CRITERIA FOR THE SELECTION OF ACCIDENTS FOR SIMULATION AND RECONSTRUCTION

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ABSTRACT

The selection of investigated real accidents for reconstruction in dummy and cadaver tests up to now is more a matter of feeling than a matter of rational decision. This paper presents an attempt to evolve criteria for valuation. Final aim is to develop an equation that manages to compare different real accidents and to figure out the aptitude for reconstruction by means of a single number.

INTRODUCTION

Efforts to increase the effectiveness of biomechanic investigations and to facilitate applicability of biomechanic results to real world cars in recent years have led to new types of investigation. The reconstruction of real accidents in tests is one of the new approaches. As the financial expenditures for those tests are comparatively high, it is necessary to restrict to some important accidents which have to represent the entire real world accident events. The selection of accidents to be reconstructed is mostly based on emotive decisions on significant parameters that are for instance: obviously frequent type of accident, obviously adequate severity of injury, average occupants, etc. Valuating the combination of the accident parameters is mostly a common-sense based decision.

In order to make the selection of accidents comparable, reproducible, objective and rational, calculation schemes have to be developed that take into consideration the statistical distributions of important parameters. These parameters have to be valuated; the seperate valuations have to be combined to a coefficient that makes possible to compare different real accidents.

Additionally, the coefficient has to bring about classification of the fidelity of the reconstruction of real accidents.

DISTRIBUTION OF ACCIDENT PARAMETERS AND THEIR WEIGHT

The real world accident events can be described by the distribution of their parameters, as are:
- severity of injury (AIS),
- change of velocity (Δv),
- collision speed ($v_{coll.}$),
- mean deceleration,
- age of occupants/pedestrians,
- height of occupants/pedestrians, etc.

As the severity of injury is deemed to be the basis for selection the other parameters have to be related to the distribution of AIS. The type of relation depends on the aim of the investigation. Supposing, the reconstruction of a representative accident were to be performed, at first the parameters of the representative accident had to be found out or set up. For example, these might be the average or the median value of the parameters, see fig. 1.

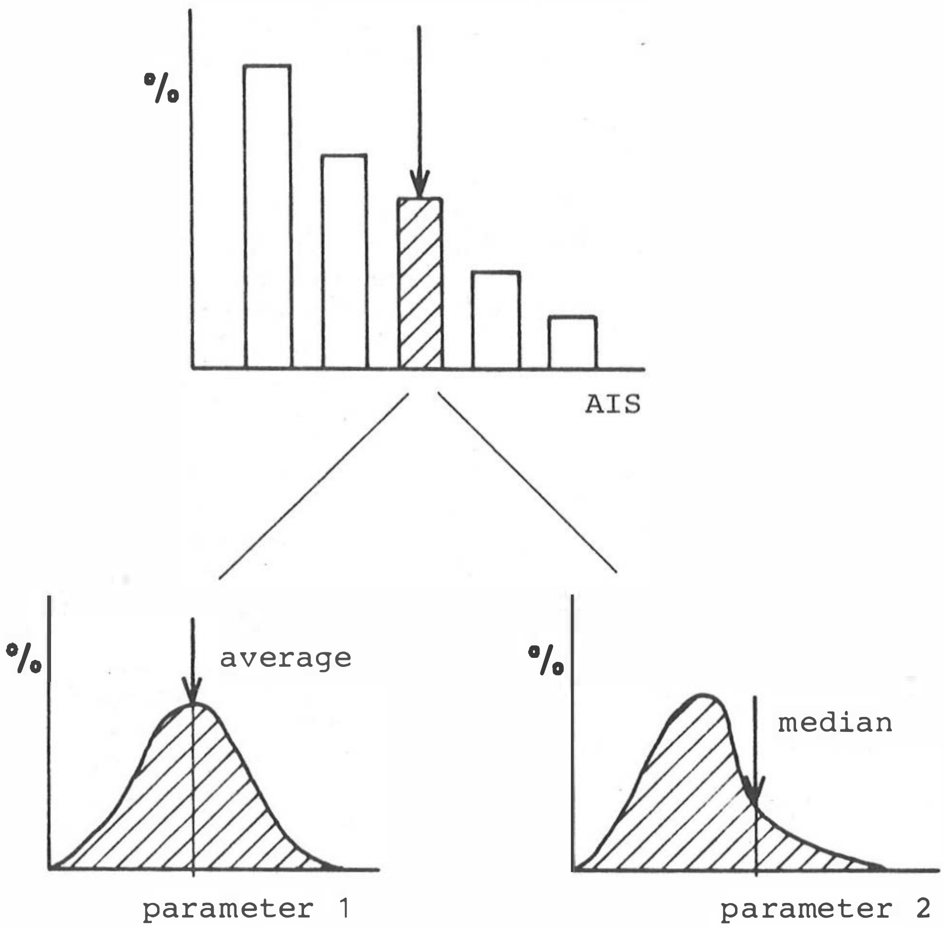

Fig. 1: Determination of the injury level and its corresponding representative parameters

Consequently, a real accident has to be found the parameters of which correspond to the respective values of the distributions. Probably, there will not be any real accident that corresponds exactly. So, among those accidents which are similar, that which resembles best has to be determined. This decision shall be made in an objective manner by means of a calculation scheme.
For that, ranges of tolerance of the parameters and weighting factors for divergent values within the ranges of tolerance are necessary. The respective weighting factor describes the influence of the parameter on the severity of injury (AIS), see fig. 2.

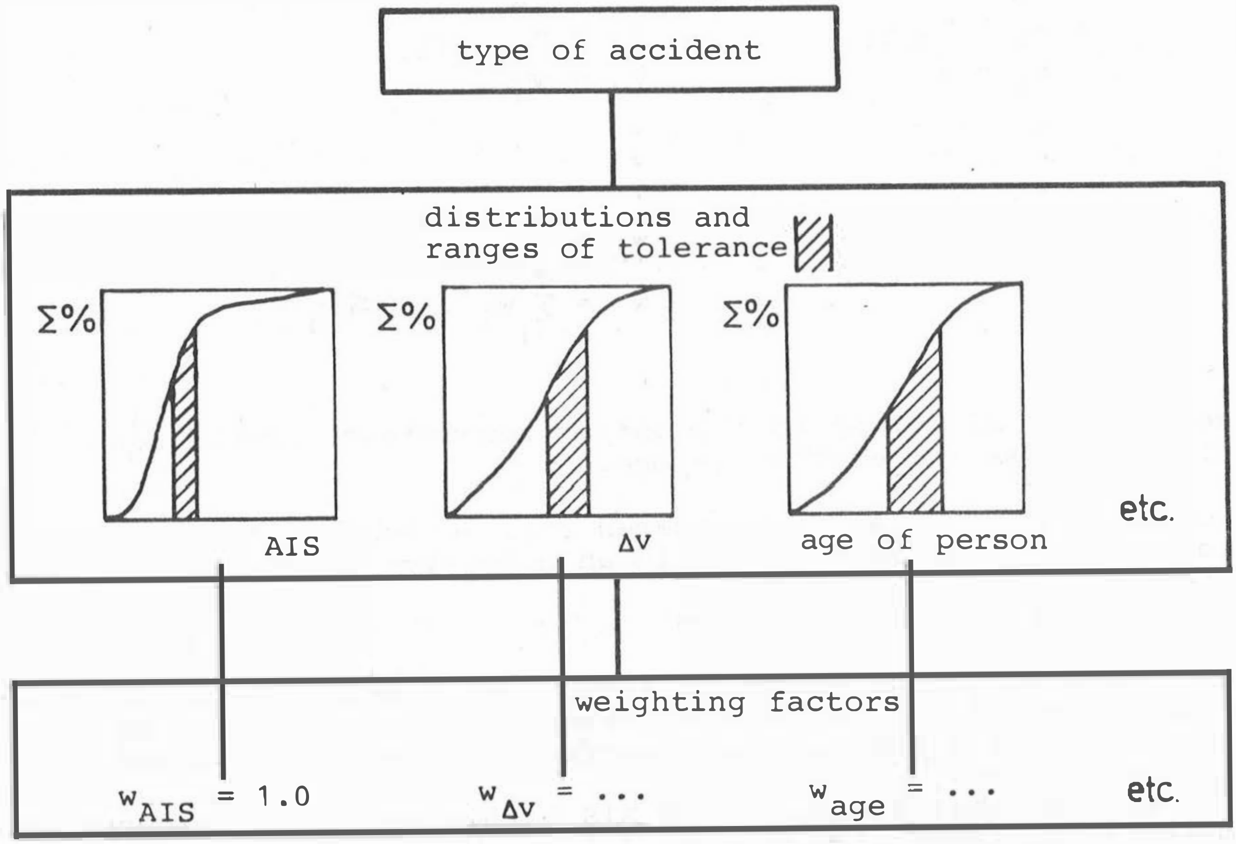

Fig. 2: Accident parameters: distributions
ranges of tolerance
weighting factors

The values of the imaginary representative accident as well as the diverging values of the real accident and the weighting factors are elements of an equation that yields a number of fidelity (NOF), describing the fidelity of the real accident in relation to the representative accident.
This equation reads e.g.:

$$NOF = \frac{1}{\sum_{i=1}^{n} \left| \frac{x_{i\ representative} - x_{i\ real\ accident}}{x_{i\ representative}} \frac{w_i}{w} \right|}$$

where NOF = number of fidelity, $0 \leq NOF \leq \infty$

$x_1 = AIS$ $w_1 = w_{AIS}$

$x_2 = \Delta v$ $w_2 = w_{\Delta v}$

$x_3 = v_{coll.}$ $w_3 = w_{v\ coll.}$

$x_4 = \bar{a}$ $w_4 = w_{\bar{a}}$

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$x_n = \ldots$ $w_n = \ldots$

$w = \sum_{i=1}^{n} w_i \quad , \quad 0 \leq w_i \leq 1$

Higher values of NOF stand for better resemblance of the real accident to the representative one.

So out of many similar investigated real accidents the best for reconstruction can be selected in an objective procedure.

EVALUATION OF WEIGHTING FACTORS

The evaluation of the weighting factors w_i, which are to describe the influence of the respective parameter on the severity of injury (AIS) is a problem that cannot be solved in the scope of this presentation.
It is obvious that divergence of AIS influences the divergence of the entire accident directly, thus $w_{AIS} = 1.0$ is required.
No other weighting factor w_i can be of greater significance than w_{AIS}, so the values have to be $0 \leq w_i \leq 1.0$. Evaluation of the factors, based on research results, is an important task for the near future.

The following list may be a first attempt for classification of the weighting factors.

parameter	most important	very important	important	weighting factor
AIS	x			1.0
age of person	x			1.0
Δv		x		0.75
$v_{coll.}$		x		0.75
$\bar{a}$		x		0.75
height of person		x		0.75
weight of person			x	0.5
impact direction			x	0.5
impact area			x	0.5

Rough, preliminary classification of weighting factors.

PROTECTION CRITERIA

Protection criteria can be established in two different ways.

The "determination approach" requires a decision (politically or common-sense based) which level of injury is considered "supportable" with respect to severity and frequency of a respective accident situation. Dependencies of resulting AIS on speed change, collision speed, mean deceleration, etc. describe the accidents. From this, tolerance ranges of the parameters can be fixed, which represent a "supportable" accident with "supportable" AIS. A real accident within these ranges is suitable for reconstruction. An accident, exceeding at least one parameter's tolerance range has to be cancelled.

Another approach ("frequency approach") is to determine the other parameters of a "supportable" accident by referring to their cumulative frequencies. The values of the parameters are ascertained at the same level of cumulative frequency that is associated with the "supportable" AIS. These values, which are possibly forced up by this action, can then be basis for evaluation of protection criteria. This kind of proceeding is found on the assumption, that increasing values of the parameters mean aggravation of the accident situation, i.e. an accident of

less severity and less load on the occupant/pedestrian results in lower degree of injury than an accident with higher values of parameters does.
Thus, if protection criteria are accomplished at high levels, they will also be accomplished at lower levels.

EVALUATION OF PROTECTION CRITERIA THROUGH TESTS

Out of the amount of investigated real accidents that which has the best NOF is selected. Data measured in several tests simulating the real accident can be used as protection criteria if resemblance of injury severity and motion sequence between real accident, dummy test and cadaver test can be attained. This progress from definition of a "supportable" AIS to ascertainment of protection criteria is shown graphically in fig. 3.

CADAVER AND DUMMY TESTS

Evaluation of protection criteria with the aid of cadaver tests requires resemblance of the cadaver's anthropometry to that of the injured person. In this coherence it seems expedient to apply NOF to classify the fidelity of cadaver tests and/or to choose the case with the best resemblance, if several tests are prepared for performance and a cadaver is available. For that purpose the equation of NOF has to be reduced to parameters describing the injured person resp. the cadaver, e.g. age, height, weight, etc. By applying NOF this way different cadaver tests and their results can be compared with regard to the real accident and can be judged by their fidelity.
Equivalent considerations are valid for dummy tests, see fig. 4.

CONCLUSION

Selection of real accidents for reconstruction can be made more objective by introducing a schematic selection criterion. The elements of the demonstrated criterion NOF are not yet completely known.

Proposals for selection and filtering of real accidents as well as dummy and cadaver test configurations connect investigated real accidents and the evaluation of protection criteria.

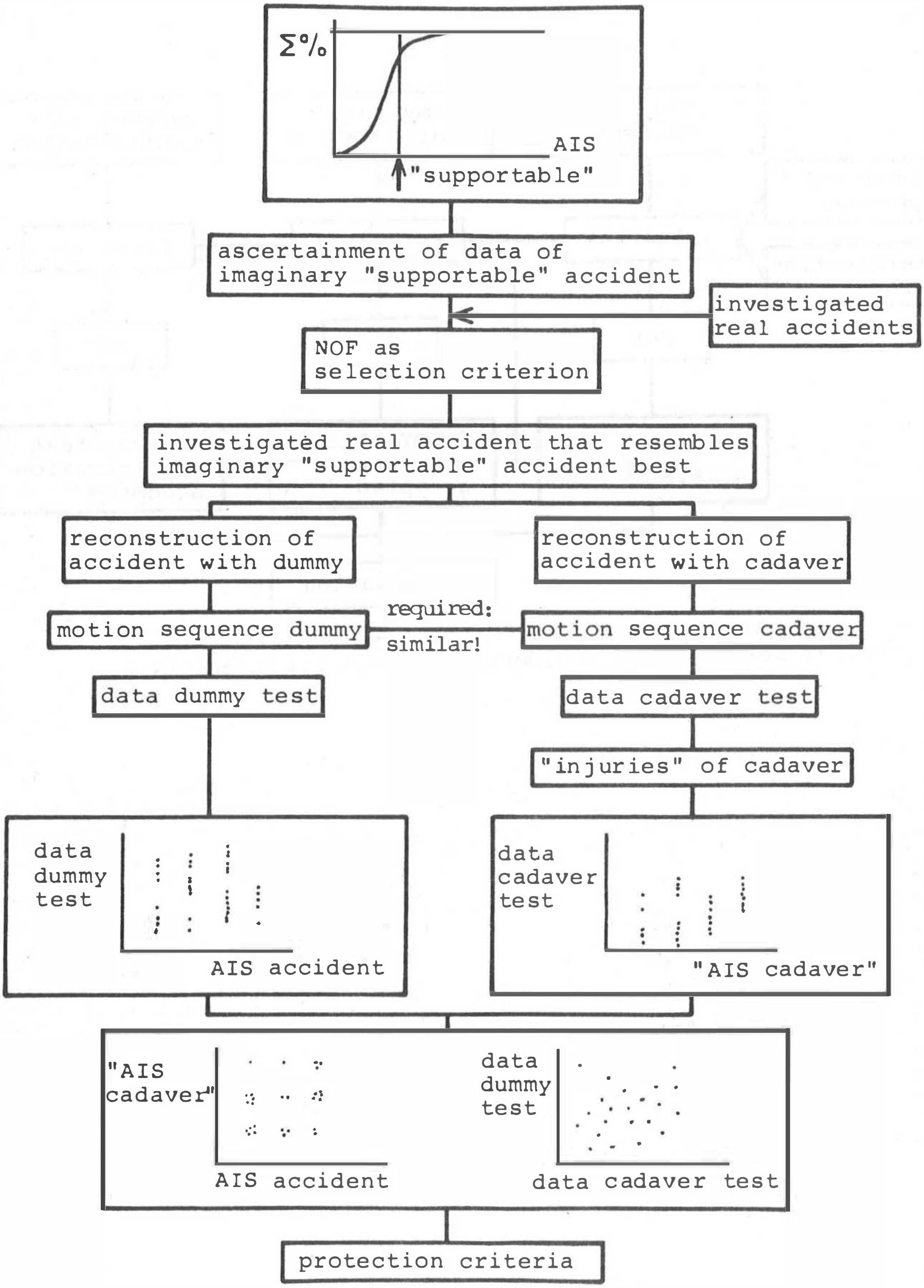

Fig. 3: Evaluation of protection criteria

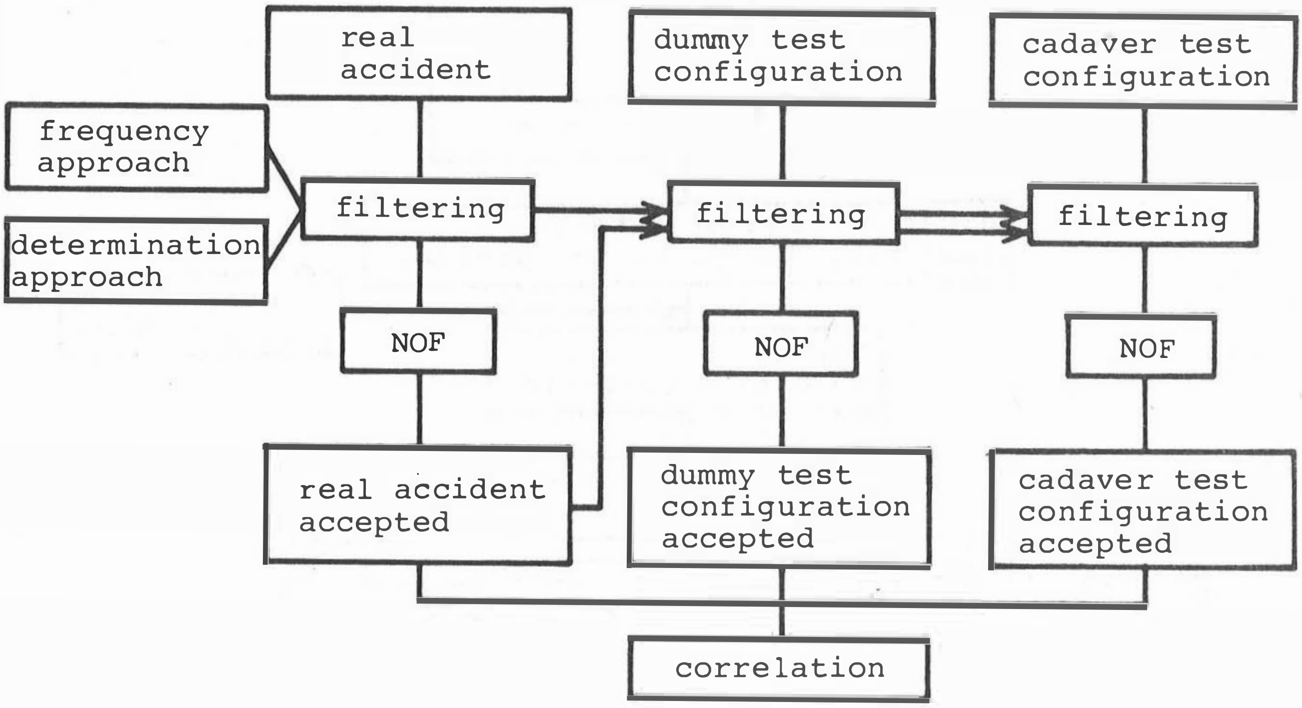

Fig. 4: Selection of accidents and test configurations