against drunken driving aimed at the drivers of private cars only* ;
- improvement of the road infrastructure (protection against impacts with trees or other fixed obstacles -especially by the installation of guardrails- for private cars* ;
- increase by 20 percentage points of belt-wearing rates amongst front seat passengers in private cars over the whole road network and at all times of day and night ;
- driver training and education in difficult road conditions (slippery roads, black ice, fog, etc...) including the use of certain driving aids.

PRIORITY 2

Expected gain could reach 500 deaths and 500 to 2200 seriously injured persons for each of the following measures :

- obligatory wearing of three-points seat belts by all adult rear seat passengers in private cars ;
- improvement of the restrain system for rear seat passengers on the assumption of a theoretical wearing rate of 90 % (optimisation of the restraint system's fitting including the form and the stiffness of the rear seat ;
- buzzer for non wearing of seat belts (hypothesis : increase of 5 to 10 percentage points in belt wearing rates) ;
- elimination of intrusion into the passenger compartment in asymmetric frontal impacts of the 30° barrier type, up to a speed variation of 65 km/h ;
- protection in side impacts for a speed variation of the struck car of the order of 30 km/h.

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* Potential maximal value which could be reached only at a 100 % efficiency.

PRIORITY 3

Expected gain could reach 100 deaths and from 300 to 2000 seriously injured for each of the following measures :

- obligatory protection for children of less than 10 years old (special seats, belts) ;
- increased conformity to the obligation to wear helmets by all two-whell motorised vehicle riders ;
- fitting of anti "run-under" devices on the front of heavy trucks (limitation of intrusion into the car at a speed variation of 50 km/h in hypothesis of a high rate in belt wearing ;
- protection of car occupants in side impacts into the struck car at a speed variation of the order of 25 km/h ;
- protection of both adult and child pedestrians up to 40 km/h impact speed (by structural changes to the vehicle parts struck by pedestrians' heads) ;
- obligatory helmet wearing by cyclists.

PRIORITY 4

Expected gain could reach 50 deaths and from 250 to 1600 seriously injured for each of the following four measures :

- prevention of head injuries by modifications to steering wheels and/or by improvements in restraint system performance in frontal impacts up to speed variation of 50 km/h or more and a belt wearing rate higher than 90 % ;
- prevention of the risk related to excessive movement of the pelvis in frontal impacts in case of 3-points belts with a wearing rate higher than 90 % ;
- protection of child and adult pedestrians' head injury in impacts at up to 40 km/h by changes to the vehicle parts struck by the head but limited to the bonnet and the wings ;
- improvement of anti "run-under" systems on the side of heavy trucks (aimed at preventing "run-under" by cars).

PRIORITY 5

Expected gain could reach 30 deaths and from 100 to 1600 seriously injured for each of the following measures :

- prevention of risk linked to the excessive movement of the pelvis in frontal impact (hypothesis of a belt wearing rate such as that observed in FRANCE in 1984) ;

- prevention of head lesions by modifying the steering wheel and/or restraint systems in frontal impact for speed variation of 50 km/h or more and for a rate of belt wearing by drivers such as that observed in FRANCE in 1984 ;

- protection of pedestrians' lower limbs by a reduction in the stiffness of front-end vehicle segments which are those with which contact is first made (at speed variation of 30 km/h or less) ;

- obligatory fitting of headrests for front seat car passengers.

OTHER MEASURES THAT ARE IMPORTANT BUT, DUE TO LACK OF DATA, UNABLE TO BE PLACED IN A RANK ORDER OF PRIORITY

- Anti-lock brake systems
- "Anti-drowsiness" devices fitted to the steering wheels of private cars and trucks
- Devices capable of detecting the presence of obstacles in foggy conditions.

Such measures are however included in the driving aids mentioned in Priority 1.

CONCLUSION

However much the foregoing classification of potential gains may appear to call for discussion, there are some vey weighty considerations which emerge and which are most unlikely to disappear even if different analyses were to be carried out.

Thus the measures against drunken driving and the obligations to wear the restraint systems currently fitted in vehicles at all times and places are demonstrably the most effective in terms of the benefits they would bestow and also the most "cost-beneficial" since the costs involved are amongst the lowest for society.

On the contrary all new measures leading to vehicle modifications necessarily involve a far from negligible cost for society whereas the expected benefit appears considerably more limited than for measures such as those concerning alcohol or constant seat belt use by passengers.

Besides this the measures concerning cars which aim to improve further frontal impact protection have shown themselves, in the situation pertaining in FRANCE in the 80s (FRANCE has had obligatory belt wearing for front seat passengers since 1973), always to be very competitive with measures designed to improve side impact protection or that of pedestrians. This would be seen to be still more true if the relative costs of these different measures were to be shown.

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ANNEXE

METHOD USED IN ORDER TO EVALUATE THE EFFECTIVENESS OF A ROAD SAFETY MEASURE

Example : INCREASING IN THE RATE OF SEAT-BELT WEARING AMONGST FRONT SEAT CAR OCCUPANTS THROUGHOUT THE ROAD NETWORK

An attempt to estimate safety gains (expressed in numbers of deaths forestalled) by increases in the rate of seat-belt wearing amongst private car passengers only, is here presented as an example of the procedure followed.

The basic data which this analysis uses are drawn from the files of SETRA (Table 1) for 1984.

	KILLED	INVOLVED
IN BUILT-UP AREAS		
- Drivers	1152	176532
- All Passengers (Right-Front + Rear)	703	50964
OUTSIDE BUILT-UP AREAS		
- Drivers	3350	69541
- All Passengers (Right-Front + Rear)	1906	51881

Table 1 : PRIVATE CAR OCCUPANTS KILLED AND INVOLVED IN PERSONAL INJURY ACCIDENTS

On the basis of these data, we observe :

a/ that the distinction between front and rear seat passengers does not appear ;

b/ that vehicle occupancy rates, mainly on the network dealt with the National Police (1.3), may be thought to be too small.

The National Road Safety and Traffic Observatory proposes the following estimates :

- the rate of occupancy of private cars (VP) in built-up areas is of the order of 1.5 ; that of the rear seats in built-up areas is of the order of 0.2 ;
- the rate of occupancy of VPs outside built-up areas is close to 1.8 ; that for the rear seats in the same circumstances is of the order of 0.3.

Besides this, analysis of the characteristics of fatal private car accidents undertaken in 1980 shows that 15 % of the killed in VPs were in rear seat positions (within and outside built-up areas).

Bearing this in mind, the corrected numbers of killed and involved passengers are shown in Table 2.

	KILLED	INVOLVED
WITHIN BUILT-UP AREAS		
- Drivers	1152	176532
- Passengers in front seats	425	52960
- All front-occupants	1577	229492
MORTALITY RATE : 0.69		
OUTSIDE BUILT-UP AREAS		
- Drivers	3350	69541
- Passengers in front seats	1118	34770
- All front-occupants	4468	104311
MORTALITY RATE : 4.28		

Table 2 : PRIVATE CARS FRONT-SEAT OCCUPANTS KILLED AND INVOLVED IN PERSONAL INJURY ACCIDENTS

HYPOTHESES

The coefficients suggested below are drawn from the files of the bidisciplinary survey of the Association PEUGEOT SA/RENAULT and are considered to be "proposed" coefficients.

a/ In all situations the effectiveness of the seat belt in reducing risk of death is estimated to be 60 % (rate of mortality of unbelted front-seat occupants = 2.5 times that belted front-seat occupants).

b/ For all accidents occurring in built-up areas it is estimated, in 1984, that the rate of belt wearing amongst personal injury involved front seat occupants is 30/35 %.

c/ For all accidents outside built-up areas the estimate is 50/60 % belt wearing rate amongst personal injury involved front seat occupants.

Applying these hypotheses, we obtain :

- Within built-up areas (b = belted - ub = unbelted) :

. Belted killed	255		
. Belted involved	74585	Mortality Rate b	0.34
. Unbelted killed	1322		
. Unbelted involved	154907	Mortality Rate ub	0.85

MRub - MRb = 0.51

(Nota : The rate of belt wearing amongst those killed in front seats is about 16 %).

- Outside built-up areas

. Belted killed	1570		
. Belted involved	59979	Mortality Rate b	2.62
. Unbelted killed	2898		
. Unbelted involved	44332	Mortality Rate ub	6.54

MRub - MRb = 3.92

(Nota : The rate of belt wearing amongst those killed in front seats is about 35 %).

EVALUATION OF THE GAIN IN LIVES SAVED BY AN INCREASE OF 20 POINTS OF SEAT BELT WEARING, OTHER THINGS BEING EQUAL

- Within built-up areas

When 100 involved passengers are converted from the unbelted to the belted category we have : - 0.51 killed.

We would therefore have the following changes :

. an increase of 10 points of seat belt wearing (that is to say that there are 10 % more belted occupants in front seats)

$$\frac{0.051 \times 229492}{100} = 117 \text{ deaths forestalled}$$

. increase of 20 points : GAIN = 234 LIVES.

- Outside built-up areas

When 100 involved passengers are converted from the unbelted to the belted category we have : - 3.92 killed.

We therefore have the following changes :

. increase of 10 points of belt wearing

$$\frac{0.392 \times 104311}{100} = 409 \text{ deaths forestalled}$$

. increase of 20 points : GAIN = 818 LIVES.

For FRANCE as a whole in 1984 an increase of 20 points of belt wearing would have enabled a reduction in deaths of between 1000 and 1100 to achieved.