

## Research Association for Biomechanics at the Federal Highway Research Institute

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### Introduction

With the introduction of safety-belts having to be worn in the Federal Republic of Germany as from 1976, an important step was taken to increase passive safety. Further improvements require a progressive adaptation of safety mechanisms and safety equipment to human tolerance limits. At the instigation of the Federal Highway Research Institute (Bundesanstalt für Straßenwesen) three separately compiled literature studies were published in one combined report (1). However, the large variation in the results achieved makes it clear that the level of knowledge at present is still very scant. There are various reasons for this: the different research methods and research conditions, the bad reproductibility of results due to difficulties in measurement technique as well as to the complexity of the human body. Consultations in a working group of the EEVC (2) have, moreover, made it clear that previous investigations into human tolerance limits have frequently been carried out without reference to actual accident occurrence. Based on this situation the Federal Highway Research Institute in collaboration with the Berlin University Institute for Country Transport (Institut für Landverkehrsmittel der Universität Berlin) and the Laboratory of Physiology and Biomechanics Paris (Laboratoire de Physiologie et de Biomechanique Paris) took the initiative of founding an International Research Association for Biomechanics which is reported on here.

### Objective and Research Programme

In order to be able to check on the effectiveness of safety systems even during their development, the assessment of mechanical dimensions, measured on dummies, in the form of so-called protective criteria, is necessary. The general objective of the Research Association for Biomechanics is thus to ascertain human tolerance limits and their correlates in the form of these protective criteria. Investigation into real accidents was chosen as the research method for the study of this correlation. This method is, among others, described in (3): injuries arising from real accidents are compared with measured variables on cadavers and dummies in reconstructed accidents.

Backed up by accident statistics and taking into consideration previously undertaken research projects in the field of biomechanics, the following research complexes were chosen for the next two years as being of special importance (4) :

- a) Reconstruction of accidents with lateral collision
- b) Reconstruction of pedestrian accidents with head injuries and
- c) Reconstruction of frontal accidents for the solution of special problems

The three subjects in the form of project drafts are expounded in the following.

- a) Reconstruction of accidents with lateral collision

The following injuries are of predominant interest:

brain injuries, skull injuries, neck injuries, thorax injuries, abdominal injuries and pelvis injuries.

For brain injuries the assessment of acceleration by the HIC and other functions is specially important. For neck injuries the connection between lateral flexion and rotation are to be examined, whereby tractile and compressive force, flexion and shear forces represent the relevant parameters. The thorax injuries are to be examined taking into consideration the frequency of intrathoracular injuries with and without rib fractures, whereby measure dimensions like deceleration and transversal deformation are ascertained. For abdominal injuries the problem of penetration as well as of forces and deceleration on the pelvis, and substitutes for the injury causing parameters, should be ascertained. The kinematic and the interaction between the car occupants as well as the influence of vehicle crushing on dummy accelerations is to be taken into special account in the preparatory work for this research.

In two years 10 selected accidents are to be reconstructed in 10 pretests with dummies, 10 dummy tests and 10 cadaver tests.

The accidents to be reconstructed are selected on the basis of the following limitations:

- well documented reconstructable accidents
- in the vehicle investigated there should have been at the most two front passengers (either wearing safety-belts or not). (For standard tests one cadaver should be used in cadaver tests, and two dummies in dummy tests)
- only vehicles less than 5 years old and which are still manufactured
- European vehicles
- one vehicle should be moving, the other not.

- b) Reconstruction of pedestrian accidents with head injuries

With the investigation of this complex, the important thing is the interdependence of head injury on the crash speed, on the shape of the bonnet, the striking surface, the size of the

pedestrian, on his or her position and movement relative to that of the vehicle and the influence of vehicle braking.

On the basis of two vehicle speeds (20-25 km per hour and 40-45 km per hour) two pedestrian categories (child dummy of 6 years of age, adult as cadaver or dummy without any body size limitations) and three different vehicle frontal structures, about 20 accidents are to be reconstructed in 20 pretests with dummies, 20 dummy tests and 20 cadaver tests in two years. The pedestrian is to be hit from the side and not be moving.

c) Reconstruction of frontal accidents for the solution of special problems

Firstly, thorax injuries are to be investigated, particularly concerning the connection between the crushing of the chest and deceleration on the dummy or the cadaver; furthermore concerning the force caused by the shoulder strap of the safety-belt, and concerning the correlation between rib fractures and intrathoracicular injuries.

Secondly, abdominal injuries caused by wrongly worn safety-belts and submarining incidence should be investigated. Because of the difficulty in reconstructing accidents with head impact, injuries to the skull, brain and neck for car occupants wearing safety-belts are to be investigated with less priority. The important thing here is the checking of the applicability of the HIC as well as the clarification of the influence of rotational acceleration on the injuries. Furthermore a combined tolerance limit for linear and rotary acceleration should be ascertained.

5 accidents with 15 tests, 5 pretests, 5 dummy tests and 5 cadaver tests are to be reconstructed. As the criteria for selection, the same conditions hold true for these frontal accidents as for the lateral collisions with the following additional conditions:

- vehicle/vehicle-accident or vehicle against rigid object (tree/wall)
- collision speed in the region 40-60 km per hour (ETS)
- two people sitting at the front, but no children, all wearing safety-belts
- the vehicle investigated should only be moving in a forward direction both before and during the crash.

The research assignments described go over and beyond the possibilities of a single research institute. The International Research Association should enable an increase in the total number of accidents to be reconstructed and bring an improvement of communication between the research groups, particularly

in respect of a prompt exchange of experience with research methods as well as discussions about research assessments and results. Finally the association can expect an increase in the effectiveness of the funds which are made available for research by avoiding duplication in research and by higher quality of research results.

The association is supported by:

- Committee of car manufacturers of the Common Market (CCMC)
- Forschungsvereinigung Automobiltechnik e.V. (FAT)
- Rechtsmedizinisches Institut der Universität Köln
- Institut für Landverkehrsmittel der TU Berlin
- Organisme National de Securite Routiere (ONSER)
- Laboratoire de Physiologie et de Biomechanique
- Bundesanstalt für Straßenwesen (BASt)

The Federal Highway Research Institute has agreed upon the selected research topics, the research methods and the organization of the association with those institutes involved. The carrying out of the tests, the autopsy and the documentation have in particular been standardized very extensively.

Since in the next report, method problems in the reconstruction of accidents and the definition of protection criteria will be gone into in greater detail, (see also (5)), the organizational structure and the question of financing are to be shown here.

#### Organization of the Association

Three executive bodies have been set up for scientific and business management of the association:

Steering committee, management and project leader

In the steering committee proposals for the research programme are discussed and the schedules fixed. For the individual topics, project leaders are chosen who are specially responsible for seeing that the investigations are carried out co-ordinatedly, that the objective is correspondingly fixed and presented to the committee in the form of a closing report. In this panel, in agreement with all the parties to the contract, decisions are made about the type and timing of publication of research results. The management has the task of ensuring a flow of smooth and complete information. It also supports the organizational carrying out of the programme. It supervises the rules agreed upon concerning co-operation, it documents the annual financial expenditure of the association and sees to it that research financing is carried out according to contractual right.

The organizational structure is described in detail in fig. 1,2.

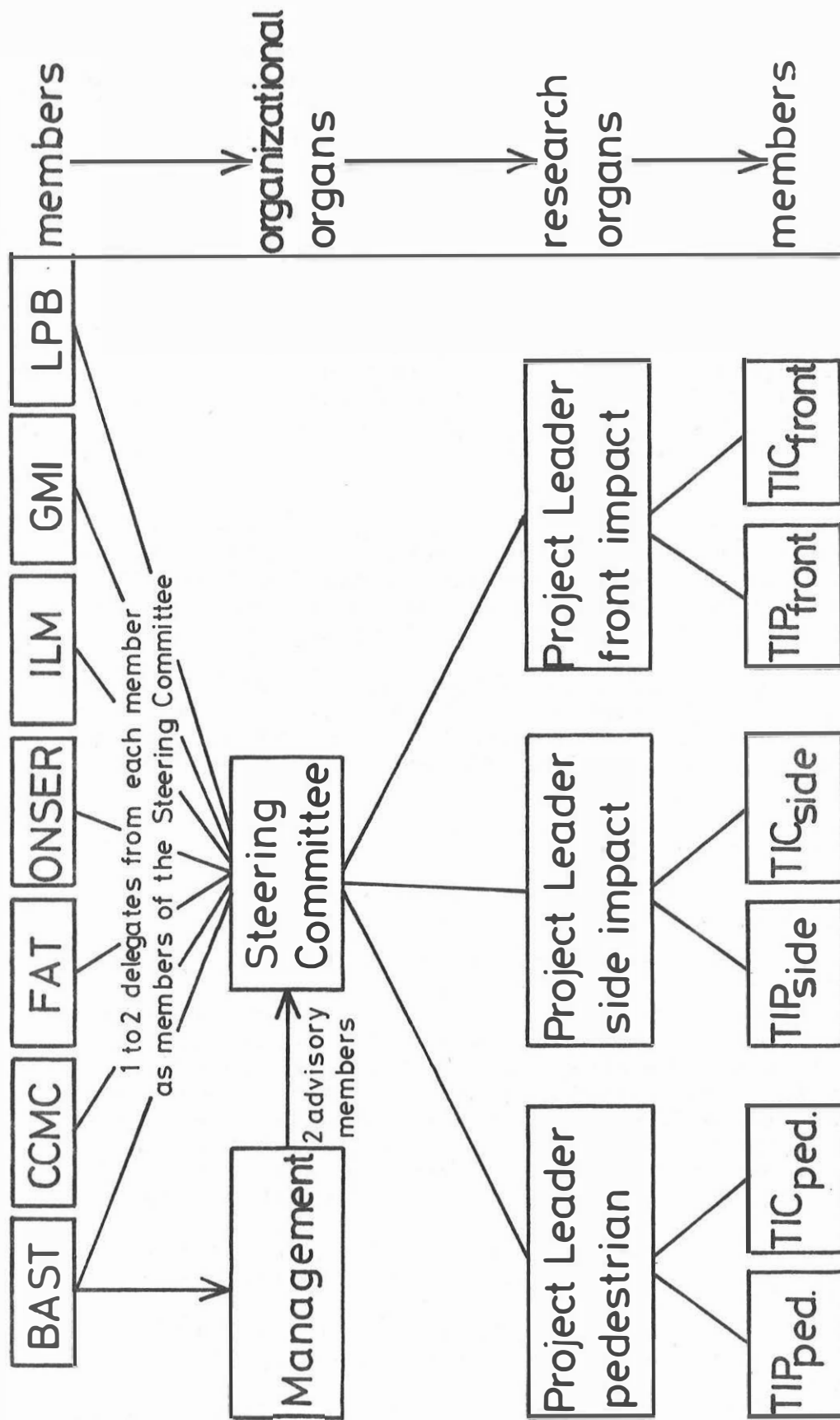


fig.1: organizational structure of organs and members

from: ILM, TUB, may1977 He

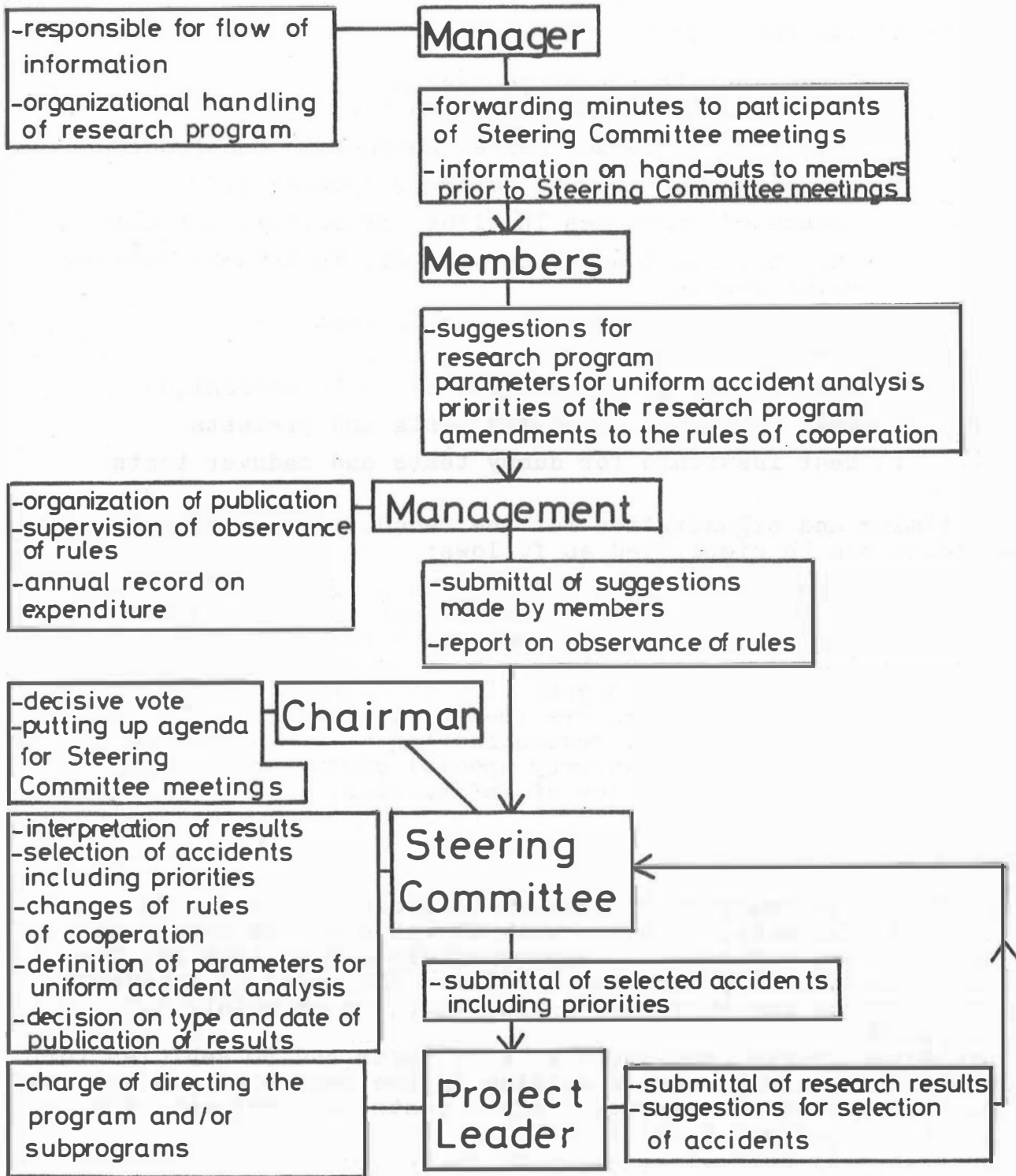


fig.2: obligations of organs and members

from: ILM, TU B, may 1977 He

Abbreviations for figure 1:

BAST : Bundesanstalt für Straßenwesen  
(Federal Highway Research Institute)

CCMC : Committee of Common Market Automobile Constructors

FAT : Forschungsvereinigung Automobiltechnik e.V.

GMI : Rechtsmedizinisches Institut der Universität Köln

ILM : Institut für Landverkehrsmittel, Technische Universität Berlin

ONSER : Organisme National de Securite Routiere,  
Laboratoire des Chocs

LPB : Laboratoire de Physiologie et de Biomechanique

TIP : Test institute for dummy tests and pretests

TIC : Test institute for dummy tests and cadaver tests

The timing and organization for the reconstruction of an accident can be simplified as follows:

After the selection of an accident, the project leader calls for detailed information from the in-depth studies. The test institute for dummy tests and pretests carries out a pretest as a result of this information. The results from this test serve as a basis for the preparation of dummy and cadaver tests. The results of these tests are then brought together by the project leader. The total reconstruction of a case takes approximately 20 weeks, whereby special circumspection and care are devoted to the flow of information.

### Costs

For the reconstruction of lateral collision for about 10 selected accidents, 30 tests with 60 vehicles are required. The costs are estimated at approximately 0.9 million DM. The reconstruction of pedestrian accidents for about 20 accidents with 60 tests and 40 vehicles will cost approximately 1.1 million DM.

5 selected frontal accidents with 15 tests and 30 vehicles for reconstruction will cost something in the region of 0.5 million DM. Thus the total research project costs for 1977 and 1978 amount to nearly 2.5 million DM in all.

Approximately half of this amount is borne by the FAT and the CCMC, whilst the other half is borne by the Federal Highway Research Institute.

### Outlook

With the forming of the described association, there were, in addition to the clarification of scientific questions, also

organizational problems, problems concerning contractual rights and financial problems, all of which had to be solved. All those participating in the association have the founded hope that through the agreed collaboration in this field, good research results will quickly be achieved, leading to noticeable progress in vehicle safety.

The arranged projects in the first phase should be extrapolated and extended in a gradual system, if need be in a modified form. After a period of two years a check must be made to see whether the association has proved sufficiently successful that an expansion by further European countries would appear sensible.



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