4. ALTERNATIVES FOR AN ADEQUATE DATA ACQUISITION PROGRAM

The elements of an adequate data acquisition program have been previously described as comprising a mass data acquisition system with acceptable crash severity capability, a precision crash dynamics measurement system and special investigatory procedures such as multidisciplinary accident investigating teams (MDAI) and fatal accident reports (FAR).

Section 3 has described the quantitative requirements for mass accident data collection. It has been indicated that approximately 500,000 to 1,000,000 accident reports per year are needed to obtain early warning of motor vehicle hazards and to obtain confirmation of the effectiveness of various safety programs in a timely way to a reasonable level of significance. The exact number of annual accident reports needed depends on the level of detail of the desired results, the frequency of the event being investigated, the desired accuracy and confidence level of the information being obtained and the time by which the information is desired.

For example, if one wishes to determine the fatality rate in rollovers of belted drivers in one year to an accuracy so that the standard deviation is 30% of the mean, 130,000 accident reports would be needed. However, if one wished to determine the probability distribution function of car weight in cases where belted drivers are killed in rollovers to an accuracy of 5% with a confidence of 95%, 3,500,000 accident reports would be needed.

The kind of data needed for this mass acquisition system is generally agreed to be a causal severity index, vehicle identification number, road and visibility data, injury scale, restraint system and usage, driver and occupant descriptions and seating positions, with many other items required, perhaps on a special survey basis, to answer specific questions.

There are a number of ways to obtain a causal severity index. If a cheap ($2) two axis crash recorder can be developed --and there are some concepts worthy of exploration--their installation on production cars is justified. This possibility is more fully discussed later in this section.

In the absence of a cheap crash recorder, vehicle deformation should be used as a causal severity index. There are at least two major approaches, one following the lead of Professor B.J. Campbell at the University of North Carolina, and the other following the approach of Professor Lawrence Patrick at Wayne State University, the Biomechanics Research Center and practiced in a recent Volvo-Wayne State University study.[24/]

The State of North Carolina uses police reports of severity reported by the TAD system.* Police training has evidently been sufficiently good to obtain useful reports[7/] although the data base has been small and the severity reporting system quite simple. The disadvantage of this approach is summarized by Griffin:[7/]

----

* A police officer using the TAD system rates severity on a 1 to 7 scale by matching the damaged vehicle with a manual of photographs of typical accidents.

"Rural accidents tend to be more severe than urban accidents, therefore, police level data for a given state must be generalized with caution, even within that state.

"It is not simple to generalize police level data from one state to other states. States differ with respect to traffic density, number of interstate highways, and weather conditions. All of these factors interact with accident types and configurations, and thereby affect the benefits to be derived from a safety device.

"Finally, police level data are not recorded in detail. Levels of vehicle damage and occupant injury are evaluated by an officer who may be trying simultaneously to summon medical aid, direct traffic, and determine whether or not a law has been broken. Under these circumstances, the data yielded by these investigators is very good, but necessarily the collection of data should not be considered the officer's area of expertise or his major area of responsibility."

Professor Campbell 10/ feels the cost of improved police reporting could be nominal and that it would be important to extend the North Carolina system, or some improvement of it, to a number of states that might together provide 600,000 - 1,000,000 reports which would be less biased than those from rural North Carolina alone.

It is difficult to accurately determine the cost of this system, but $3-10 per report is approximately correct, or a total of $10 million for one million reports. However, there is some question of the adequacy of police data for many needs.

professor Patrick's approach to the recent Volvo experiment[24/] might be utilized to improve the reporting of causal severity by police. Staged crashes of major U.S. models, front, side and rear into poles, barriers and cars at three speeds could be used to obtain calibrated deformation data. The one-time cost of such a program is estimated* to be $3-5 million. There are a number of possible ways to use these data. Police could be trained to photograph** the damaged vehicle from a few aspects after having placed appropriate identification placards and scales on the damaged vehicle. The film could be subsequently processed at various centers to derive the severity data by analysis Of the photographs and by comparison with the calibrated deformation data. The total accident report including police and medical data, if any, could be assembled at the photographic analysis center.

Alternatively, it might be possible to train police equipped with appropriate templates to measure the collision deformation in conformance with a handbook based on the calibrated deformation data from the staged crashes. Appropriate supplies, compensation and incentive would have to be provided to local police. A cost of $10-20 per accident report might be sustained by more detailed analysis of this reporting system. Therefore this type of mass accident data system might cost a total of $25-30 million for the first year including non-recurring capital as well as operating costs.

----

* Conversations with Professor Patrick.

** Mr. John Garrett of Calspan reports some success in Western N. Y. comparing estimates of severity from police photographs with estimates of professional accident investigation teams.

In Section 2 there was also described the need for some precision reference data. This need was stressed by almost every participant in the Workshop.[1/, 10, 11, 13, 14/]. In particular sume 10,000 sophisticated recorders with an accuracy of 1-2 mph*, are needed to obtain in one year's time a representation of the probability distribution of severity of accidents (above the police reporting threshold) with severity (barrier impact speed), to an accuracy of 5% and at a confidence level of 95%. If this representation of the distribution of severity were limited to frontals only, the confidence level would be only 80% with an accuracy of 5%. Alternatively, 20,000 recorders could be used to obtain this distribution for frontal collisions to an accuracy of 5% at a confidence level of 95%. The cost of sophisticated crash recorders in these quantities is approximately $200. Therefore the total cost of this basic program is between $2 and $4 million plus the cost of data retrieval and analysis.

The cost per accident report from the sophisticated crash recorder** would be approximately $2,000 the first year, declining to $1,000 over the first two years, $500 over the first four years, $200 over the first ten years. This is the normal characteristic of the flow of benefits over a period of time from an initial capital expense.

----

* This corresponds to a 3.8 - 7.6% change in the cumulative distribution of fatalities or an annual dollar cost equivalence of approximately $250-500 million in estimating the effectiveness of occupant restraint systems.

** Described later in this section.

The SMAC system of computer-aided accident reconstruction could also be used to obtain precision reference data, and is competitive with the sophisticated crash recorder. It is our opinion that the SMAC system, while extremely clever and promising, has not completed its development cycle, and must be operated by full time professionals. These might be specially trained police. However, some means would have to be found to compensate state and city police for performing NHTSA work. If a SMAC van is to operate around the clock, a crew of eight per vehicle would be required. If as many as 100,000 accidents were to be investigated per year with 500 vans, a total crew of approximately 4000 men would be required at an annual cost of $60 million. Thus, the manpower cost seems to limit the SMAC system to obtaining relatively small numbers of reports, say 10,000 per year or lower. The SMAC system like the sophisticated crash recorder, seems most useful for special data gathering programs requiring precision severity data. If 2500–5000 accidents are to be investigated per year, perhaps 15–20 vans would be required at a total manpower cost of $1.8 - 2.4 million plus the cost of equipped vans and processing centers, or roughly $500 per case.

These costs should be compared to the current costs of MDAI investigations at $2000 per case on scene and $800 per case off scene , FAR reports at $15 per case, Level II reports at $100 per report.

Some safety devices, particularly those with uncertain performance and high cost to the consumer, could be subjected to a field test prior to general introduction. Some Federal agencies, The Food and Drug Administration, for example, do require extensive tests of products before general use. These tests, if properly designed and monitored, could yield invaluable data on the benefits from such devices.

However, a safety feature like the 5mph bumper or passive restraints can probably not be sold on a trial basis depending on market forces alone. Therefore, Federal sponsorship would be necessary to design the field trial, pay the cost of installation and monitor the results. This process would be expensive but, when viewed against huge consumer costs, may be worthwhile.

Such a test has been suggested for passive restraint systems by the National Motor Vehicle Safety Advisory Council, a body advisory to the Secretary of Transportation, by a Resolution adopted by an 11 - 5 vote on November 19, 1974.*

It is the feeling of a number of both the academic and automotive participants in the Workshop, and the authors of this report, that a field trial of 100,000 - 200,000 passive restraint systems is necessary.

The size of the field trial of passive restraints arises from the following considerations. If one assumes that the passive restraint is effective in reducing fatalities by 50%, then it would require three years of field trial of 200,000 equipped cars to determine the probability density of severity given a fatality to an accuracy of 10% with 80% confidence. On the other hand, if one wished to determine whether the fatality rate in all passive restraint equipped cars had decreased by 50% to an accuracy of 20%, 125,000 installations would be required to obtain an answer in one year. If on the other hand, one wished to determine the performance to the same accuracy in light cars as compared to heavy cars, one would have to wait two years, assuming the 125,000 car sample was split equally between heavy and light cars.

----

* See Appendix L.

For this field trial to be unbiased, these systems would have to be installed in small and large vehicles in representative parts of the country with a representative set of drivers. Since market forces cannot be depended upon to provide this, it is probably in order for the Federal mandator of the proposed regulation to support the trial. The cost of such a program could be $30 - $60 million.

In summary, an extensive mass accident data system of one million reports annually may cost

(1) $3-10 million annually using the North Carolina approach of upgrading police reporting, plus the cost of improvements in severity estimation;

(2) $10-20 million annually using the Wayne State - Volvo approach to obtaining accident severity, PIUS the costs of reporting factors other than severity, plus a one-time cost of $5 million for calibrated vehicle crash data and other capital expenditures:

(3) $10 million annually to obtain severity information alone if a cheap ($2) crash recorder could be developed and installed on 50% of all new production. One would have to add. to this cost the cost of collecting the records, analyzing the data and coalescing this information with other accident information in a mass data file.

These several approaches are potentially mutually supportive rather than competitive. There is presently no such thing as a cheap recorder, so one cannot depend on it for severity data. Should one be developed, it would be extremely useful for mass accident data. A serious effort toward this objective should be undertaken. If the Wayne State - Volvo approach to obtaining accident severity could be developed to apply to the U. S. problem, then it might be used in conjunction with the North Carolina approach as a better method of estimating severity.

A needed tool for precision research on the crash dynamics of a few thousand accidents annually may be obtained by either SMAC simulation or precision crash recorders.

(1) $2-4 million first cost for 10,000 to 20,000 sophisticated crash recorders plus the cost of the facilities and personnel needed to analyze and correlate the data produced as an annual expense.

(2) $2-2.5 million annually for personnel on vans plus the vans themselves and analytical equipment.

It would seem possible to put emphasis on one or another of these programs. In doing this NHTSA should take into account the somewhat higher first costs of the crash recorder program as compared to the somewhat higher annual operating costs of the SMAC program. Obviously this cost analysis must be viewed against the differences in the kind of data obtained from the two approaches. The SMAC vans do get trained investigators to the scene. NHTSA can best evaluate if this capability is justified in view of the multidisciplinary accident investigating teams. Since MDAI teams report on 1500-2000 cases per year from a perspective that is broader than crash dynamics, it seems advisable to maintain this capability.

The field trial of 100,000 - 200,000 passive restraint equipped cars in a representative sample would cost 30 - 60 million dollars first cost plus annual analysis expense.

Thus in addition to the current accident program of approximately $5 million covering such activities as MDAI, FAR, Level II reports, NHTSA and the Congress should consider adding a mass accident data system that might cost $5 - 20 million annually, a precision crash dynamics system (probably sophisticated crash recorders) at a first cost of $2 - 4 million, and finally a field evaluation of passive restraints costing $30 - 60 million. Table 4 summarizes the existing programs and the recommended alternatives for the additional data that we deem to be required.

The genesis of this OTA study was an issue concerning sophisticated crash recorders and their proper use in accident data retrieval.

TWO types of crash recorders have been developed under NHTSA sponsorship.

one of these, commonly known as the “tape recorder,” was developed by AVCO Systems Division, Wilmington, Massachusetts. It is designed to measure and record vehicle parameters before, during and after a crash. The time history of the following quantities is recorded prior to the crash:

TABLE 4

EXISTING AND PROPOSED PROGRAMS

DATA NEEDS / ALTERNATIVES AND COSTS	MASS ACCIDENT FILE (500,000-1,000,000 REPORTS ANNUALLY)	PRECISION CRASH DYNAMICS (2,500-5,000 REPORTS ANNUALLY)	SPECIAL STUDIES
Medical and Police Reports Using TAD	$3-$10 Per Report, North Carolina Prototype		
Medical and Police Reports Using VDI or CDC	Upgraded Severity Capability as Compared to system Above		
Medical and Police Reports Taking Photos to be Compared to Calibrated Crashes	$10-$20 Per Report Wayne State - Volvo Prototype, Probably the Best Severity been Demonstrated for this file		
Medical and Police Report Using Cheap Crash Recorders if Available	$10 Per Report for Severity Plus $3-$10Per Report for all other information		
Computer Simulation (SMAC) (15-20 Vans)		$2 - $2.5 Million Annual Personnel Charge Plus $1.5-$2 Million First cost	

Table 4 - continued

DATA NEEDS / ALTERNATIVES AND COSTS	MASS ACCIDENT FILE	PRECISION CRASH DYNAMICS	SPECIAL STUDIES
Sophisticated Crash Records (10,000-20,000)		$2- $4 Million First costs Plus Annual Analysis & Maintenance costs of $0.5 - $1 Million	
Multidisciplinary Accident Investigation reams (MDAI)			1500 Reports/year At $2000 Per Report on Scene, $800 Per Report Off Scene
Fatal Accident Reporting System			55,000 Death Reports Per Year Contemplated At a Cost of $1 Million, Uncertain Severity Indica-tions
Level II Restraint System Investigation			Analysis of Restraint System Effectiveness From Police and Medical Reports, $100 Per Case
Field Trial of Uncertain and/or Expensive Safety Aids			100,000 - 200,000 Car Field Trial of Passive Restraints $30-$60 Million One Time Cost

Brake pressure (200-2000 psi, accuracy ± 7%

Steering wheel motion (1260°, accuracy ± 3%)

Speed (as derived from the speedometer cable)
(0 - 120 mph, speedometer accuracy)

Longitudinal and lateral vehicle acceleration
± 1 g, accuracy ± 5%

During the crash is recorded the time history of:

Longitudinal acceleration (± 50 g, accuracy ± 3%)

Lateral acceleration (± 50 g, accuracy ± 3%)

Vertical acceleration (in vehicle coordinates)
(± 50 g, accuracy ± 3%)

Prior to the crash, the recorded data are sampled at a 20 per second rate. During the crash, the recorded data are sampled at a 200 per second rate. The duration of the tape record is from 6 minutes prior to the crash to 10 seconds after the crash. A garden variety endless-loop 8-track cartridge is used as the storage element.

Recording is done in digital (PCM) format. The total system includes each of the several sensors, a crush sensor and a recorder, packaged separately.

The other recorder, commonly known as the "disk recorder," was developed by Teledyne Geotek, Garland, Texas. It is a single unit that records, only during the crash interval, the time history of lateral, longitudinal accelerations. The range of accelerations measured is ± 50 g, with an accuracy of ± 8%.

The disk recorder is much simpler and less expensive than the tape recorder, and has been purchased and installed in experimental quantities by NHTSA. 1050 have been installed in fleets throughout the country, including air bag equipped cars.

The tape recorder is intended to provide data that could give useful information on the handling, braking, speed and forces experienced by the vehicle prior to the crash. Both recorders provide a crash-acceleration time history, which yields information on the forces to which the vehicle was subjected during the crash, and which, if properly interpreted, can give magnitude and direction of crash severity.

In Fiscal Year 1975 testimony, a total cost estimate of $10 million for a crash recorder program was presented. This program would have procured 100,000 disk recorders as compared to the previous 85,000 disk recorders (at $75 per unit) and 15,000 of the more expensive tape recorders for a total cost of $15 million. The program costs include support for initial purchase and funds allocated for analysis of the data provided by the recorders.

The Transportation Systems Center of the Department of Transportation (Mr. Louis Roberts) has examined the feasibility of a somewhat cheaper, all solid state, more accurate alternative to the Teledyne Geotek disk recorder, and have concluded that such a unit could be built at a unit cost of $125 in quantities of 100,000. With this recorder, three-axis accelerations would be measured to 1%.

C. Y. Warner and Joseph Free of Brigham Young University, and Brian Wilcox and Donald Friedman of Minicars, Inc.* have proposed as a severity measuring device a very simple two-axis integrating accelerometer whose outputs are change in velocity during the crash interval. The Breed Corporation is also developing two cheap crash recorders. One will provide information indicating that the crash resulted in a velocity change of more than 30 mph. This is accomplished by a latching system. The other system provides a direct reading of crash severity. A combination of Coulomb and viscous forces acting on a mass provide a system that is insensitive below a threshold, responds to the vehicle change in velocity during the crash, and latches after the crash indicating the change in velocity experienced.

We believe that development of a cheap and simple severity measuring and recording device is highly desirable. There appear to be many feasible design alternatives to the Warner device, and they should be examined. A recorder that is designed to measure average acceleration during the crash interval, as opposed to velocity change alone, should be considered. Lynn Bradford, NHTSA crash recorder program manager, concurs that only the two horizontal components of acceleration need be sensed, and that the third axis can be omitted.