3. CHARACTERISTICS OF AN ADEQUATE DATA COLLECTION PROGRAM

In Section 2 the general needs of an adequate accident data collection program have been identified and the inadequacies of the present system have been presented. In this section, three characteristics of a satisfactory data collection program are discussed: the quantities and rate of data acquisition, the importance of an unbiased sampling plan and the measurement of causal crush severity.

a. QUANTITIES AND RATES OF DATA COLLECTION

It is reasonable to require the data collection system to provide timely evaluation of the effects of automobile design changes, whether voluntary or made in compliance with official safety standards. This suggests that the national data collection system should be designed to gather vital information within a single year.

As Kidd points out,[15] ~Definition of the total number of accident cases required annually for an adequate national data bank can be made if (1) the questions to be asked of the system can be identified both for the present and future; (2) the accuracy with which the particular data elements can be measured is known or can be appropriately examined; and (3) the statistical analysis techniques to be employed can be agreed upon.”

But rate depends also on the speed with which results must be realized. Rapid feedback from the field is essential to the evaluation of the effectiveness of changes, so as either to reinforce the decision made by the designer or rulemaker or to dissuade him from an erroneous decision.

In the case of general accident statistics, the population of crashes does not represent the statistically stable ideal (stationary time series) because of continually changing mixes of car sizes and weights, changing rules under which cars are operated (for example, the Federal 55 mph speed limit) , changes in the quality and extent of highways, variation from season to season and year to year in total miles driven, and modifications to vehicle designs, both voluntary and in compliance with safety standards.

The allowable lag in production of statistics, based on the foregoing considerations, appears to be about one year. This, in turn, suggests that a sufficient body of data should be gathered within one year to detect differences in injury incidence as a result of actions on the part of the government or the carmakers.

In the following paragraphs we will estimate what this may mean in terms of the number of reports required per year and, if causal severity were to be obtained through the use of crash recorders, the number of crash recorder installations that would be needed. Some less important data might be acquired over longer periods, lessening the amount of data required annually.

We have previously indicated that one objective of collision data gathering is the construction of cumulative distribution functions for severity for all accidents, all injury accidents, and all fatal accidents. The first of these is needed to provide reference or baseline statistical information from which other important statistics may be derived; the second and third are needed to validate the rationale used in rulemaking. A statistical technique* permits prediction of the number of

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* The Kolmogoroff-Smirnov test; see, for example, “Non-parametric Statistical Inference.” J.D. Gibbons, McGraw Hill 1971.

observations in a random sample that would be required to construct these distribution functions with a confidence of *x* percent that the function derived from the sample will be within Y percent of the true distribution. Table 1 tabulates the number of samples required for several levels of confidence and accuracy.

Table 1

Number of Observations Required To Construct Cumulative Distribution Functions

Deviation From "Truth"	Confidence Level 80%	90%	95%
1%	11,449	14,884	18,496
2%	2,862	3,721	4,624
3%	1,272	1,653	2,055
4%	716	913	1,156
5%	458	595	740
8%	179	233	289
10%	115	150	185

The table indicates the number of reports that would be required to construct distribution functions of severity if severity could be measured for each year.

The tabulated numbers represent also the number of reports needed in a segregated category to construct a severity distribution function for that category. Taking a typically acceptable statistical level of 95% confidence, 5% accuracy, 740 fatality reports would be required to construct a severity distribution function for fatalities; 740 injury reports would be required to construct severity distribution function for injury cases. Suppose it were desired to examine the distribution function for car weights in injury cases, independent of all other factors; again, 740 reports would be required in which weight was stated.

The need for a large number of annual reports arises when a particular set of events to be examined has low probability of occurrence in the sample. Suppose, for example, one wishes to determine the distribution of car weight in rollover injury accidents for two categories of occupants: belted and unbelted, 740 reports in each of the two categories would be required. Injury accidents constitute 33% of reportable accidents, and the probability that an injury accident was a rollover [3/] is about 8%. Perhaps 25% of those injured wore belts. Thus 0.67% of reportable accidents were rollover-injury-belted, and to find a sample of 740, an aggregate of 111,000 reports in the ‘reportable accident” category would be required. (This same set of reports would provide more than enough unbelted-rollover-injury events.) If only injury accidents were reported, a sample of 37,000 reports would suffice. If the same analysis were to be done for fatal rollover accidents drawn from a mass accident file, the file would have to number 3,500,000 to find 740 fatal-rollover-belted events. The reason for the much larger data file in this case is that there are far fewer fatalities than injuries.

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[*] $0.25 \times 0.08 \times 0.333 = 0.0067$.

Analysis of infrequent events requires many input reports. But the fact that events are infrequent does not make them unimportant. The best example of this is traffic fatalities, which, though infrequent, cost society almost as much as automobile injuries and damage combined.

Suppose that a new restraint system modification were implemented, and one wished to confirm, to a confidence level of 95%, that it reduced the incidence of occupant fatalities in the population of all accidents by 10% over the old restraint system.[*] Assuming the old system had a (perfectly known) fatality rate (when used) of 0.06%. We are seeking to verify that the new restraint system gives a fatality rate of 0.054% or less. The use rate on the new restraint system is expected to be 50%. An upper bound on the number of accident reports required to determine the fatality incidence to the desired accuracy is found to be 768,000. If this were to be accomplished in the first year Of the new installation, reports would be needed on about 30% of all accident involvements of new U.S. automobiles. Clearly, reports on fatal accidents alone would not be useful, as fatality incidence could not be determined.

The foregoing calculation makes use of an expression for the number of samples n required to determine with accuracy σ a proportion p in the population from which the sample is drawn, namely:

$$n = \frac{p \quad (1-p)}{\sigma}$$

Clearly, if the same question were restricted to side impact accidents a sample of 768,000 side impact accidents would be needed, but since side impacts constitute 1/6 of all accidents and were drawn from a sample of all accidents, that sample would have to number 4.6 million.

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[*] A practical example of the kind of question NHTSA and safety researchers seek answers to.

One can now see, from the examples given, the extent to which numbers of reports required depend on the questions asked. Efficient sampling to minimize the number of samples requires a basic set of questions to provide baseline statistics with supplementary surveys to obtain the answers to specific questions.

Based on the previous examples of questions that might be asked of an accident file, we believe that 500,000 to 1,000,000 cases per year, collected in accordance with a carefully designed sampling plan, is needed by NHTSA and others.

We determine now the number of crash recorders that would be needed to determine accident severity distributions if recorders were the chosen technique to measure accident severity. The number of recorders required depends on the probability occurrence of the type of collision. About 7.5% of all cars are involved in reportable accidents, 2.5% in injury accidents, and 0.04% in occupant-death accidents each year.

Table 2 indicates the number of recorders required to get the needed data each year to construct severity distribution function curves to 5% accuracy (5% corresponds to approximately 2 mph in estimate of barrier equivalent impact speed) . The figures in the column headings are the probabilities that a recorder equipped car will be involved in an accident of the type indicated; 100% recovery of recorder data is assumed. 30% of involvements are considered to be of “reportable” severity: that is, that the damage to the vehicle is of sufficient extent, or that there is an injury, either of which would require reporting the accident to police.

Table 2

Number of Recorders Required to Secure in One Year Data Needed to Construct Severity Distribution Functions to 5% Accuracy

Confidence Level	Accidents Above a "Reportable" Severity Level P = 0.075	Injury Accidents of All Types P = 0.025	Fatal-to-Occupant Accidents of All Types P = 0.0004
80%	6107	18,320	1,145,000
90%	7933	23,800	1,487,500
95%	9867	29,600	1,850,000

If it were further required to construct these distribution functions for smaller classes of accidents (frontal, side, rear, rollover) the number of recorders required, for 90% confidence and an accuracy of 5%, would be as shown in Table 3. (Based on accident type probabilities given in references 3 and 6.)

Table 3

Number of Recorders Required to Secure in One Year Data Needed to Construct Severity Distribution Functions With 90% Confidence of 5% Accuracy

	Accidents Above a "Reportable" Severity Level	Injury Accidents	Fatal Accidents
Frontal	16,190	64,324	2,917,000
Side	46,665	58,048	5,313,000
Rear	27,355	170,000	29,750,000
Rollover	198,000	297,500	9,297,000

As the cell size becomes smaller -- that is, as the data is subdivided into more and more classes of interest -- the number of reports needed in each cell for the construction of the particular distribution function of severity remains the same; but the number of recorders required to assure that required number of reports in each cell increases rapidly. Clearly, either a very large number of recorders would need to be installed in the U.S. automobile fleet, perhaps one in each car, or alternate methods of obtaining a measure of severity, such as measuring structural deformation of the automobile, should be used.

If a very cheap (say, $2) crash recorder does not become available, then it is clear that crash recorders become impractical because of costs as a means of measuring severity for mass accident data files, which are needed to evaluate events of low probability yet events of great importance.

b. THE NEED FOR DEFINITION, MEASUREMENT AND REPORTING OF CAUSAL CRASH SEVERITY

Throughout earlier sections of this report, reference has been made to accident severity. It is important to note that what is meant is _intrinsic_ or _causal_ severity, as opposed to the severity of the outcome of crash, such as the degree of injury or damage. As indicated earlier, selection of a sample based on outcome inherently biases the sample and masks the effects of design changes. What is needed, instead, is a bank of data that will permit determining, for a given causal severity or range of causal severities, the outcome as a function of other factors -- car weight, occupant age, passenger compartment design, etc.

For example, in establishing bumper standards, it would be useful to know, first, the probability distribution for causal crash severity and second, the relationship between costs to repair car damage and the severity of the collision in the absence of damage limiting bumpers. From this information could then be predicted the gross benefits of new bumpers that prevented damage in accidents up to a specified severity level.

In determining the efficacy of an existing motor vehicle safety standard for occupant protection, it is important to be able to establish how the probability of injury (or degree of injury) is affected by meeting the standard. This implies a need to develop a file of crash reports whose inclusion is based on causal severity level (as opposed to outcome) , so that the incidence of injuries can be compared for cars that meet the standard and those that do not. Stratification of the data by causal severity levels would make it possible to draw inferences about benefit of the standard as a function of severity. Without the severity measure, the levels of exposure of uninjured occupants cannot be determined, and the basis for finding and comparing injury incidence is lacking.

It has been pointed out in an earlier section that there are doubts about the validity of the NHTSA curves of the cumulative distribution functions of barrier equivalent impact speed (BEV or EBS) for injury accidents and fatality accidents. Validating these curves from real-life accident data would require measurement and reporting of the causal severity of fatal and injury accidents.

The measurement and reporting of causal severity in crashes provides a relatively unbiased method of screening crashes for investigation and introduction into a file. Once the severity distribution function for all crashes is established with sufficient accuracy, reports can be identified by severity level, and only the number of reports needed in each stratum can be selected for admission to the file. Knowledge of the severity distribution functions both for the population and for the file permits analysis of the constrained file and extending inferences to the universe of crashes. At the same time, the size of the file can be reduced by preventing the entry of ‘the voluminous reports of low severity crashes whose frequency is high.

B. J. Campbell[10] feels that a crucial need in the field of crash injury is the means to forge a meaningful link between laboratory test crash data and events as they occur in the field:

> “In the staged crashes in the laboratory, telemetric procedures are used for recording data and one can justify in considerable detail the physical system in which the crash occurs -- the ‘g’-forces, the rate of onset, delta ‘v’ etc. But when one is forced to use nonhuman subjects then one is left in the situation of knowing a great deal about the physics of the crash but knowing little of the actual injuries that might have occured in such a crash. On the other hand, in real world automobile crashes one can learn about the actual outcomes in terms of survival and injuries, but the input variables mentioned before are unknown.
>
> “The need to link these two systems is apparent. Engineers who design protective systems need to know about stopping distances, forces, decelerations, etc. But knowing these things is of too little help unless one has a way to relate them to real world injuries.”

Clearly, a measure of real-world crash severity would help provide such a link.

The question remains as to what constitutes a proper causal severity measure, or “Vehicle Crash Severity Index (VCSI)"[19,22] This question is independent, of course, of what parameters are being or can be measured, such as vehicle deformation, acceleration time history, speed at impact, etc.

The severity measure that has been used in tests, some crash reports from the field, and in motor vehicle safety standards is Barrier Equivalent Impact Velocity (BEV or EBS). It is of interest to examine whether this is a reasonable measure of causal severity, both as regards occupant injury and vehicle damage.

What injures unrestrained and loosely restrained occupants is the so-called “second collision” of the occupant with the interior of the automobile, such as the windshield, dashboard, B-pillar, etc., or with the restraining belts or air bag. The speed with which an occupant impacts an interior element has fair correlation with the injuries he suffers. The speed of impact is determined by the average car acceleration component in the direction from the object to the occupant and the distance between the two:

$$V = \sqrt{2ad}$$

The commonly used head injury criterion is:

$$HIC = \left[\frac{\Delta v}{\Delta t}\right]^{2.5} \frac{\Delta t}{g^{2.5}}$$

Where Δt is the time duration and ΔV is the head speed change during the hardest bump. If the final head speed is zero and there is only one bump, this becomes

$$H\ I\ C = V^{2.5} / (\Delta t)^{1.5} g^{2.5}$$

or, in terms of car average acceleration during the crash, is:

$$H\ I\ C = 2.38\ a^{1.25}\ d^{1.25} / (\Delta t)^{1.5}\ g^{2.5}$$

Thus, we observe that the criterion for head injury severity increases with car acceleration during the crash interval, but at a slightly greater rate.

If the occupant is tightly restrained, he is subjected to the same acceleration as the occupant compartment of the automobile. The forces he experiences are in proportion to this acceleration and the weight of his own body. It has been determined by investigators[23/] that human tolerance limits can be best expressed in terms of the acceleration to which a person is subjected during the crash interval. It is important to note that rapid variations of acceleration with time are not felt by the unrestrained occupant in crashes in which his motion has a forward component relative to the car, as he is in “free flight” until he impacts the interior. The fully restrained occupant feels these changes (called “jerk”) but there is no evidence to indicate that they inflict more than minor punishment; the damage to the restrained occupant appears to result from the average level of acceleration he is subjected to during the crash.

Thus we observe that the two most important measures of injury tolerance can be related directly to vehicle acceleration during the crash. The next question is whether and how barrier impact velocity is related to this acceleration.

Running a car into a barrier causes deformation of the car ("crush"). It has been found in the laboratory that there is a linear relationship observed between impact speed and residual crush. The average acceleration during the crash[3] is:

$$a = -\frac{V_o k}{2}$$

where V_o is the barrier impact speed and k is a measure of the "stiffness" of the car. Thus we observe that the car acceleration is directly proportional to the barrier impact speed, but also t. the stiffness, which is higher in small cars than it is in full size vehicles.

We conclude, therefore, that barrier impact speed is a reasonable indicator of injury-related causal severity provided that car stiffness is taken into account.

K. L. Campbell[20] has evolved a sophisticated approach to relating vehicle damage to collision severity. In this approach the dynamic force-deflection characteristics are used to estimate the energy absorbed in plastic deformation of the vehicle. A linear force-deflection characteristic is the simplest (but not necessarily the most accurate) model leading to the observed linear relationship between impact speed and crush distance, and is used by Campbell. The energy can then be expressed as an equivalent barrier speed (EBS or BEV). The approach has been partly validated for frontal impacts in angle and offset barrier tests: The BEV estimates based on vehicle damage differed from the true impact speeds in the angle barrier case, over impact speeds ranging from 18 to 31 mph, by an average of -0.35 mph, with a standard deviation of 2.85 mph; and in the offset barrier case, over a narrow range of impact speeds around 30 mph, by an average of -0.01 mph, with a standard deviation of 1.64 mph. The input information items required to make the estimate were the crush coefficients as determined from pure frontal barrier tests for each of the various automobiles, together with the actual detailed crush measurements in the test impacts. K. L. Campbell believes that the technique can be extended to side and rear impacts; such an extension would, of course, require determination of side and rear crush coefficients. The crush coefficients, as defined by K. L. Campbell, are the slope and intercept of the curve of impact speed as a function of crush distance. The slope is identical to the reciprocal of the “stiffness” constant we used in the previous paragraphs.

A. B. Volvo employed a series of eleven full-scale frontal barrier, car-to-car and car-to-pole impact tests[24] to obtain data on crush characteristics of the Volvo model 140 automobile. This information was used in conjunction with detailed measurements of deformation incurred in real-life impacts to estimate barrier equivalent speeds for 128 collisions.

In uncomplicated collisions, we believe that similarity between real-life collision-caused vehicle deformation and that produced in a laboratory staged crash having the same point and direction of impact, implies correspondence between the forces and rates of application. Thus measurements of vehicle deformation can be analyzed, compared with the outcome of staged crashes, and used to estimate barrier equivalent impact speed. However, it is not possible to say that equivalence of deformation always implies equivalent dynamic forces.

Average acceleration during the crash interval appears to be a reasonable measure of causal crash severity. There are several methods by which it can be measured:

(1) By a crash recorder that records acceleration time history (later to be time-averaged over the crash interval to get a severity measure) absent a cheap crash recoder, that directly averages accelerations over the crash interval. The limitation of this approach relates to the large number of recorders required for mass accident files designed to illuminate rare events and the substantial expense associated therefore with this technique. For special measurements such as severity distribution functions, the number of recorders required becomes much smaller, and then this technique of severity measurement becomes appropriate.

(2) By measurement of vehicle deformation (the vehicle is its own crash recorder) and conversion to barrier equivalent speed or average acceleration. The limitation of this approach relates to the limited availability of calibrated deformation information derived from laboratory crashes. Another limitation for mass accident files is the limited ability of police, at the scene of an accident, to judge deformation either using the calibrated crash deformation information, or some other technique, in a consistent reliable manner.

(3) By computer reconstruction of the collision[15/] (SMAC) in an iterative simulation process that is driven to match the reconstructed accident to real-life observations of skid marks, vehicle positions, etc. Momentum changes, in conjunction with known vehicle stiffness characteristics, can be used to estimate crash accelerations. The limitation of this technique is that it requires trained investigators who can estimate the initial conditions of the crash so as to initiate the computer simulation. If the simulation does not converge to the actual disposition of vehicles after the crash, the estimated initial conditions must be revised.

It must be recognized that the crash severity index is a vector, and has magnitude and direction. Two linear accelerometers are necessary to measure its components in the horizontal plane. A third (vertical) component is measured with experimental crash recorders, but does not appear to be very useful.

A problem arises in using vehicle deformation to measure damage-related crash severity; obviously, the cause and the outcome are related. If the outcome is defined as physical deformation, the relationship is one to one. If the outcome is defined as cost to repair, the cause and the outcome are not identical. There is also a flaw in the use of acceleration during the crash interval as a measure of causal severity: if vehicle exteriors were softened, so that average collision accelerations were lowered, average severity would decrease even if the average impact speeds remained the same. So the injury mitigating effects of vehicle softening would be obscured in the collected data. Similarly, where vehicle crush is used to determine severity, if vehicles are designed using resilient materials that do not permanently deform, the average severity would decline despite unchanged average impact speed.

Thus we believe it is important that the National Highway Traffic Safety Administration undertake the job of defining causal crash severity in the most useful and realistic way.

There are several measures of severity currently in use that are quite crude and inaccurate and should be supplanted by better methods.

The deformation extent, a quantity somewhat related to severity, is often reported in Level II (greater depth than the police report) and Level III (in-depth) investigations. The deformation extent is one element of the collision deformation classification (CDC) code assigned in accordance with the Society of Automotive Engineers recommended practice SAE J224a. However, SAE recommended practice J224a warns "The extent number should not be used as a tool for determining severity or energy required to duplicate the damage. For vehicles of the same basic type, it does serve as a tool for gathering together vehicles which have similar damage characteristics. "

Some reports give the full CDC (sometimes known as "VDI") code,* which describes the direction of force, general area of deformation, specific horizontal area, specific vertical area, type of damage distribution, and extent. The Fatal Accident Reporting System reports only impact points and an abbreviated damage extent number.

Police reports often include estimates of traveling speed prior to impact, a very poor indication of severity because of the uncertainty of the effects of braking just prior to impact. Sometimes "impact speed" is estimated and reported; again this is a very dubious measure of severity because it is neither uniformly defined nor readily estimated. It may be, depending on the investigator, either speed relative to the ground at the instant of impact of speed relative to the struck or striking object. Ford Motor Company[21/], in an analysis of the differences between investigators' reports of impact speed and the speed

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* See, for example, reports on crash recorder equipped cars, reference 19.

changes indicated by crash recorders, found differences as great as 40 mph and a standard deviation of 11.9 mph in 20 collisions involving crash recorder equipped cars. The average was a speed overestimate of 14.7 mph by the investigators.

MDAI teams and other in-depth investigators may report their judgment estimates of equivalent barrier speed (EBS) based on their background of understanding of the relationship between EBS and vehicle deformation in laboratory crashes.

To summarize,

(1) Average acceleration during the crash interval is a reasonable measure of the intensity component of a causal crash severity index, but has some deficiencies as such.

(2) NHTSA should, with the approval of the accident research and statistical community, settle on and begin to use an acceptable definition of crash severity index.

(3) If average acceleration during the crash interval is the appropriate measure, there are several ways of measuring or estimating it with reasonable accuracy.

(4) Several indices of severity currently in use are so erroneous, misleading, or ill-defined, as to be valueless, and should be either upgraded or discarded.

C. THE CRITICAL IMPORTANCE OF AN UNBIASED, RELEVANT, AND ADEQUATE SAMPLING PLAN THAT IS APPROVED BY EXPERTS

In order to meet requirements for collision data collection, it is necessary to generate a plan for sampling and to implement it. The plan should call for collection of a representative sample of crash data in quantity sufficient to be useful at a rate sufficient that the data is timely, and in enough detail and with enough accuracy to permit answering outstanding essential questions.

Thus there are three separable issues:

(1) The methods of assuring that the sample is representative.

(2) The quantities and rates of data gathering.

(3) The information content, detail, and accuracy of reporting.

The problem of securing a representative sample is a difficult and subtle one. To quote Versace (Ford Motor Company)[16/] on the need for scientific sampling:

> "Not only is an increased quantity of data required but the sampling of the accident universe must be by sophisticated protocol. The last of the three reasons given above implies the need for a disciplined approach to the data, to avoid ending up with data which are biased in the factors underlying them. That requires a scientific approach to data collection, not just pouring more dollars into it and

> cranking up the administrative machine to get a bigger program going but doing it in the same old way, Data gathering programs must be designed by the same people as will design the analyses that will be applied to the data. No less expertise than the Census Bureau applies, or the Gallup Poll, will suffice. Fortunately,NHTSA has been bringing in very competent people of late, people who know that a data collection scheme must be designed from the start with the method of analysis of the resulting data a key determiner of how the data should be gathered."

The importance of representativeness of the sample is hard to overstate.[8/], [9.] The sample should be representative of the entire population of automobile collisions or have an accurately known relationship to that population. If the sample is selected in some way -- that is to say, if the sample is biased -- inferences drawn from the sample may be faulty. For example, consider a sample in which only injury accidents are represented. If, say, wearing' belts reduces the risk of injury 50%, belted occupants will be underrepresented by 50% in the sample. Two incorrect inferences might be drawn by a naive observer: 1) occupants in accidents don't wear their belts; 2) most of the belted occupants in the sample were injured; obviously belts are not very effective.

Despite the importance of avoiding sample bias, much of the material in the existing national files is heavily biased and, until recently, little thought was given to rectifying this deficiency. NHTSA has contracted with the Highway Safety Research Institute of the University of Michigan to evolve a national crash data sampling plan which, presumably, will be based on sound statistical principles.

The questions to be asked of the data file determine the sampling plan: that is, the selection of regions to be sampled and, within those regions, the collisions on which information is to be collected; the quantity and rate of acquisition of case reports; and the information -- kind and reporting precision -- required in each report.

Examples of such questions are:

(1) How effective have the requirements of MVSS 206 (which specifies crash load requirements on locks, latches, and hinge systems) been in preventing occupant ejections? In preventing occupant injury? Are there significant differences in capability between makes and models of automobiles?

(2) How effective are belt restraint systems (specified by MVSS 208) in preventing injury and death? How does the effectiveness vary with accident severity? Car weight? Occupant age?

(3) At what collision severity level should the bumper system prevent damage to the automobile? Should the requirements be different for front and rear bumpers? For different car sizes and weights?

(4) How important is car visibility in preventing collisions? Are the requirements of MVSS 108 (for lighting) effective in satisfying the needs for nighttime visibility?

(5) What are the factors in passenger compartment design that are of significance in contributing to or preventing occupant injury? To what extent do the characteristics of the occupant himself influence the injury picture? What are the interactions of these factors?

As an example, the last question suggests a number of items of information required for inclusion in reported crash data. According to Lawrence Patrick of Wayne State University[10/], "complete injury data must be included in the accident data. Sex, age, weight, height, and general physical condition are all important factors . . . The type and degree of injury of each occupant including the minor bruises and abrasions and going through the severe bone and soft tissue damage are required. It is important to have complete data on the restraint systems used and the interior components of the vehicle that caused the injury." Also needed, according to Professor Patrick, are impact velocity (as a measure of severity) and direction, location of the impact, seating positions of the occupants, vehicle rigidity, and vehicle interior design.

The design of the sampling plan is critical to the utility of the bank of data that will be acquired through the sampling process. If the reported information is inadequate, crucial questions that one wishes to ask of the file will be unanswerable. If the sample fails to represent the U.S. crash universe, or contains biases, the answers to questions may be quite wrong. And if the quantities of cases on which answers are based are inadequate, the confidence one can assign to the answers is low.

Thus we believe that the National Highway Traffic Safety Administration should proceed urgently with the development of a sampling plan (hopefully, the contract with HSRI will provide the necessary result; if not, it should be augmented).

When completed, but before the plan is implemented, it should be submitted to, reviewed by and approved by a jury of nationally known experts representing the disciplines of accident and injury research, motor vehicle design, rulemaking, and statistical sampling and analysis.