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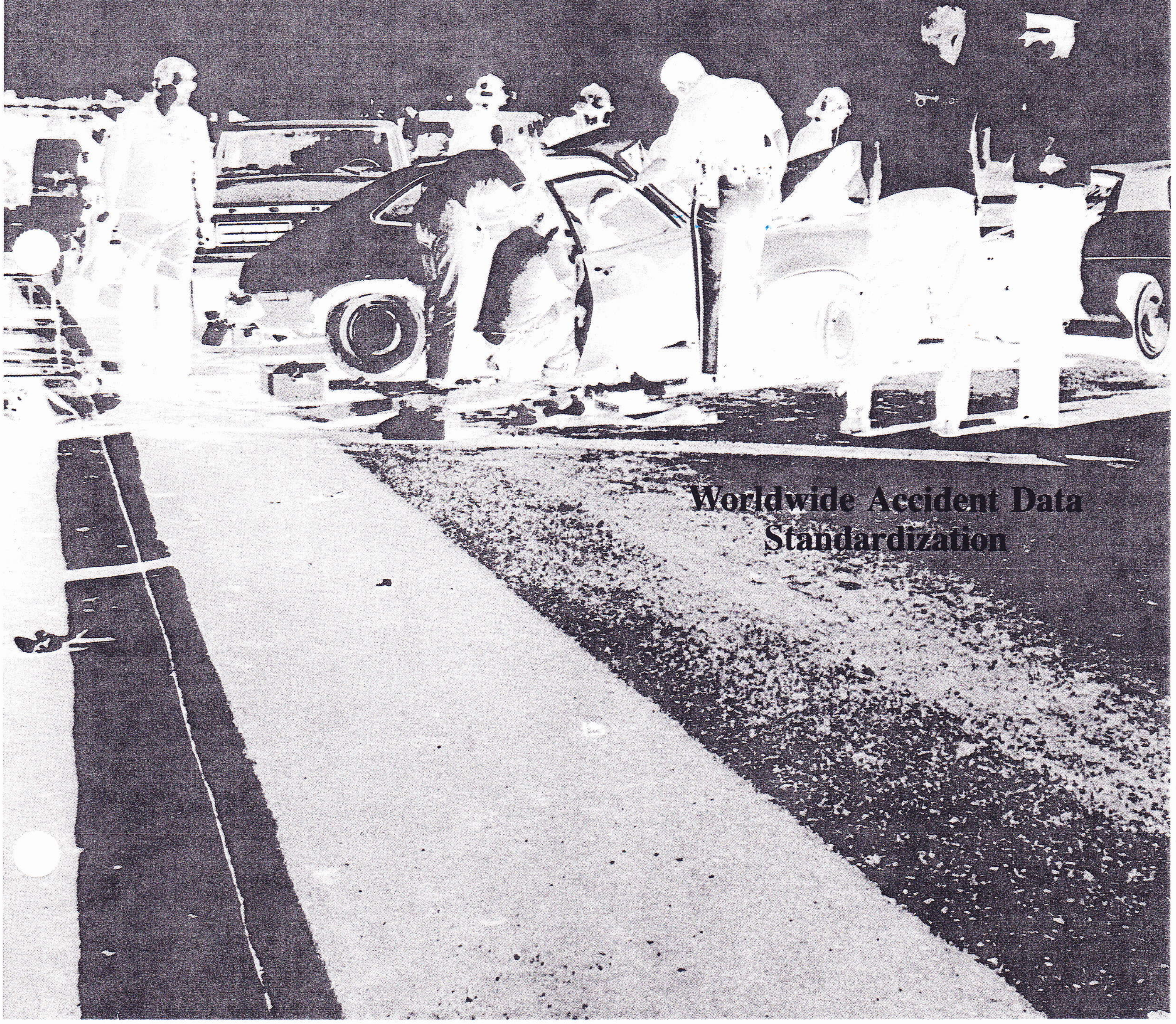

Worldwide Accident Data Standardization

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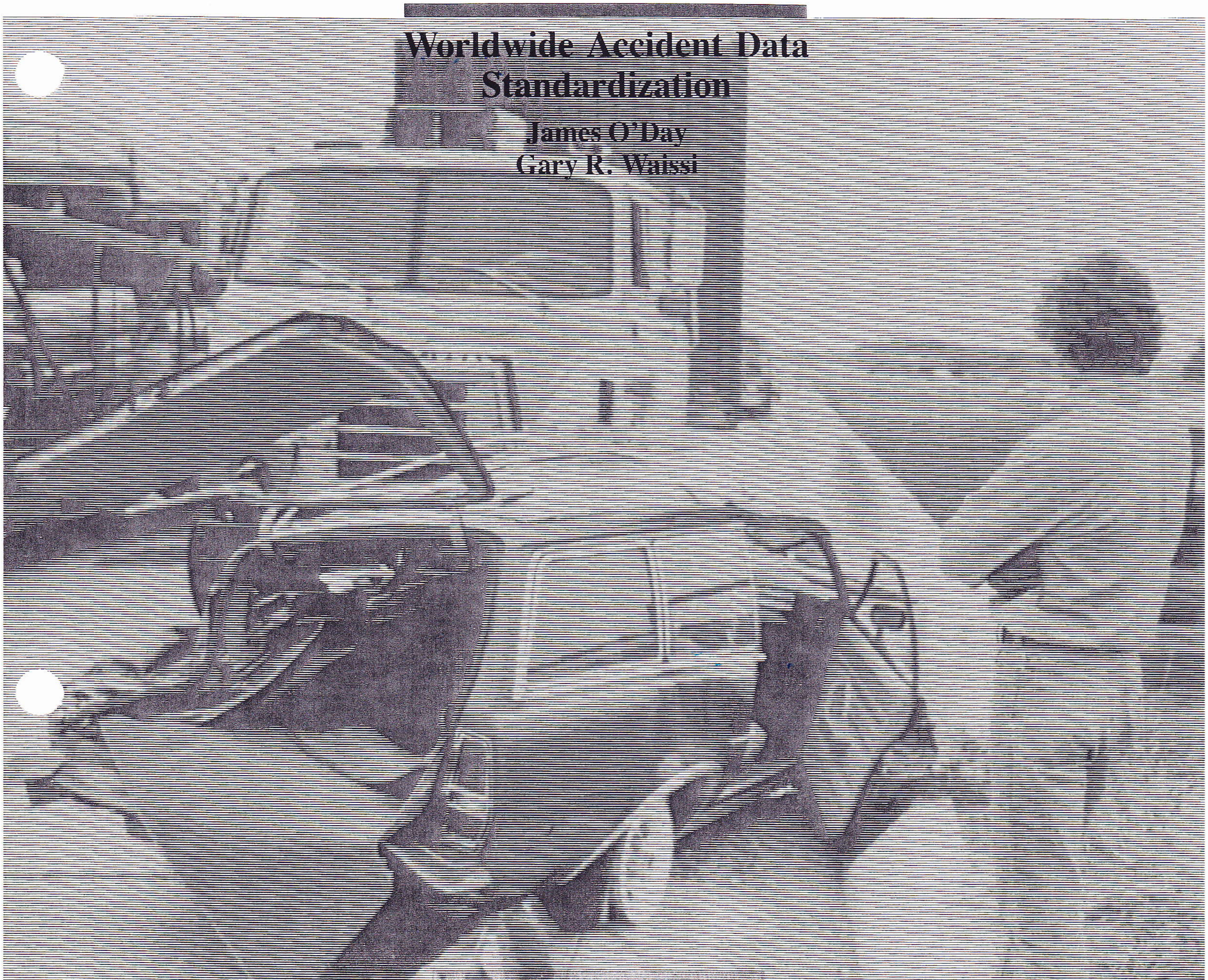
Worldwide Accident Data Standardization

James O'Day
Gary R. Waissi



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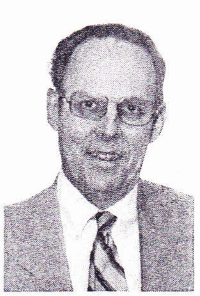

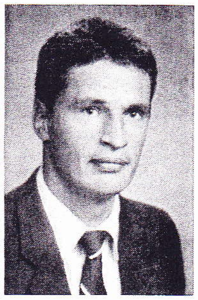

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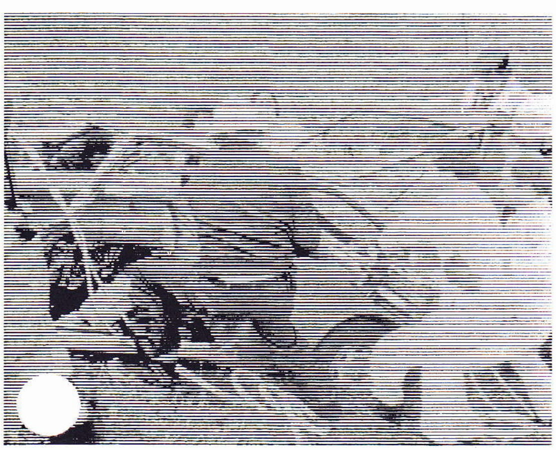
INTRODUCTION

Traffic accidents resulting in death and injury are a worldwide problem, and are not limited to just those nations with advanced highway systems and high vehicle ownership rates. But global statistics on accidents are less exact than might be expected. The reasons for this lie in the different ways information concerning accidents is reported, collected, and processed in different national and state or local jurisdictions.

Traffic accident data are collected and processed by police and highway agencies throughout the world, but the methods, or protocols, for such collection have been developed rather independently. This makes direct comparisons among countries difficult, and presents obstacles to summing data over two or more jurisdictions. Such independent development may also lead to variation or inconsistency in setting rules for traffic operations or standards for manufacturing. Both of these areas — operating rules and standards — can have a significant impact on accident and injury rates.

In an effort to better understand the current nature and extent of the problem, a project was undertaken at UMTRI to document the state of accident reporting in many parts of the world, particularly as it may be applied to the development of vehicle manufacturing or performance standards. In addition to collecting and reviewing a considerable amount of literature, direct contact was made with government, industry, and academic research communities concerned with accident investigation and data processing in America, Europe, and Australia. The emphasis in these interviews was on in-depth methodology, but information was also collected about police-reporting methods in a number of countries.



Numerous countries have fostered the operation of in-depth or multidisciplinary accident investigation programs, generally focusing on a subset or sample of all accidents. While there is much variability in the data resulting from police reports, in the in-depth programs there is a greater opportunity for international standardization. Indeed, there is nearly worldwide common use of injury scales and, to a more limited extent, vehicle damage scales. There is an awareness nearly everywhere of the need for following strict statistical procedures in acquiring in-depth data if they are to be used for drawing national inferences, but the methods for implementing such procedures vary from country to country. Most in-depth programs select accidents for further investigation from the collection of police reports, so that non-representativeness in the police data may be reflected in the in-depth collection.

The scientific community is both aware of the variability of reporting and in general agreement that something should be done about it. The World Health Organization (WHO), for example, sponsored a conference in Vienna as long ago as 1975 at which the topic of accident data consistency was discussed at length (World Health Organization 1975, 1976). Solutions were proposed, but these have evolved very slowly.

The general recommendation of the conference was that public health epidemiologists — i.e., those scientists studying all the elements contributing to the occurrence or non-occurrence of traffic accidents and injuries — should carefully examine the extent to which coding conventions, underreporting, and misreporting affect the national statistics. Although there are a few analytical adjustments possible (for example, increasing the fatality estimate for those countries which only count immediate deaths), the serious analyst must do much more than that to make useful international comparisons.

CURRENT STATUS OF INTERNATIONAL STANDARDIZATION

European Cooperation on Safety Regulations

There are presently two international organizations through which cooperation on European safety regulations has been established. They are the United Nations Economic Commission for Europe (ECE) and the European Economic Community (EEC). The ECE regulations are recommendations for member countries, but the EEC directives are mandatory. The EEC has at present eleven member countries: Belgium, Denmark, Federal Republic of Germany (West Germany), France, Greece, Ireland, Italy, Luxembourg, the Netherlands, Spain, and the United Kingdom. Nineteen countries belong to the ECE: all the countries of the EEC except Ireland, and in addition, Austria, Czechoslovakia, Finland, the German Democratic Republic (East Germany), Hungary, Norway, Romania, Sweden, Switzerland, Spain, and Yugoslavia.

Through the ECE, 53 safety regulations have been enacted, while the EEC has been responsible for 46 regulations. Not all of the regulations have been adopted by all of the ECE member countries, but, for example, Sweden has adopted 37 of the 53 regulations (Gustafsson et al. 1984).

Mass Accident Data Standardization Efforts

In 1975, the European Motor Vehicle Symposium was held in Brussels, with attendees from the EEC member countries, the United States, and Japan. At this meeting, the establishment of a uniform system for accident data reporting and recording within the EEC was proposed with funding from the EEC and the member states (Andreasen 1975). The proposal included a 3-5 year time frame for creating the system. The goal was that EEC member countries would report annual information on road accident statistics using a standard format including vehicle and injury information. A similar and more recent proposal was made by Ercoli and Negri (1985) at the International Meeting on the Evaluation of Local Traffic Safety Measures. They indicated that the standardization proposed in 1975 had certainly not been achieved.

In-depth Accident Investigation Standardization Activities

The U.S. National Highway Traffic Safety Administration (NHTSA) sponsored a group of accident investigation programs in NATO countries in 1973 (Sethness et al. 1973). An accident report form was developed, based largely on the General Motors (GM) Long Form, and accident investigation activities were implemented in six European countries. This activity brought the Vehicle Damage Index (VDI, which in the U.S. has now evolved into the Collision Deformation Classification, or CDC), the Abbreviated Injury Scale (AIS), and other conventions into common use in the European community. While the NATO program operated for only a short time, there are remnants of it in several in-depth programs currently operating in Europe.

In the U.S., the National Accident Sampling System (NASS) was developed as a means to make national estimates of accident and injury frequency—a task which was difficult using data from the variety of police reporting systems. While data in the NASS are not as detailed as in some previous Multidisciplinary Accident Investigation (MDAI) programs, emphasis has been placed on recording injuries and vehicle damage precisely, while maintaining a proper statistical sampling procedure to represent the nation. In most other countries, the investigation team's location has been determined by availability of personnel, and statistical sampling procedures are used within such a non-randomly-chosen location. There is relatively little formal coordination among nations in these in-depth programs, but there are many similar procedures evident.

Fatal Accident Reporting

Fatal traffic accidents constitute a special subset of all accidents, and data about them are important to program planning. In the U.S., a national fatality file, the Fatal Accident Reporting System (FARS), has been created in a common format, relieving the problems occasioned by differing state reporting formats. Australia, another country with many different internal reporting methods, has taken a similar step in creating a national fatality file. Canada, on the other hand, has encouraged the various provinces to develop similar reporting formats, and is able to have a reasonably consistent national accident file with fatal accidents as a subset. Most other countries considered in this study have their own national reporting forms, and thus the fatal accident data are available as a subset of the national accident file. But no two countries in Europe have accident report forms that are identical, and most are quite different in detail (Ercoli and Negri 1985).

BACKGROUND AND HISTORY

World Health Organization

In 1969, the Nineteenth World Health Assembly asked the World Health Organization (WHO) to investigate the issue of traffic accident research on an international basis. Based on this request, a questionnaire was sent in 1969 to the member countries. The information requested included the following:

1. The definition of a fatal accident as used in the particular country and reporting procedures for fatal accidents.
2. The threshold for reporting a non-fatal traffic accident.
3. For both fatal and non-fatal accidents, identification of the agency recording the data, the agency compiling the data, and the types of statistical reports and their frequency.
4. Information about special accident investigations or studies, and their coverage (geographical, population, etc.).
5. Information about the circumstances of the accident, type and severity of injury, severity of accident, place, time, and characteristics of those involved.

Completed questionnaires were received from 61 member countries, states, and territories.

The question about definition of *fatal accident* and threshold time applied only to accidents causing death either immediately or within a specified time period. The most common definition is a 30-day-rule for fatal accidents as reported by twelve countries. Somewhat surprising is that ten countries indicated no limit at all. The agencies involved are most commonly police, followed by hospitals, out-patient services, and insurance companies. Note that in 50 countries police are recording fatal accidents, but notification of fatal accidents for statistical purposes occurs in only 35 of the 61 countries. The survey found that the number of countries publishing statistics was remarkably high: 52 out of 61 publish fatal accident statistics; the respective number for publishing non-fatal accident statistics is 46 out of 61.

International Accident Investigation Workshop: NATO-CCMS 1973

At the International Accident Investigation Workshop, held in Brussels in 1973, representatives of several countries presented their views resulting from the project on in-depth accident investigation methodology and standardization organized by NATO and its member countries. Initially, nine countries showed interest in working in the project (Belgium, Canada, France, the Federal Republic of Germany, Italy, the Netherlands, the United Kingdom, the United States, and non-NATO member Sweden as observer). The following is a summary of proposals and statements made by several contributors at the meeting.

The Italian report (Franchini 1973) proposed to shorten and restructure the original NATO-CCMS accident report form into the following four separate forms:

- One form on location and accident types, filled in by police.
- One form on damages suffered by

the considered vehicle, filled in by a technical report team.

- One form on damages suffered by the other vehicle if applicable, filled in by a technical report team.

- One form on injuries occurring to each occupant, filled in by both a technical report team and a medical team.

A modified NATO Collision Analysis Report Form (CARF) was presented by the U.S. team. The modifications were based on the international cooperation and comments from other teams throughout the project duration. The new CARF is based on the original developed by the U.S. from the protocol used in the Multidisciplinary Accident Investigation Program.

The Swedish report (Bohlin and Samuelsson 1973) proposed uniform coding, and suggested data elements in three in-depth accident recording areas: accident type, driver behavior, and vehicle movement.

U.S. Programs

In the U.S., the National Highway Traffic Safety Administration (NHTSA) had defined and supported three levels of accident investigation beginning in the late 1960s. These were loosely defined as:

- Level 1: Police investigations leading to collections of what is generally considered mass accident data.

- Level 2: A variety of programs lying between the Level 1 and Level 3 extremes (an early example was the Calspan ACRS program).

- Level 3: Rather complete individual studies conducted by in-depth or Multidisciplinary Accident Investigation (MDAI) teams.

In the early 1970s, under NHTSA sponsorship, several efforts were funded to do tri-level investigations — notably at Calspan, and to some extent, at The University of Michigan and other sites — and to develop compatible data sets at all three levels. It was intended that the tri-level programs would include a census of police-reported accidents for some geographic region of interest, a representative sample of accidents investigated in modest detail, and a selection of MDAI cases with great detail. Sampling methods were relatively informal, but there were many analyses conducted with such data.

As the new federal safety agency began its work in 1966, there was much variation in police accident reporting even within individual states. One of the safety agency's earliest programs promoted the within-state standardization of police accident reporting, and by the mid-1970s nearly every state was internally consistent in report format. Among states, however, there was still much variability. Although many codes had been standardized through the work of National Safety Council committees, there were evidently differing interpretations of the rules.

NHTSA assisted in sponsoring the work of the American National Standards Institute (ANSI) D-20 committee which formulated a set of recommended codes to be used by the various states. But changes in accident reporting protocol and the forms used by the police are infrequent, and still depend heavily on local issues. Consequently, the U.S. has little capability to aggregate police-reported accident data across state boundaries because of the differences in data elements, the differences in reporting thresholds, and local differences in interpretation and application of the written rules.

EXPERIENCE IN OTHER COUNTRIES

Many countries are less state oriented, and have had common reporting forms at the national level for many years. The U.K. traffic accident reporting form (STATS-19), for example, has been modified from time to time, but a single version is in use throughout the U.K. The member countries of the ECE and EEC, as well as South Africa and Japan, have common reporting methods within each country. The European countries, especially the members of EEC, have encouraged joint international efforts for common accident reporting systems through the organizations, committees, and working groups within the ECE and EEC. Australia, and to a more limited extent, Canada, however, have variability comparable to that in the U.S., with each state or province having its own unique reporting method.

Asia

Andreassend (1982) reviewed the accident reporting systems of twelve developing Asian countries: Bangladesh, Hong Kong, India, Indonesia, Iran, South Korea, Malaysia, Pakistan, the Philippines, Singapore, Sri Lanka, and Thailand. In each of these countries an official report form is used for accident reporting and investigation.

European Countries

The research by Ercoli and Negri (1985) compared the present forms from Belgium, Denmark, France, Italy, the Netherlands, Portugal, Spain, Sweden, the United Kingdom, West Germany, and Yugoslavia.

A resemblance index was developed — a sort of correlation coefficient telling how alike or different any two forms are. The highest value was the index between Spain and Portugal — a value of 0.24. The lowest value was 0.0512 for the comparison of the Netherlands and the United Kingdom. The only data element values common to all eleven forms were those related to time and date of occurrence of the accident.

The authors suggested that a common form might be accomplished as a set of core data to be collected in every country, with each country free to add other variables as it desired. They suggested five groups of information:

1. Identification
2. Scene, conditions, environmental circumstances
3. Vehicles involved
4. Data relative to the drivers and/or pedestrians involved
5. Post-accident effects to persons

EEC Member Countries

Andreasen (1975) compared the accident reporting forms of the nine European EEC member countries with respect to the following categories: availability of data on accident factors, unit factors, and human factors.

Four of the nine EEC member countries (Belgium, Denmark, Ireland, and the Netherlands) have adopted the ECE accident-type category definitions as such. The other five have combined some accident definition categories into broader categories. In many countries the broad accident categories are further broken down in greater detail. Andreasen points out that there are "crucial differences between the various countries in classifying individual accidents" to the ECE categories. Other European countries, e.g., Finland (VALT 1984), have adopted the ECE accident-type categories in a slightly modified form.

In the EEC countries, types of units involved in accidents are well reported, the only unclear issue being the criteria for differentiating between light and heavy trucks. But only two countries record the road type, and this of primary importance for international comparisons.

POLICE/MASS DATA

Police reporting of traffic accidents is important to the estimation of the frequency of accidents, injuries, or other events within any jurisdiction. It is also important to the operation of in-depth accident investigation programs, particularly with regard to representativeness, since most of these use the police-reported accidents as a sampling frame.

A World Health Organization Ad Hoc Technical Group provided an excellent summary of the state of coverage of traffic injuries in police reports in a number of European countries (World Health Organization 1979). It was reported that a Swedish study in 1969 found that only 28% of persons seriously injured in road traffic accidents were reported as such in official road accident statistics, and that a further 20% were recorded as only slightly injured — i.e., 52% of the injured persons did not appear in the police statistics at all. In a British study covering the period from 1974-1976 (Hobbs et al. 1979), it was reported that nearly 30% of all road traffic accident casualties were not officially reported, even though they attended hospital for their injuries.

By contrast, recent work in the Netherlands, communicated to the authors by S. Harris (SWOV), indicated that about 85% of the accident victims admitted to the hospital were also recorded as injured in the police accident record system, and that this fraction had been stable for several years. This knowledge then provides a basis for doing further analytical work with the police data there.

Nearly all jurisdictions have some nominal rule about which accidents are to be reported officially. Often this is a combination of injury level and damage — for example, at least $400 in property damage or an injury requiring treatment. But in practice, such rules are seldom followed precisely, and there is usually some underreporting.

Zylman (1972) conducted a study in two states in the U.S. on the use of driver records to measure driving behavior. He drew two conclusions in this regard: "(1) The likelihood of having a collision recorded on one's record may be more dependent on local policies and practices than on one's driving proficiency, and (2) any measurement of collision occurrence based on population, registered vehicles, mileage, etc. of two or more agencies without first ascertaining the use of terminology, interpretations, policies, and practices of those agencies is subject to question."

In the U.S., most states use an injury scale identified as KABC0, in which *K* is killed, *A* indicates that the person was incapacitated (but not necesarily admitted to the hospital), *B* a visible but non-incapacitating injury, *C* a complaint of pain, and *0* uninjured. These codes are used so that (except for delayed fatalities) the officer can code the injuries on the report form at the time of the field investigation.

Most other countries use a definition of *serious injury* as one which requires overnight hospitalization, although several individuals have indicated that they use *more than one night in the hospital* for the serious tag. For lesser injuries, some jurisdictions have only one code, and some have several.

There are similar variations in vehicle damage scales at the police level. The Traffic Accident Damage (1967) scale has been very useful for analytical purposes, but it is used in only a few states. Some jurisdictions have written descriptions of damage, some have pictorial representations, and some have a simpler code of two or three levels (e.g., towed or not towed).

One other item that is important enough to be universally reported is the accident type or configuration, but again there is little consistency in the coding. To some extent, this is the result of local needs — a region with few trees may combine striking trees and utility poles. Another region may identify them separately. Such variations again make it difficult to aggregate the data across jurisdictions. For many years the Australian national file was able to identify only two types of accidents, single or multi-vehicle, although every state form provided for much more detail than that.

The U.S. Fatal Accident Reporting System

Because the remaining variation precludes direct aggregation of data, NHTSA proceeded to develop a national system for reporting of fatal accidents, and this has now resulted in eleven years of data about U.S. fatal accidents in a nearly common format. Data are gathered on all fatal accidents occurring in the 50 states, the District of Columbia, and Puerto Rico. State-employee analysts compile the data under contract with NHTSA, and forward it to a processing center in Washington, D.C.

The Fatal Accident Reporting System (FARS) analysts determine the fatal accidents that qualify for inclusion, gather pertinent data, and code them onto three forms: the accident level, vehicle/driver level, and person level forms. Data are then forwarded to NHTSA's National Center for Statistics and Analysis. The primary sources to complete the coding of the above forms are police reports, registration files, death certificates, coroners' reports, emergency medical services reports, and State Highway Department files. With data from these sources, the forms are coded in accordance with the *Coding Validation Manual*, published and updated annually by NHTSA (Sebastian 1981). Since 1979, the contents of the forms have been transmitted by remote data entry to the data bank at the National Center for Statistics and Analysis.

Effort is placed on consistent, complete, and accurate reporting, recording, coding, and analysis of the data. Various mathematical and statistical methods are used to detect errors in coded data and to estimate values for missing data.

While there may still be some uncertainties in the FARS data, it is accepted by most in the U.S. as being a complete record of fatal traffic accidents, and containing accurate information regarding most of the factual elements of the data — vehicle make and model, driver sex and age, accident type, etc. For the U.S. as a whole, this development solves the threshold consistency problem by concentrating on only fatal accidents, achieves good coverage because fatal accidents are well investigated and reported in all states, and provides a level of detail useful to national planning.

Canada

There is more consistency among the Canadian provinces' accident report forms than in either the U.S. or Australia. The forms for New Brunswick, Nova Scotia, Prince Edward Island, Saskatchewan, and Newfoundland/Labrador vary mostly in the printing. Diagrams of eleven accident configurations (head-on, rear-end, struck fixed-object, etc.) are provided so that the reporting officer can check the most appropriate one; these are exactly the same in all five of these provinces. There are slight differences, however, in the coding of major contributing factors and the sequence of events. Injury coding is slightly different in Newfoundland, where the seven-level codes of the other provinces have been collapsed into five levels. All define major injury as "hospitalized." And all use an eight-point compass face to code the location of damage on the vehicle. Vehicle repair cost is to be estimated and reported by the officer in all five provinces.

But the Quebec report form is quite different from these first five. The injuries are coded in just four levels. There is a twelve-level pictorial selection of accident configuration, but the codes vary from those discussed above.

Ontario has developed a new report form which will be in use in 1988. This form has a twelve-level initial impact type which corresponds roughly to the accident configuration codes used in the five provinces discussed above.

However, the Ontario codes are all different, and could not be easily combined with those of the provinces discussed above.

British Columbia and Manitoba have similar but different sixteen-level accident-configuration codes. Many of the code levels are the same, but the code value for fixed object in Manitoba corresponds to the value for bridge in British Columbia; the code for off-road left in Manitoba uses the same number as the code for one-way street in British Columbia. Alberta does not provide a coded description of the accident configuration, but does have a place on the form for a collision sketch.

The Northwest Territories accident-report form is different from all the other Canadian forms, having different codes for road type, condition, weather, and street lighting (e.g., light failed). The Northwest Territories seem to be unique in including both a vehicle identification number (VIN) and an odometer reading.

Transport Canada has concluded, however, that there are enough similarities among the reports from different provinces to justify creation of a national accident file based on computer records furnished by the provinces. It is apparent from the above discussion that some variables must be recoded to a common set of values, but there has evidently been a strong coordinating effort present in Canada to bring about the present state of affairs. Transport Canada has not developed a separate fatal accident file (comparable to the U.S. FARS), but the fatal accident subset of the national file is available in computer form.

Australia

Although there are only six states and two territories in Australia, traffic accident reporting in each jurisdiction has developed quite independently. As a result, there is little capability to aggregate the reported data at the federal level with the kinds of detail available locally.

For reasons similar to those expounded in the U.S. (e.g., variations in coding and different reporting thresholds), the Australian Federal Road Safety office has created a computerized national data base for fatal accidents beginning in 1981. The present methods for developing the data set involve preparation of suitable coding forms and a coding manual for training, keypunching and validation of data entry, and the use of range and consistency checks to ensure completeness and accuracy (Scott and Furphy Engineers 1985).

The Australian fatal accident data file is stored in a computer in Canada (because the contractor's main computing facility is there), and is accessed by satellite communication from points within Australia. The files are relatively small compared to those of the U.S. and the disk-based data access is essentially instantaneous. Data for 1981, 1982, and 1983 are presently on line; data for 1984 and 1985 were being prepared by a contractor in early 1987 and may be finished by now.

The United Kingdom

Traffic accidents are reported in the United Kingdom by police officers filling out a form known as STATS-19. The current version is in use throughout the U.K. The responsibility for the building and maintenance of the STATS-19 computer file lies within the Transport and Road Research Laboratory (TRRL) at Crowthorne, and the individual-year files each contain data on about 350,000 accidents. Some ten years of data are maintained in disk form, and personnel at Crowthorne estimated that there are about 4,000 inquiries each year — each being a single search from one year of data.

The STATS-19 file may be augmented when additional data are available. For several years, TRRL has received hospital data from Scotland and has merged that with the STATS-19 data file. This permits more detailed analysis of injury factors such as a comparison of injury experience prior to and after the seat-belt law.

STATS-19 data are also used to select cases for further study. Several years ago, for example, there was a study of accidents involving heavy-goods vehicles. Cases were identified by computer analysis of the STATS-19 files, and subsequently the more detailed information was obtained by reading the original police reports.

The active analysis program with the STATS-19 data at TRRL helps to discover shortcomings of the data. Several years ago, for example, it was found that the city of London failed to report about fifty fatalities into the STATS-19 file because of a special routine for handling these cases. This constitutes about 1% of the U.K.'s total fatalities, but a larger fraction of urban fatalities. In another case, a jurisdiction that had a large number of concrete utility poles had argued strongly against identifying these in a revision of the accident report form. They lost the argument, but thereafter no pole accidents were reported from that jurisdiction. Such analytical findings should ultimately lead to an improved and more reliable and useful data set.

Denmark

The traffic accident reporting system was revised in Denmark during the 1970s and a new system came into effect in January 1976. Most of the data are collected using police reports. The technical sections of local road authorities convert the police data into coded form. The recording of the coded data, consistency checks, and accuracy checks are performed by the Danish government's Department of Statistics (Danmarks Statistik). Hence, the primary accident data suppliers are police, hospitals, and local road authorities. The primary data processors are local road authorities and the Department of Statistics. Among data users are the data suppliers and data processors as well as government legislative bodies, press, highway administration, and various research organizations and universities.

A standard set of forms was introduced for the data supplier, data processor, and data-user groups. The forms and their uses are:

1. ***Preliminary Report Form:*** This form is prepared by police and is sent to the Department of Statistics (Danmarks Statistiks) within 24 hours if the accident involved a personal injury. Otherwise this form is not used.
2. ***Road Accidents, Police Form:*** This form is retained by the police to supplement police reports and is used as a backup.
3. ***Road Accidents, Final Report:*** This form is the primary data source for the Department of Statistics. The form is prepared by the police and supplemented by the local road authority, and is sent to the Department of Statistics within five weeks of the accident.

Sweden

In Sweden, the official accident statistics are based on police-reported information. Other data in Sweden are obtained by Folksam, the largest motor insurance company in that country, and by the Volvo Corporation (for cars manufactured by that company).

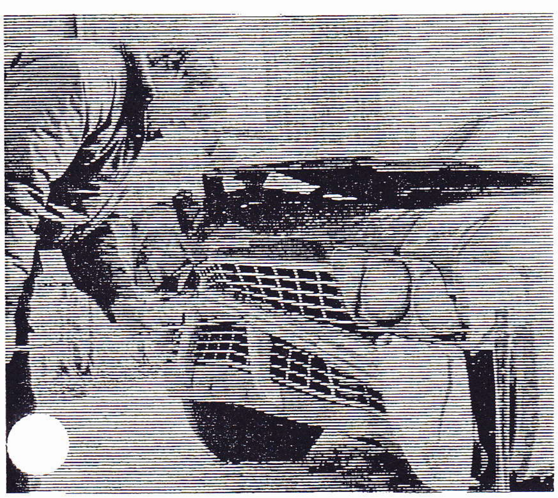
Police-reported accidents include those accidents at which the police are *necessary*. This may include non-injury accidents in which police are required to remove the vehicles or to write official reports to protect a not-at-fault driver.

For inclusion in the Official Swedish Road Traffic Statistics, an accident must occur on a road with at least one vehicle moving. Folksam, however, attempts to include all accidents, even those occurring in private areas. The reviewed five-year Folksam study (Nygren 1984) included only those accidents involving passenger cars in private use. It is pointed out in that study that the degree of underreporting of accidents and injuries is not known. Sweden, with a total population of about 8 million and 3.5 million vehicles, has about 70,000 police-reported traffic accidents, 800 fatalities, and 16,000 injuries (serious and minor combined) per year. These figures may be compared with those of Michigan, a state with comparable population (9.2-million persons and 6-million vehicles in 1980). In 1981, Michigan had 303,000 reported traffic accidents (more than four times as many as Sweden), 1,589 fatalities (about double that of Sweden), and 136,000 injuries (8.5 times the count in Sweden, although more than half of the Michigan injuries were at the *C*, complaint of pain, level). This suggests either a much lower accident and injury frequency in Sweden, or considerable underreporting.

West Germany

The West German government is actively working in various ECE and EEC committees, and has set up federal guidelines for adopted ECE regulations (as applicable) covering automotive safety standards. The German Department of Transportation (Bundesministerium für Verkehr, BMV) and the German Motor Vehicle Transport Administration (Kraftfahrt-Bundesamt, KBA), in cooperation with the various states, prepare regulations and standards to be adopted in West Germany based on the ECE and EEC regulations. Specific standardization goals and responsibilities of various parts of the government are tabulated in *Unfallverhütungsbericht* (1980). There are three major accident statistics programs, summarized in the following paragraphs.

The official German road accident statistics (die Bundesstatistik der Strassenverkehrsunfälle) are published annually (Bierau 1985, Strassenverkehrsunfälle 1974). It gives general facts on road traffic accidents. Since 1953, all police-reported accidents have been recorded in this compilation. Detailed recording of pertinent accident data is done for accidents with an estimated property damage of over DM 3000. Accidents below this threshold are only counted, with no detailed reporting. The pertinent accident data are divided into three categories (general accident data, involved persons, and injured passengers) and reported on standard forms.



The German Motor Traffic Insurers initiated the automobile traffic accident investigation and accident prevention work in Germany by founding an Accident Prevention Committee in 1953. In 1967, the same organization created a plan to collect and compile traffic accident data for accident research purposes. The first study was primarily dedicated to occupant protection. The German Motor Traffic Insurers, today the German Association of Third-Party, Accident, Motor Vehicle, and Legal Protection Insurers (HUK-Verband), has been involved in an extensive accident-research program related to interior safety of automobiles since 1969.

Since 1976, the HUK-Verband research has been able to use insurers' accident reports to focus on selecting specific car models in which occupants were/were not injured. The goal is to evaluate a new car model's safety within a short time period after the model's introduction. HUK-Verband (1978) states as their objective "the realization of a combination between large-scale investigation and included in-depth case analyses in special consideration of problems of current interest."

In the HUK-Verband (1978) study, the investigation was based on accidents reported to the HUK-Verband by all German motor traffic insurers. Trained engineers from the Department of Automobile Engineering analyzed the accident data on a case-by-case basis and filled out collision analysis reports. Data bases were created on a HUK-owned computer. The structures used permitted the selective calling and evaluation of each record of each accident case.

Finland

The Finnish Motor Insurer's Bureau (Liikennevakuutusyhdistys-LVY) initiated a fund and created the Traffic Safety Committee of Insurance Companies (VALT) in 1967 to improve and widen the scope of national traffic safety work.

VALT has organized thirteen road accident investigation teams, one for every county, and one for the city of Helsinki. VALT publishes an annual report, *Traffic Accident Statistics of Insurance Companies*, on traffic accidents compensated for from third-party motor insurance.

One of the responsibilities of VALT is national fatal accident investigation and reporting. The adopted in-depth Fatal Accident Research Plan for 1985 (VALT 1984) is based on the VALT recommendation from 1981. The general goals are to improve and develop traffic laws and regulations, and to improve the safety of traffic, road environment, and safety of motor vehicles. The specific goals are to study individual accidents and accident causes, create a data bank for data handling and statistical analysis, and increase and improve cooperation with, and training of, police and other officials. This joint effort of public and private interests in creating more accurate data resources is an important and noteworthy program. The official general accident report is published annually by the government's Statistics Center, Tilastokeskus.

IN-DEPTH ACCIDENT DATA

Collection of very detailed information about a relatively small number of traffic accidents may be characterized as an in-depth accident investigation process. While the level of detail collected in police investigations serves a useful purpose in establishing counts of crashes, injuries, and fatalities, and also in providing information about accident types and locations, it is inadequate in providing the kinds of information necessary to vehicle-design choices as well as for many changes in other parts of the traffic system. In-depth accident investigation methods permit extremely detailed information to be collected for a small number of accidents at a reasonable cost. The resulting data may then be used for planning and design.

In many parts of the world, in-depth accident investigation methods seem to have proceeded from a few detailed case studies to a more structured format, and then to some kind of sampling procedure to represent a larger population. In the U.S., early case study work was sponsored by both the government and the automobile industry, and resulted in a collection of reports in a variety of formats.

Following the 1969 Airlie House Symposium (NHTSA 1969), both the industry and government-sponsored programs standardized on the GM (General Motors) Long Form for reporting. In 1975 NHTSA and the automobile industry defined a fairly strict sampling plan for case selection for five accident investigation teams operating in the U.S. (Kahane et al. 1975). While the geographic location of the teams was predetermined by existing contracts, each team used statistical sampling methods to select cases for inclusion. The resulting data set was then used to draw inferences about the effectiveness of the various kinds of restraints in use at that time.

At about the same time, the elements of a national accident investigation system using sampling techniques were defined (O'Day 1974). In the late 1970s, these early designs led to the National Crash Severity Study (NCSS), a sampling program using a judgement technique to provide a balance of rural and urban accidents, and later to the National Accident Sampling System (NASS) which provided a probability sample of traffic accidents in the whole of the U.S.

Similar sequences of events have occurred in other countries, and present programs range from simple case studies and careful local sampling to methods for estimating national accident characteristics. Investigation protocols have been developed by many investigators, and the present programs have many similar data elements. This seems to have come about mainly through informal interaction and local selection of the more useful techniques.

Data Acquisition and Sampling

There are three dimensions of in-depth accident investigation programs which, in part, determine their utility. These are (1) the sampling procedures — the sampling frame and the subsequent sampling method, (2) the method of data acquisition, and (3) the timing of the investigations (either at the time of the accident or later).

Sampling Considerations

In most in-depth investigation programs, cases for further study are chosen from a sampling frame that comes from the police record of accident occurrences. Methods of choosing cases from a sampling frame vary widely. In the early U.S. case study programs, choices were pretty much up to the investigator. In the more recent programs (in the U.S., the United Kingdom, West Germany, Canada, Australia, and others), great attention has been given to proper statistical design so as to well represent larger populations.

Data Sources and Acquisition

Parallel data acquisition is based on several data flows accumulated in the same time parallel to each other. In many countries the police agencies, the hospitals, the insurance companies, and in some cases, the national motor vehicle inspectorates all collect accident data using their own resources.

Sequential data collection is the accumulation of a variety of data about an accident into a single data base. This implies a strict order for collection, e.g., the police officers record information at the scene, then the mechanical inspection of the vehicle is carried out, and then the injury diagnosis is performed at the treatment facility. Most of the in-depth programs reviewed here involve a combination of these two methods and require considerable interaction and cooperation among police, hospital, and other agencies to produce accurate information.

On-Scene Versus Follow-Up Investigations

Another major choice in in-depth programs is whether to investigate accidents *on-scene* or to perform a *follow-up* investigation some time after the fact. In the first case, the investigative team can obtain first-hand knowledge of activities at the site of the accident, and is in a position to record volatile information that might otherwise be lost. However, there is a tradeoff in completeness of coverage, as the on-scene investigations are time-consuming and (without an inordinate effort) may miss cases that should properly be in the sample. Most U.S. programs seem to have settled on the follow-up technique, but there are still some programs of the first type operating in other countries.

Crash Severity Measures

A meaningful collision (crash) severity measure provides a means of quantifying the diversity and variations of the characteristics and factors involved in the crash phase of vehicle accidents (Kahane et al. 1978). Ideally the measure would be such that all collisions with the same *crash severity* would produce the same injuries for a given occupant (Marquardt 1977). With this measure, it is then possible to study the effects and variations of vehicle differences and improvements, occupant characteristics, occupant position, restraint systems, etc. on occupant injuries resulting from a given collision.

A measure of crash severity should (1) portray a theoretically correct picture of the forces involved in the collision; (2) be consistent and uniform so that the severity ratings may be used on all accidents; (3) be easy to apply, calculate or obtain, and be quantitative in nature; and (4) be understandable and have meaning to nontechnical people.

The severity measure proposed by Campbell (1974) involves relating vehicle damage to a so-called equivalent barrier speed (EBS). The measure, called Delta-V, describes the *instantaneous* change in velocity of a vehicle during impact. It is defined to be a function of two variables: the ratio of the colliding vehicle weights and the difference in velocities of the vehicles. The EBS is based only on energy absorbed by the case vehicle, whereas Delta-V takes into account the energy absorbed and conservation of momentum for *both* vehicles (if two vehicles collide). Hence, when accident data are collected for each vehicle, the Delta-V can be calculated. If information on a two-vehicle collision is available for only one vehicle, it is appropriate to use the EBS.

Energy Basis for Collision Severity

The EBS is defined as a vehicle velocity at which the kinetic energy of the vehicle would equal the energy which was absorbed in plastic deformation of the vehicle. First, a vehicle's dynamic force-deflection characteristics are determined. An approximate linear relationship between vehicle residual crush and impact speed is found. The second step is the estimation of EBS. It assumes that characteristics do not vary across the width of the vehicle in cases involving non-uniform

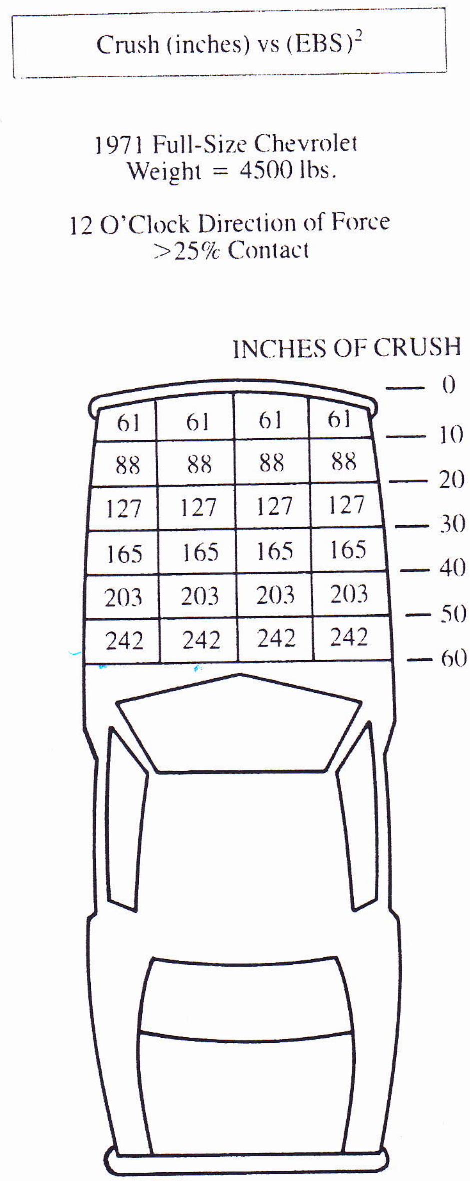
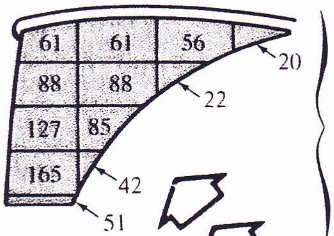
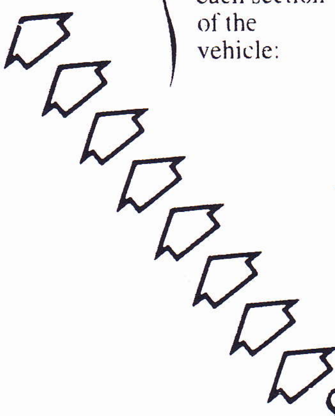


FIGURE 1. Pictorial representation of crush versus EBS (equivalent barrier speed) for 1971-1972 full-size Chevrolet (Campbell 1974).

An instrumented crash test was conducted:
Impact Speed = 30.6 mph
Vehicle Weight = 4333 lbs.





Adding the energy absorbed in each section of the vehicle:

61
88
127
165
51
61
88
85
42
56
22
+ 20
866

$$\left(866 \times \underbrace{\frac{4500}{4333}}_{\text{(correction factor)}}\right)^{1/2} = 30.0 \text{ mph}$$

= EBS estimate, which is a good approximation of the impact speed of the crash test (30.6 mph)

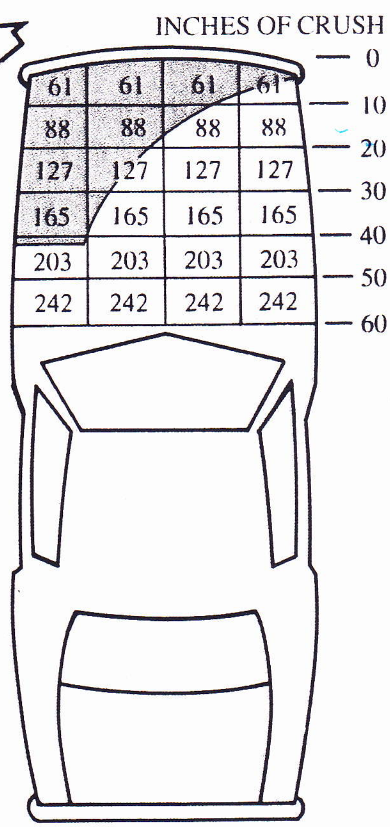


FIGURE 2. Application of pictorial approach to 30 mph offset barrier impact (Campbell 1974).

damage (i.e., the fender is no stiffer than the center of the vehicle). Damage vertically is assumed to be uniform, and damage by underride or override is not considered. With these assumptions the force-per-unit width as a function of crush is calculated, and then the energy absorbed by the vehicle is computed by integrating the force over the crush distance and over the vehicle width. After this, damage patterns need to be approximated in terms of crush as a function of the width of the vehicle front.

A pictorial representation of the energy absorbed by sections of the vehicle (see, for example, Figure 1) facilitates the easy determination of EBS for more sophisticated models and for various damage patterns. To use Figure 1 to get an EBS for a damage pattern sustained by a vehicle, the damage pattern should be sketched over the vehicle picture. The total energy absorbed is the sum of the *crushed* squares. Partial squares are allotted in proportion to area. The square root of the number is the EBS for that damage pattern collision (see Figure 2 for an example).

Crash Severity Measurement by Delta-V

Delta-V is defined to be "the change in velocity that occurs in a fraction of a second during a vehicle collision while primary vehicle damage is occurring" (Marquardt 1977). Delta-V is suitable as a measure of collision severity in the context of a collinear vehicle-to-vehicle collision where occupant ejection, or occupant-compartment deformation, is not a dominating injury factor. The two vehicles have a closing speed equal to the difference of their velocities. After impact, crushing and deflection occurs in a fraction of a second, bringing the vehicles to a common velocity. For analysis purposes, the impact is considered inelastic, thus the secondary effect of rebound is ignored. Eventually the pavement-surface friction will bring the vehicles to a stop. In the impact phase, friction is a secondary effect and will also be ignored.

During the crushing phase, a vehicle undergoes large velocity changes (Delta-V or peak contact velocity, PCV) in a short time period. The large g forces involved create a high potential for injury because the occupant must also undergo this same change in velocity. Delta-V is then the maximum velocity with which an unrestrained occupant can contact the vehicle interior.

Delta-V Using the CRASH3 Program

The CRASH program (Calspan Reconstruction of Accident Speeds on the Highway) — the current version is known as CRASH3 — is being used for determining collision severity in the U.S. National Accident Sampling System (NASS) accident data collection program. CRASH3 is also used in other research programs sponsored by the National Highway Traffic Safety Administration (NHTSA). The *damage only* option of CRASH3 has been the basis for establishment of crash severity (Delta-V) in the NCSS accident database. About 45% of the accident-involved vehicles in the NCSS were given an accident-severity measure by CRASH. The major advantage of the CRASH algorithm, compared to traditional accident reconstruction methods for determining the Delta-V from vehicle damage, is that the method is independent of skid distances and momentum. The method requires comparative crash test data and crush measurements taken from the accident vehicles or estimated from the vehicles (Woolley et al. 1986).

Other automobile accident-reconstruction programs are the Equivalent Energy Speed-Accident Reconstruction Method (EES-ARM), the Impact Momentum of a Planar Angled Collision (IMPAC), Vehicle Trajectory Simulation (VTS), Tractor Braking and Steering simulation (TBS), Simulation Model of Automobile Collision (SMAC), and the Highway Vehicle Object Simulation Model (HVOSM). In general, these programs provide simulations of collision and vehicle trajectory to varying levels of complexity and sophistication.

Vehicle Damage Scales

There are a number of more detailed vehicle-damage recording methods in use for in-depth investigation, and several of these are discussed here.

The Collision Deformation Classification

The U.S. Collision Deformation Classification (CDC), as published in the SAE J244, Recommended Practice 1986, is a seven-character code consisting of the following:

1-2: Force direction during impact
3: Area of deformation
4: Specification longitudinal or lateral location of deformation
5: Specific vertical or lateral location of deformation
6: General type of damage distribution.
7: Extent of damage.

The Vehicle Deformation Index

The Vehicle Deformation Index (VDI) was an earlier version of the CDC. It is pointed out in Ashton et al. (1973) that the VDI cannot be used for comparing accident severities between vehicle types, but it has usage when comparing vehicles with similar design characteristics.

The term VDI, which was in use at the time of the NATO program in 1973, seems to have been retained in most European usage. The German HUK-Verband uses a system developed from the VDI that appears to be somewhat different than the CDC as described in SAE J224.

HUK-Verband Body Deformation Classification

For body deformation classification, the West German HUK-Body Deformation Classification uses a scale divided into five categories. The classification is used for the most severely deformed body parts for front, rear, and side impact (scale 1 to 5 where 1 = minor damage and 5 = total damage extending to person compartment and in side impact, a total damage of the person compartment). The classification is used, for example, in Finland and West Germany.

STATS-19 Body Deformation Classification

For recording body deformation the British Department of Transport uses the STATS-19 Vehicle Record Form. In this form the vehicle deformation is classified into eight categories indicating the region of damage only. The eight categories are the following (British Department of Transport 1983):

0 = None
1 = Front
2 = Back
3 = Offside
4 = Nearside
5 = Roof
6 = Underside
7 = All four sides

Injury Scales

The Abbreviated Injury Scale (AIS)

This scale is used for coding injuries incurred in traffic accidents (AAAM 1980). The AIS is ordinarily used by specially-trained research teams that obtain medical, vehicle, and environmental data on traffic accidents.

In the developmental stages the AIS scale was viewed as a part of a Comprehensive Injury Scale (CIS) concerned with energy dissipation, threat to life, permanent disability, and treatment period. It is now generally agreed that the AIS mainly reflects the threat to life, and other scales have to be used to describe the risk of permanent disability as well as other effects of accident injury.

Maximum AIS (MAIS) and Overall AIS (OAIS)

The MAIS, as used by NASS programs in the U.S., is the maximum known AIS among observed injuries to a single person. The OAIS considers the total effect of multiple injuries using as a criterion the threat to life. The OAIS has, in some studies, been reported as a higher value than the MAIS, but the usage now seems obsolete. The OAIS involves careful clinical evaluation of overall effects of individual injuries for the body as a whole.

Injury Severity Score (ISS)

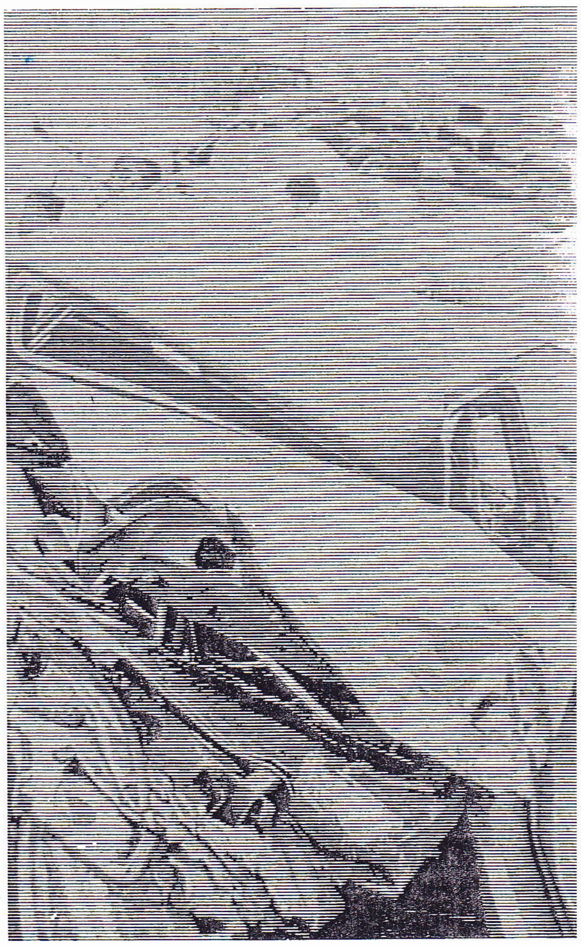
The ISS is a method for describing the overall severity of injury to more than one area of the body as well as of isolated injuries. The numerical system rates each injury and then adds the squares of the highest AIS rating for each of the three most severely injured body areas. The ISS is a measure of the risk of injuries leading to hospital care and/or death, but it is not a measure of the risk of permanent disability (Nygren 1984, Baker et al. 1974, Baker and O'Neill 1976, Reinfurt et al. 1987). The ISS takes into consideration the combined effects of multiple injuries.

Occupant Injury Classification (OIC)

The OIC scheme was developed at The University of Michigan (Marsh 1973a, 1973b). The coding convention was derived from the CPIR (Collision Performance and Injury Report) of General Motors Corporation, and the NATO Collision Analysis Report Form. The aim was to correlate injury sources (contact areas) and specific injuries. The OIC is similar in form to the Collision Deformation Classification (SAE 1972), but applies to the human body rather than a vehicle body. In the OIC, four dimensions or facets are described by letters: body region, aspect, lesion, and body system/organ. To the four-letter code a fifth element, an AIS severity number, is added. A particular injury is then coded with four letters plus a number.

KABCO Injury Scale

A widely-used injury scale in the U.S. has been the KABCO scale. While it is usually employed in police

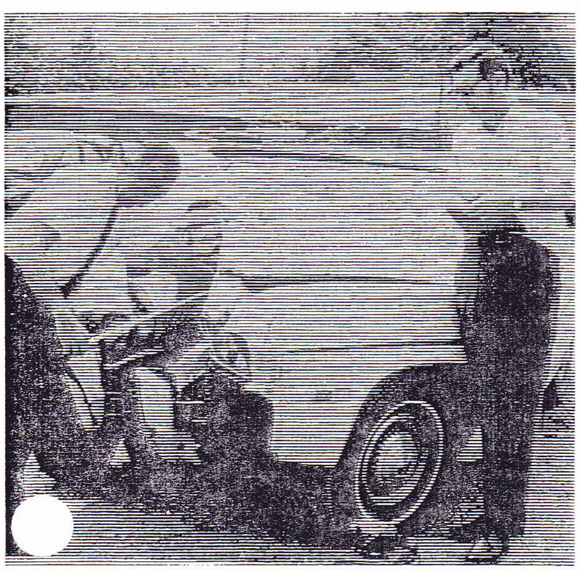


accident data reporting, it is sometimes used as the basis for further selection of in-depth cases, and is typically carried forward into the in-depth data sets. The KABCO scale was developed for use by non-medically trained police personnel. It has five levels, from fatal to no injury (Reinfurt et al. 1978). This scale is extended in the U.S. NASS and FARS programs by adding injured (severity unknown), died prior to accident, and unknown if injured.

Other Injury Scales

The fourteen-point ICDA Threat-to-Life Scale, predicts the unconditional probability of a fatality prior to release from hospital as a function of a specific primary injury, age of occupant, and extent or number and severity of secondary injuries. The nine-point AIS Threat-to-Life scale predicts the conditional probability that death will result given that the individual does not die before reaching an initial treatment facility. It was developed based on a transformation of the primary ICDA code to an AIS severity code (Reinfurt 1978).

The New York State Injury Coding Scheme (NYSICS) consists of three components: the location of the victim's most severe injury, its type, and the victim's physical/emotional status (Baum 1978). The Comprehensive Injury Scale (CIS) was developed by the American Medical Association (AMA) and published in 1972. The CIS ranks injuries "in terms of the amount of energy dissipated, the threat to life, the amount of permanent impairment, the length of treatment period, and the frequency with which the injury occurs" (Reinfurt 1978).



Other existing injury scales include the Trauma Index (TI) and the Cumulative Illness Rating Scale (CIRS). The TI has been shown to reliably predict death and/or hospital stay. The CIRS goes beyond the TI by requiring a licensed physician to make the pertinent medical judgements (Reinfurt 1978).

Injury Scales Used in Different Countries

The AIS and its modifications are used widely in recording injury severity in in-depth programs. In some cases, e.g., the United Kingdom, Sweden, and Finland, the AIS is complemented by the ISS. There is, however, variability within countries and states as well as within agencies, depending on the purpose and level of detail of their particular programs.

Police reporting in the U.S. commonly uses the KABCO scale but others are also used. The NASS program uses the KABCO, the AIS and MAIS, the ISS, and the OIC. The data are complemented in the NASS by recording hospitalization and length of stay in hospital, number of lost working days, time of death, and number of the OICs. The FARS relies mostly on the police reporting, i.e., the KABCO scale, and complements this by separately recording hospitalization and time of death.

Since 1976, Denmark has classified personal injuries for their official statistics into four categories: fatal, serious injury, minor injury, and uninjured.

For accident reporting in Japan, the national police agency uses the so-called JAIS scale for injury severity coding. The JAIS coding scheme is a modification of the AIS injury scale. The Accident and Emergency Services Committee of Japan, and other such committees, have considered the adoption of the AIS scale for injury severity coding (Kimura 1978).

The German Association of Third-Party, Accident, Motor Vehicle and Legal Protection Insurers, HUK-Verband, has used the revised AIS as presented in the 18th Conference of the American Association for Automotive Medicine (1974) for the following body regions: head and neck, chest, abdomen, extremities and/or pelvic girdle, general (HUK-Verband 1978). The HUK-Verband also uses the Overall Severity Index (OSI) for recording injury severities.

In Sweden, the Folksam Insurance Group uses the AIS with the ISS. In Finland, VALT (1984) uses the ISS and a modified AIS to numerically describe the overall severity of an injury or injuries to different body regions. The AIS, as used by VALT in Finland, and corresponding to the older U.S. version (Fenner 1969), is a scale from 1 to 9 (6-9 being different categories of fatality) for five body-region categories: general, head and neck, chest, abdominal, extremities and/or pelvic girdle.

IN-DEPTH PROGRAMS IN SELECTED COUNTRIES

Australian In-Depth Programs

Australia has had a variety of in-depth accident investigation programs over a period of more than 15 years. These comprised relatively informal sampling plans, but collection of great detail in such urban areas as Melbourne, Sydney, and Brisbane.

While the earlier programs typically included all types of vehicles and accidents, more recently there has been concentration on accidents of current high interest. The Victorian Road Traffic Authority studies pedestrian and bicyclist accidents. Sampling is based on hospital records, and includes all persons (of the appropriate category) admitted to any of five hospitals over a defined twelve-month period, plus a random 2/7 of those persons treated and released at the same hospitals. Injury data are recorded in a modified AIS/OIC code, using only the body region, injury type, and extent codes.

The Traffic Accident Research Unit (TARU) of New South Wales has recently completed an in-depth series of investigations for forward control vehicles (passenger vans), these being chosen because they were observed to be overrepresented in both accidents and injuries. A 1986 study at TARU concentrated on motorcycles, and particularly on head injuries. In these studies, injuries are recorded using the AIS but not the OIC. The numbers of cases are small, and injuries are reported in detail on written forms and pictorial sheets.

The University of Adelaide has conducted in-depth investigations in the past, and has used the AIS/OIC codes for injury recording. In addition, there has been some use of the CRASH and SMAC programs. These were evidently not used elsewhere in Australia.

Canadian In-Depth Programs

Canadian in-depth programs began in the 1970s in a manner similar to those of the U.S. Several university research organizations were contracted with to provide a modest number of in-depth investigations, with selection methods initially being defined by the investigators.

More recently there has been a sequence of programs, each lasting several years and specializing on one category of accident. Such a study of pick-up trucks and vans was completed about two years ago, and presently the activity is concentrating on passenger-car involvements.

Sampling in the present Canadian program seems similar to the procedures used in the 1977-1979 U.S. NCSS program, using existing teams in their own locales but implementing a random selection procedure for accidents occurring in those regions. The current program is producing approximately 2,400 accident reports per year with ten teams.

Injuries are recorded using both the AIS and the OIC scheme. A large number of detailed reporting forms is used, covering such topics as the scene, the vehicle, the damage, cargo, occupant and injury descriptions, child seats, vehicle motion and instability, mechanical failure, etc.

Currently the data are entered into local microcomputers by the team personnel and then forwarded by telecommunication to the University of New Brunswick for processing. The data are then nominally available for analysis, but outside users must request computer runs through Transport Canada.

Finnish Fatal Accident Reporting System VALT

One of the responsibilities of VALT is national fatal accident investigation and reporting. The adopted in-depth Fatal Accident Research Plan for 1985 (VALT 1984) is based on the VALT recommendation from 1981. This program has been developed for detailed investigation of essentially all fatal traffic accidents that occur in Finland. The work is largely sponsored by an insurance association, but is also supported by voluntary efforts of many companies, and governmental agencies, and individual citizens.

Fatal accident investigation is carried out by special accident investigation teams. A team usually consists of the following specialists: a police accident investigator, a vehicle engineer, a road and traffic engineer, and a medical doctor. In some cases, railway engineering and bus-body construction specialists as well as psychologists and other experts may serve on the investigation teams. The team's task is to report and investigate specified traffic accidents, and make traffic-safety-improvement recommendations based on results of the investigation. Each team member is assigned specific tasks and uses standard forms for reporting.

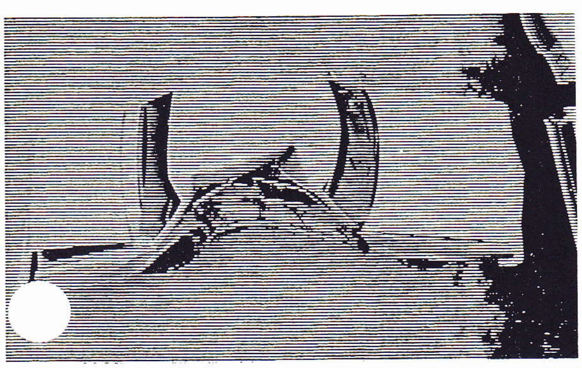
BASt In-Depth Accident Investigation Program (West Germany)

The BASt In-Depth Accident Investigation Program attempts to collect pertinent accident data immediately after an accident has occurred. Data collection is on-site and further information is obtained later from hospitals, car-body shops, junkyards, etc., using automotive, engineering, and medical experts. The program is carried out jointly by the Medical University of Hanover (Medizinische Hochschule Hanover, MHH) and the Technical University of Berlin (Technische Universität Berlin), supported by the police, local fire departments, and rescue service organizations.

The accident data collection is limited to the Hanover metropolitan area which has a population of 550,000. Between 1973 and 1983, data for about 2,000 sampled accidents were collected. Data are stored and handled using the Scientific Information Retrieval (SIR) system. The accident investigation team consists of one medical expert and two mechanical experts. Since 1984 the sampling procedure has been changed to reduce sampling and data collection and handling costs, and a coordinator has been added to the team. The coordinator receives all accident calls from police and local fire departments in a center, selects the accident to be investigated, and, by radio contact sends the team to the accident site. All injury accidents within the Hanover metropolitan area which occur during the team's active period of ten-hours-a-day form the sampling frame.

Swedish In-Depth Programs

The most detailed in-depth investigations in Sweden are conducted by the Volvo Corporation through follow-up of accidents involving vehicles which they have manufactured. About 45,000 accidents (in an insured population of about 300,000 to 400,000 cars) are reported to Volvo each year through their insurance operation which insures new cars for three or five years against damage. Of these 45,000 accidents, about 2,000 are serious enough to warrant reporting in greater detail and computer-file storage. Thirty to sixty cases are selected each year for in-depth investigation, the majority of them from Sweden, but a few from other European countries. For this smaller group, very detailed information is sought. Vehicle damage is recorded in such a manner that accident-reconstruction techniques can provide collision speed estimates. Occupant injuries are recorded using both the AIS and a modified (and much enhanced) Occupant Injury Classification scheme. Volvo data are used primarily by company personnel for redesign activities. Their results are published from time to time in the scientific literature.



The United Kingdom In-Depth Program

In-depth accident investigation has been underway in the U.K. for a number of years, but recently the U.K. has settled on a program with strict sampling procedures. Currently there are two major investigative teams — one at the University of Birmingham (covering a mostly urban region) and one at Loughborough (covering a mostly rural region). In addition, there are four smaller activities operating within the British Department of Transport which contribute data to the same composite file.

Final file construction is accomplished at Crowthorne under the auspices of the Transport and Road Research Laboratory (TRRL). Birmingham and Loughborough each produce about 350 accident reports annually. The current sampling frame includes passenger cars less than six years old. From this list, an attempt is made to cover all fatal accidents, 50% of the serious injury accidents (as defined by the police report) and 20% of the minor injury accidents.

Using the Statistical Package for Social Sciences (SPSS), both the Birmingham and Loughborough teams enter their data in digital form to build working files at the accident, vehicle, and occupant level. Data are subsequently forwarded to Crowthorne, where they are edited and combined into one national file — national representativeness being defined somewhat as in the U.S. NCSS program, with appropriate rural and urban representation from the two teams.

While many analyses of the U.K. in-depth data have been completed at the local level (i.e., at Birmingham and Loughborough), the national files are just now becoming available for use. The SPSS files produced by the field teams are transformed at TRRL into a database management system. TRRL found the latter system most convenient for editing, and had nearly completed this file at the time of our visit in December 1985. TRRL is evidently willing to make inquiries of these data on request at a cost. Overall direction of the program is provided by a committee that includes representatives from government and industry. The current studies of passenger cars five years old or less stem from a combination of the industry's interests in design and the government's interest in vehicle inspection and other factors. Presently these programs are sponsored 75% by the government and 25% by the automobile industry (British Leyland and Ford). These industrial participants have access to the data as needed. Other potential users are expected to request analyses of the data through TRRL.

SUMMARY AND CONCLUSIONS

The original purpose of this project was to document the state of accident reporting in many parts of the world, particularly as it applies to the development of vehicle manufacturing or performance standards. Obviously, greater consistency in the data would limit the uncertainties in such applications. There are currently many inconsistencies among nations in both the *threshold for accident reporting* and in the *detailed definition of variables* which make international comparisons difficult. For fatal accidents, these differences are somewhat less severe, and should permit useful international comparison for some variables. The definition of variables (particularly injury and vehicle damage scales) for *in-depth accident investigation* is reasonably consistent across national boundaries, and perhaps data files based on these investigations would be useful in studies of such international topics as vehicle standards. But there are still differences in coverage for in-depth studies that make it difficult to compare accident frequencies among nations.

Mass Accident Data Considerations

In order to aggregate traffic accident data over two or more jurisdictions or, for example, to make direct comparisons between accident or injury frequencies, the data should either represent the same kinds of populations or be adjusted to account for any differences.

Such an adjustment is sometimes done for fatal accidents, since different countries have different standards for reporting these. The U.S. used a one-year-from-date-of-accident rule for many years, but settled on a 30-day rule in connection with the present FARS program. Some countries have counted only those persons killed at the scene of the accident or dying before they reached a hospital. There have also been six-day rules, 90-day rules, etc. If the relationship between time of accident and time of death were stable and well known, and if there were no other problems (misreporting, variation in rules for inclusion as a traffic fatality), then data from various countries could be corrected to a common meaning and direct comparisons made. Indeed, such adjustments have been made, although relatively little has been done regarding the prediction of errors in the process.

For non-fatal accidents there seems to be more variation in reporting. Data sets might be considered equivalent if the following conditions are met:

1. THE THRESHOLDS FOR REPORTING ARE THE SAME. For example, some jurisdictions may require an accident to be reported if there is an injury requiring hospitalization, another may require a report if there is any injury or property damage exceeds a certain amount, another may require at least one vehicle towed from the scene, etc.
2. RULES FOR REPORTING ARE APPLIED IN THE SAME MANNER. There is considerable evidence that the actual reporting practices vary with local interpretation. If all accidents with a certain dollar damage are supposed to be reported, the chance of a report being made is much higher if a police officer attends the scene of the accident. In many jurisdictions drivers are supposed to make their own reports, but are evidently less likely to do so than is an officer.
3. SCALES ON WHICH COMPARISONS ARE TO BE MADE ARE THE SAME. For example, the common injury scale used in the U.S. has three grades of non-fatal injuries — *A* for a disabling injury, *B* for a visible but non-disabling injury, and *C* for a complaint of pain. By contrast, most European countries define the most severe non-fatal injury level as one requiring hospitalization of at least one day. There seems to be no method at present which would permit useful combination of injury data from two such jurisdictions.
4. SCALES ARE INTERPRETED AND APPLIED IN THE SAME MANNER. The application of scales for reporting injury (as well as other codes for reporting such information as vehicle damage, accident type, cause, etc.) depends on training and local interpretation. Even such a definition as *hospitalized* may not describe injury consistently because hospitals may be less available in one region than another.
5. NO (OR AT LEAST A MINIMUM OF) MISSING DATA. Every effort must be made to ensure that data is included that should be included, and that missing (e.g., unreported) data is minimized.

All of these considerations are also important to in-depth accident investigation, since in-depth cases are usually selected from a list of police-reported accidents.

The users of accident data lie on a kind of belief continuum. At the one end would be those who analyze and use the data without concern for possible biases, missing data, or recording errors. At the other end would be those who refuse to draw conclusions from the data until they completely understand the same factors and the methods for resolving them. In fact, probably no one exists at either extreme. Some may use raw and unqualified data to gain insight about a problem, and most will make some tests to get a better understanding of the data before drawing published conclusions.

There have been a number of examples of efforts to better understand traffic accident data. The World Health Organization survey provided a greater understanding of reporting practices in many countries. The FARS program in the U.S. has many built-in tests to ensure, or at least test for, completeness and accuracy. In the Netherlands, the

Country	Population	No. of Accidents	No. of Fatalities	No. of Injuries	No. of Vehicles
Sweden	8M	70.000	800	16,000	3.5M
Michigan (1984)	9M	335,193	1,550	150,740	6M
U.K.	56M	350.000	5.934	328.000	17.5M

SOURCES: Swedish data from Hans Norin, Volvo, Gothenburg, Sweden, November 30, 1985. United Kingdom data from International Road Federation (1984). Michigan data from state police accident records and Verway (1985).

Figure 3: Accident Statistics for Sweden, Michigan, and the U.K.

staff at SWOV has tested reported injuries in the police accident data against those in hospital data. In the U.S. National Crash Severity Study (NCSS), reported fatalities were tested against the FARS record for the same regions. In Hanover the in-depth data are compared to the sampling frame.

Hutchinson (1985) has recently reported on a comparison of traffic fatalities reported from death certificates and from police reports in a number of countries. Among non-European countries there were large differences in both directions. Columbia, in 1977, reported 3,676 certificated traffic deaths, 69% more than the 2,172 reported by the police. Sri Lanka, in 1978, reported 411 certificated traffic deaths, 52% less than the 864 reported by the police.

While the differences were smaller in European countries, England and Wales reported 11% more certificated traffic deaths than the police records indicated. In West Germany there was a 4% difference in the opposite direction.

This is explained by the fact that the rules for reporting are sometimes different for the two data sources. For example, death certificates may include persons who died on private property, or those who died more than thirty days after the accident, and this might partially explain the difference when the certificated deaths are higher.

The situation is apparently more uncertain with regard to injury and property damage counts. We have noted that Sweden, with a population about equal to that of Michigan, reports about one-fourth the number of accidents. The United Kingdom, with a population of 55 million, reports about the same number of accidents as does Michigan with its 9 million population. Data for these three jurisdictions is displayed in Figure 3, where different ratios of injuries to fatalities can be observed. For example, the ratio in Sweden is 20:1, in Michigan 97:1, and in the U.K. 55:1. It seems likely that injuries are defined differently in these three jurisdictions, but without further information it would seem risky to make inter-country comparisons of such items as injury rates.

The work of the World Health Organization in 1969 was a step toward a better understanding of the basis for traffic accident files in many countries, but much more should (and probably could now) be done in this regard.

In-Depth Standardization Activities

NHTSA sponsored a group of accident investigation programs in NATO countries in 1973 (Sethness et al. 1973). An accident report form was developed, based largely on the GM Long Form, and in-depth accident investigation activities were implemented in six European countries. This activity brought the Vehicle Damage Index (which has now become the Collision Deformation Classification), the Abbreviated Injury Scale, and other conventions into common use in the European community. While the NATO program lasted only about a year, there are remnants of it in the in-depth programs currently operating in Europe. Since that time there have been some important changes in the AIS and the VDI as used in the U.S., but the changes have not always found their way to Europe. It is also true that changes in European practice have not been reflected in the U.S.

In the U.S., the National Accident Sampling System was developed as a means to make national estimates (which had been made difficult by the variety of police reporting systems). While data in the NASS are not as detailed as in some previous Multidisciplinary Accident Investigation (MDAI) programs, much attention has been directed to recording injuries and vehicle damage precisely, while maintaining a proper statistical sampling procedure to represent the nation. Judgement sampling procedures have been used in most other countries for accident data collection, with considerable analytical effort to describe the representativeness of the samples. While there is relatively little formal coordination among nations in these in-depth programs, there are many similar procedures evident.

In-depth investigations continue in a number of countries—some sponsored by government agencies and some by industry. Methodology across these programs is more common than in the police reporting, but still shows considerable variation.

International Fatal Accident Files

Fatal traffic accidents constitute a special subset of all accidents, and data about them are important to program planning. In the U.S., a national fatality file, Fatal Accident Reporting System (FARS), has been created in a common format, relieving the problems occasioned by the various state reporting formats. Australia, another country with a variety of internal reporting methods, has taken a similar step in creating a national fatality file. Canada, on the other hand, has encouraged the various provinces to develop similar reporting formats, and is able to have a reasonably consistent national accident file with fatal accidents as a subset. Most other countries considered in this study have a common national reporting form, and thus the fatal accident data are available as a subset of the general accident file.

While it is intriguing to consider a universal accident report form (with perfect interpretation and a common severity threshold for reporting), the likelihood of this seems to be near impossible. Accident reporting systems have generally developed to meet local needs, not to satisfy scientists interested in international comparisons, and it is difficult to argue that satisfying the local requirements is inappropriate. In the U.S. it seems likely that state-designed forms will slowly become more alike. Still, the decisions to adopt or modify a general traffic accident report form will evidently be made at no higher than a national level, and often at the level of a state or province. It seems reasonable to attempt to move first toward a reasonably common format for reporting fatal accidents. An agreement may be possible not only on a definition of traffic death, but perhaps even on an implementation of a restricted set of variables, and training which would result in a useful fatal accident file.

This survey has illustrated both the unifying and divergent tendencies within accident reporting systems. Many advances have been, and are being, made. Standardization efforts are continuing, but much remains to be done before the most direct comparisons and analyses can be made. A follow-up study to this survey is currently being conducted by UMTRI among the worldwide community of accident researchers. In addition the OECD (Organization for Economic Cooperation and Development) has established a study group working toward the international harmonization of accident investigating and reporting parameters. The international transportation research community is now moving in a direction where research can directly affect both operating rules for traffic and standards for manufacturing on a worldwide basis. This effort should be applauded and its development encouraged. □

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