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WORLDWIDE ACCIDENT DATA STANDARDIZATION

VOLUME I

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16. Abstract <p>Information has been compiled on the state of accident data collection in a number of countries--both at the mass data (police report) level and at the in-depth level. In addition to a literature review, personal contacts were made with scientists and engineers in England, Germany, Sweden, Finland, Canada, and Australia to discuss current reporting practices for in-depth or case study reports.</p> <p>Police accident reporting forms usually contain almost the same kinds of material in all of the countries studied. This includes information about the location of the accident, time, personal characteristics of the drivers, injury, the environment, and some indication of causation. However, the local development of different conventions for recording such information, and differences in case selection procedures, make it difficult to aggregate data across national boundaries or to compare data from different countries.</p> <p>For in-depth or case study reporting, the Abbreviated Injury Scale is used rather consistently worldwide, although not all users keep up with the most recent modifications. The use of the Occupant Injury Classification (OIC) and the Injury Severity Score (ISS) is less universal, although both are used in a number of countries. The most common vehicle damage scale is the Collision Deformation Classification (CDC) or a version of its predecessor, the Vehicle Damage Index (VDI). These practices make the in-depth data more comparable than the mass data. However, since sampling for in-depth cases typically comes from a sampling frame of the police reports, variation in the coverage of police reporting among countries leads to uncertainty in some aspects of the in-depth data files.</p> <p>Some innovations in reporting methods were found in remote places, and it is judged that all could profit from a more frequent and closer communication on the methods for reporting accident information for case studies. It is recommended that a more formal survey be conducted using computerized communication and conferencing techniques during the next year.</p>					
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Gary Waissi

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INTRODUCTION

Traffic accident data are collected by police and processed by police and highway agencies throughout the world, but the protocols for such collection have been developed rather independently. In addition to making direct comparisons among countries difficult, such independent development may lead to variation or inconsistency in setting rules for traffic operation or standards for manufacturing.

A number of countries have fostered the operation of in-depth or multidisciplinary accident investigation programs, generally focusing on a subset or sample of all accidents. In such programs there is a greater opportunity for international standardization, and indeed, there is fairly 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) sponsored a conference in Vienna in 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.

At this conference there was general international agreement (within Europe) on the meaning of *killed* (dead), *serious injury* (admitted to hospital), and *slight injury* (not admitted). However, it was noted that not all countries conformed. Some countries counted fatalities that occurred only at the scene or before arrival at the hospital, while others counted fatalities up to one year after the accident. Similar variation was found in the implementation of injury codes. The committee's general recommendation was that public health epidemiologists 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.

Despite problems such as these, in most countries fatal accidents are assumed to be reported rather well, and it is likely that comparisons of fatality counts and rates among jurisdictions are more meaningful than accident or injury counts. The International Road Federation (IRF), for example, publishes national statistics including highway fatalities from time to time, and includes footnotes regarding those countries which depart from the generally accepted rule to include reports of deaths that occur within 30 days of the time of the accident (International Road Federation 1984).

INTRODUCTION

GENERAL METHODOLOGY

The purpose of this project has been 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 academia concerned with accident investigation and data processing in America, Europe, and Australia. The emphasis in these interviews was on in-depth methodology, but some information was collected about police-reporting methods in a number of countries. Both are considered in this report.

There are a number of countries which may have in-depth accident investigation programs but which have not been covered in this document. Most of the reporting has been limited to countries which were actually visited. The existence of active programs, coupled with a reasonable travel schedule, dictated the present choices. This report should not be viewed as a census of all such activities.

EUROPEAN COOPERATION ON SAFETY REGULATIONS

There are 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 the 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, Andreasen (1975) proposed the establishment of a uniform system for accident data reporting and recording within the EEC with funding from the EEC and the member states. The proposal included a 3-5 year time frame for creating the system. The goal was initially that EEC member countries would report annually information on road accident statistics using a standard format including vehicle and injury information. The proposed standard record layout and form are presented in Annex II of Andreasen's publication, and is reproduced in Appendix A of this report. 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. These authors indicated that the standardization proposed in 1975 had certainly not been achieved.

IN-DEPTH ACCIDENT INVESTIGATION STANDARDIZATION ACTIVITIES

The 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 (which in the U.S. has now evolved into the Collision Deformation Classification), the Abbreviated Injury Scale, 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 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, but statistical sampling procedures are used with 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 the various 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 (Ercoli and Negri 1985).

ORGANIZATION OF THIS REPORT

The remainder of this report is organized as follows. Chapter II presents a more detailed background and history of worldwide experience in accident data collection and processing. Chapter III addresses police accident data characteristics in various countries and discusses fatal accident reporting system in several countries in which special files have been developed. In addition, there is a brief discussion of exposure information. Chapter IV concerns in-depth accident investigation programs, including discussions of injury and vehicle damage scales, sampling procedures, and some alternate sources of accident and injury information. Finally, Chapter V presents a summary of the findings of this study.

INTRODUCTION

A reference list, list of contacts pertinent to this study, and a bibliography are included at the end of the text. A number of accident report forms currently in use are reproduced as appendices in Volume II of this report.

II. BACKGROUND AND HISTORY

This chapter concerns various international and national efforts in accident investigation and standardization. The first part of this chapter outlines a 1969 study by the World Health Organization (WHO). In this study, questionnaires were sent to all WHO member countries to determine the status of accident reporting, involved agencies, data collection, and some accident terminology definitions in use by the member countries. The study showed a great variability among the countries, but it also clearly boosted the discussion and interaction so that some countries (after the publication of the results) wanted to modify and clarify their answers. This, in turn, may have somewhat affected the national and local accident data collection recording, and led to refining of the definitions.

The second part of this chapter discusses the three-year accident standardization effort of the NATO Committee on Challenges of Modern Society (NATO-CCMS) by outlining the proposals made at the NATO-CCMS International Accident Investigation Workshop in 1973—particularly the Italian proposal to shorten the original NATO-CCMS report form, the U.S. proposal for a modified NATO Collision Analysis Report Form (CARF), and a Swedish proposal for uniform accident coding.

The third part of this chapter outlines the NHTSA tri-level accident investigation programs of the late 1960s. The fourth part presents information about three studies, each of which summarizes accident data collection, recording and reporting, accident type definitions, etc. in various parts of the world. The first of these, by Andreassend, reviewed accident reporting in twelve Asian countries; the second study by Ercoli and Negri reviewed reporting in eleven European countries; and the third study by Andreassen reviewed accident reporting in nine EEC member countries. The scope of countries of the two latter studies overlaps.

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, the WHO sent a questionnaire in 1969 to the member countries to find out details about their accident statistics. The questionnaire was in English and Spanish. 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.

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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. Table 1 summarizes the answers of the 61 countries. It can be noted that 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 reporting of fatal and non-fatal accidents was also ascertained from the member countries. Table 2 summarizes the number of countries and the types of agencies involved in fatal and non-fatal accident data recording and/or notification for statistical purposes only. It can be seen that 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 are publishing fatal accident statistics; the respective number for publishing non-fatal accident statistics is 46 out of 61. The number of jurisdictions publishing monthly fatal and non-fatal accident statistics were reported as 17 and 14 out of 61, respectively. The corresponding numbers for quarterly publications were seven and five.

The question concerning threshold for reporting a non-fatal accident was not answered by 24 of the 61 countries. Twenty-six countries gave a single condition, and eight countries listed multiple conditions. Most common requirements were: "report if a personal injury occurs, report if medical treatment or admission to hospital is required, report if accident causes a defined period of incapacity," and "report if property damage exceeds a specified amount."

The information on accident situations, accident causation, and injury severity collected routinely by the agencies are given in Tables 3 and 4. It can be noted that almost all the data elements were recorded in most of the countries. The number of countries recording the cause, nature of injury, and the place of occurrence of accidents is especially high.

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 stemming 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 a non-NATO member Sweden as observer). The following is a summary of proposals and statements made by the most significant contributors at the meeting (Ashton et al. 1973, Bohlin and Samuelsson 1973, Cromack 1973, Franchini 1973, Grattan 1973, Kuiperbak et al. 1973, Marsh 1973, Sethness et al. 1973, Stegmaier 1973, Swiercinsky et al. 1973, Treat 1973).

TABLE 1

SUMMARY OF THRESHOLD TIME DEFINITIONS FOR FATAL ACCIDENTS
FROM A WHO SURVEY OF 61 MEMBER COUNTRIES
IN 1969 (World Health Organization 1972)

	Threshold Time for Fatal Accidents							
	At the Scene	1 Week	30 Days	6 Months	1 Year	3 Years	No Time Limit	*
No. of Countries	7	5	12	1	7	1	10	18

*No definition of a fatal accident or definition unclear.

TABLE 2

NUMBER OF COUNTRIES AND TYPE OF AGENCIES INVOLVED IN
RECORDING AND NOTIFICATION OF FATAL AND NON-FATAL ACCIDENTS
FROM A WHO SURVEY OF 61 MEMBER COUNTRIES
IN 1969 (World Health Organization 1972)

	Agency Involved in Recording or Notification									
	Police		Hospitals		Out-Patient		Insurance		Other	
	R	N	R	N	R	N	R	N	R	N
No. of Countries Fatal	50	35	35	24	27	20	11	6	11	10
No. of Countries Non-Fatal	47	29	26	17	19	11	9	5	6	4

R = Recording, N = Notification for statistical purposes.

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TABLE 3

NUMBER OF COUNTRIES COLLECTING DETAILED
ACCIDENT INFORMATION AT ACCIDENT LEVEL
FROM A WHO SURVEY OF 61 MEMBER COUNTRIES
IN 1969 (World Health Organization 1972)

Type of Accident	Extrnl Cause	Nature Injury	Place Occur.	Month	Day	Time	Severity Based on	
							Type Injury	Restric. Activ.
Fatal	56	50	53	50	46	45	34	8
Non-Fatal	50	44	45	45	40	41	36	14

TABLE 4

NUMBER OF COUNTRIES COLLECTING DETAILED
ACCIDENT INFORMATION AT PERSON LEVEL
FROM A WHO SURVEY OF 61 MEMBER COUNTRIES
IN 1969 (World Health Organization 1972)

Type of Accident	Sex	Age	Marital Status	Residence	Profession	Handicap	Intoxic.
Fatal	53	56	36	42	35	24	36
Non-Fatal	47	51	28	35	27	23	32

The Italian report by Franchini (1973) proposed to shorten and restructure the original NATO-CCMS accident report form (Appendix B) 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 part 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 (for example, Stegmaier 1973). The new CARF is based on the original CARF developed by the U.S. from the protocol used in the Multidisciplinary Accident Investigation Program. The first CARF form version was called the *blue* CARF, and a later modified version of it the *yellow* CARF. Appendix D shows the modified *yellow* CARF forms as presented by Cromack (1973) in the NATO-CCMS project's final proceedings.

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. The proposal for accident types is divided into five categories: (1) collision between vehicles driving in the same direction; (2) collision between vehicles driving in opposite directions; (3) collision between vehicles at intersecting roads; (4) single-vehicle accidents; and (5) collision with pedestrians or large animals. The proposal for coding of driver behavior is divided into two main categories: (1) braking, and (2) steering. The third recording area, vehicle movements, is divided into two categories: (1) skidding, and (2) vehicle maneuver. A detailed listing of the proposed coding, including variable names, is given in Appendix C.

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

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 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

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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 states. One of the 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 for several reasons. Although many codes had been standardized through the work of National Safety Council committees, there was evidently much variation in interpretation 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 states-rights oriented, and have had common reporting forms at the national level for many years. The U.K. traffic accident reporting form (STATS-19) 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, to name a few, 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 various 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.

Comparison of Accident Reporting in Twelve Asian Countries. 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. Table 5 gives a summary of structure and operation of the accident data systems in the above twelve countries. Table 6 lists the availability of nine categories of accident data by country for ten of the above countries (with the exception of Bangladesh and India). The categories included are the following:

- Time and environmental data
- Location data
- Roadway data
- Involved vehicle(s) data
- Involved driver(s) data
- Post-accident data
- Casualty data
- Emergency services data
- Police administrative and investigation data

TABLE 5

PRESENT STRUCTURE AND OPERATION OF THE ACCIDENT DATA SYSTEMS
IN TWELVE COUNTRIES IN ASIA (Andreassend 1982)

Inquiry	Bangla- desh	Hong Kong	India	Indo- nesia	Iran	South Korea	Malaysia	Pakistan	Phillip- pines	Singa- pore	Sri Lanka	Thai- land
1. Government agency charged with traffic accident reporting: Police Department Motor Vehicle Licensing Agency Highway Department Highway Police Agency	X	X	X	X	X	X	X	X	X	X	X	X X X
2. An official report form is used for accident reporting and investigation	X	X	X	X	X	X	X	X	X	X	X	X
3. Report form is in: Local Language English Both				X	X	X	X	X	X	X	X	X
4. Person who completes report: Police Officer Driver Both police and driver Highway department personnel	X	X	X	X	X	X	X	X	X	X	X	X X
5. Police attend to ALL reported accidents	X	X	X	X	X	X	X	X	X	X	X	X
6. Investigation conducted by police: On Scene Off Scene	X	X X	X	X X	X	X	X	X	X X	X X	X	X
7. Severity of accidents reported: Fatal Personal Injury All Property Damage Property Damage with Cost Limits	X X X	X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X	X X X
8. Prescribed time required to report occurrence of accident: Right after accident Within 24 hours Within 48 hours No limit	X	X	X	X	X	X	X	X	X	X	X	X

TABLE 5 (Continued)

Inquiry	Bangla- desh	Hong Kong	India	Indo- nesia	Iran	South Korea	Malaysia	Pakistan	Phillip- pines	Singa- pore	Sri Lanka	Thai- land
9. Fatality means death: On the spot Within 3 days Within 21 days Within 1 year and 1 day No time limit				X					X			X
	X	X	X				X	X		X	X	
10. Types of Personal Injuries Reported:												
Serious Injuries	X	X	X	X	X	X	X	X	X	X	X	X
Slight Injuries	X	X	X	X	X	X	X	X	X	X	X	X
11. Legal limits of intersection is:												
Building or property line			X									ROW
Kerb (Curb) line	X			X	X	X	X		X	X	X	
No limits		X						X				
12. Are traffic accident statistics officially published:												
Yes	X	X	X	X	X	X	X	X	X	X	X	X
No												
Not aware	X											
13. Government agency that publishes traffic accident statistics:												
Police Department	X	X	X	X	X	X	X		X	X		X
Highway Police Agency					X				X			
Highway Department		X										X
Central Statistics Agency			X	X				X			X	
Transport Department												
14. Frequency of publication of accident statistical reports												
Quarterly	X		X				X					
Semi-annual			X					X				
Annual	X	X	X	X	X	X	X	X	X	X	X	
15. Accident data analysis uses:												
Computer facilities	X	X		X		X		X	X	X		
Manual system			*		X		X	X				*

*NOTE: Presently using a manual system, but there are plans to use computer facilities.

TABLE 6

INVENTORY OF TRAFFIC ACCIDENT DATA REQUESTED OR POTENTIALLY
AVAILABLE FROM ACCIDENT REPORT FORMS USED IN
TEN COUNTRIES OF ASIA (Andreassend 1982)

Data Item	Hong Kong	Indonesia	Iran	South Korea	Malaysia	Pakistan	Philippines	Singapore	Sri Lanka	Thailand (Highways)	Thailand (Police)
I. TIME AND ENVIRONMENTAL DATA											
Date (Month/Day/Year)	X	X	X	X	X	X	X	X	X	X	X
Day of Week	X	X	X	X	X	X	X	X	X	X	X
Hour of Day	X	X	X	X	X	X	X	X	X	X	X
Light Condition	X	..	X	X	..	X	X	X
Weather Condition	X	X	X	X	..	X	X	X	X
II. LOCATION DATA											
Political jurisdiction	X	X	X	X	X	X	X	X	X	X	X
Name of street, road, or highway	X	X	X	X	X	X	X	X	X	X	X
Highway section or control number								X	X	X	
Name of intersec. street, road, hwy	X	X	X	X	X	X	X	X	X		
Dist./direct. from nearest landmark				X	..	X	X	X	X		
Urban or rural				X	..	X	X	X	X		
Kind of locality or area				X	..	X					
III. ROADWAY DATA											
Road type	X	..	X							X	
Road surface type		*E	X	X		X	X			X	X
Road surface condition	X	*E	X	X		X	X		X		X
Road character	X		X	X		X	X		X	X	X
Obstruction to view				X		X	X		*E		
Street lighting	X			X		X	X		X		X
Pedestrian crossing	X			X		*E		X			X
Speed limits				X		X					X
Traffic conditions	X	X		X				X			X
Traffic lanes				X		X	X	X		X	
Traffic control devices	X			X		X		X			X
IV. INVOLVED VEHICLE(S) DATA											
Year of manufacture (age)	X			X		X	X		X		
Make	X			X		X	X	X	X	X	X
Type	X	X	X	X		X	X	X	X	X	X
Color	X							X			
Plate number	X		X	X		X	X	X	X	X	X
Registry class				X			X	*E			
Place of registration				X		X	X				
Recent inspection data			X								
Owner's name and address				X		X	X	X			
Vehicle defects	X			X		X	X		X	*E	X
Parts damaged	X	X	X	X		X	*E	X		X	
Insurance coverage	X		X				X	X			
Estimate of damaged parts	X	X	*E	X		X	X	*E		X	X

TABLE 6 (Continued)

Data Item	Hong Kong	Indonesia	Iran	South Korea	Malaysia	Pakistan	Philippines	Singapore	Sri Lanka	Thailand (Highways)	Thailand (Police)
V. INVOLVED DRIVER(S) DATA											
Name	X	X	X	X	X	X	X	X	X	X	X
Age	X	X	X	X	X	X	X	X	X	X	X
Address	X	X	X	X	X	X	X	X	X	X	X
Sex	X	X	X	X	X	X	X	X	X	X	X
Occupation	X	X	X	X	X	X	X	X	X	X	X
Nationality/Religion/Race	X	X	X	X	X	X	X	X	X	X	X
Language spoken	X	X	X	X	X	X	X	X	X	X	X
Driving experience	X	X	X	X	X	X	X	X	X	X	X
Personal account of accident	X	X	X	X	X	X	X	X	X	X	X
License number	X	X	X	X	X	X	X	X	X	X	X
Type of license	X	X	X	X	X	X	X	X	X	X	X
Date and place of issue	X	X	X	X	X	X	X	X	X	X	X
VI. POST-ACCIDENT DATA											
Severity (fatal, injury, damage)	X	X	X	X	X	X	X	X	X	X	X
Type of accident	*E	*E	X	*E	*E	*E	X	*E	*E	*E	X
Type of collision	*E	*E	X	*E	*E	*E	X	*E	*E	*E	X
Property damage other than vehicle	X	X	X	X	X	X	X	X	X	X	X
Non-vehicular property damage estimates	X	X	X	X	X	X	X	X	X	X	X
Driver action	*E	X	*E	X	X	X	X	*E	X	*E	E
Driver physical condition				X	X	X	X	X	X	X	X
Driver violation or offence				X	X	X	X	X	X	X	X
Driver under influence drug/alcohol				X	X	X	X	X	X	X	X
Pedestrian action				X	X	X	X	X	X	X	X
Pedestrian condition	*E	X		X	X	X	X	X	X	X	E
Animal action				X	X	X	X	X	X	X	X
Accident diagram	X	X	X	X	X	X	X	X	X	X	X
Accident description	X	X	X	X	X	X	X	X	X	X	X
Name and address of witnesses	X	X	X	X	X	X	X	X	X	X	X
Hit-and-run cases	*E	X	X	X	X	X	X	X	X	X	X
VII. CASUALTY DATA											
Number of fatalities	*E	*E	X	X	X	X	X	*E	*E	X	X
Number of injuries	X	*E	X	X	X	X	X	*E	*E	X	X
Road-user category	X	*E	X	X	X	X	X	*E	X	X	X
Severity classification	X	*E	X	X	X	X	X	*E	X	X	X
Name	X	X	X	X	X	X	X	X	X	X	X
Age	X	X	X	X	X	X	X	X	X	X	X
Sex	X	X	X	X	X	X	X	X	X	X	X
Address	X	X	X	X	X	X	X	X	X	X	X
Occupation	X	X	X	X	X	X	X	X	X	X	X
Personal account of accident	X	X	X	X	X	X	X	X	X	X	X
VIII. EMERGENCY SERVICES DATA											
Vehicle towed by ___ to ___	X	X	X	X	X	X	X	X	X	X	X
First aid	X	X	X	X	X	X	X	X	X	X	X
Injured taken by ___ to ___	X	X	X	X	X	X	X	X	X	X	X
Name of hospital	X	X	X	X	X	X	X	X	X	X	X
Next of kin informed	X	X	X	X	X	X	X	X	X	X	X

TABLE 6 (Continued)

Data Item	Hong Kong	Indonesia	Iran	South Korea	Malaysia	Pakistan	Philippines	Singapore	Sri Lanka	Thailand (Highways)	Thailand (Police)
IX. POLICE ADMINISTRATIVE AND INVESTIGATION DATA											
Date and time notified	X	X					X				
Police notified by ___	X	X		X	X			X			
Time of arrival at scene	X		X			X					
Investigation conducted at scene	X		*E	X	*E	X					
Identification of evidence	X	X		X	X						
Photographs	X			X	*E	X					
Investigator's recommendation	X	X		X	X		X				X
Disposition of case	X			X	X		X				X
Enclosures	X			X			X				
Investigator's identification	X	X	X	X	X	X	X	X	X	X	X
Data report is made											
Report to be approved by ___	X			X			X		X		X
Date of approval	X						X				
Reporting police agency or unit	X	X	X	X	X	X	X	X	X	X	X
File/Report Number	X	X	X	X	X	X	X	X	X	X	X

*NOTE: E denotes data item does not specifically appear in the form but can be potentially extracted from some related data items.

BACKGROUND AND HISTORY

Comparison of Accident Reporting in Eleven European Countries. The research by Ercoli and Negri (1985) was motivated by setting up a standardized reporting system for road accidents throughout Europe. They compared the present forms from Belgium, Denmark, France, Italy, the Netherlands, Portugal, Spain, Sweden, the United Kingdom, West Germany, and Yugoslavia.

The authors developed a chart depicting the items of each country's form in a hierarchical fashion. The published paper contains such charts only for the Italian form. They then categorized each of the questions on the form as one of three types:

LOOSELY DESCRIPTIVE: questions which do not have a reasonable quantifiable result,

LOOSELY QUANTIFIED: "which envisage numerical replies in an area of specified variation," and

CLOSED: "where the replies are precoded, and to each alternative reply is assigned a numerical value."

They developed a *resemblance index*—a sort of correlation coefficient telling how alike or different any two forms are. A table is included that shows the value of this index for every possible pair among the eleven countries. A value of 1.0 would indicate two forms that were exactly alike; a value of 0.0 would indicate two forms that had no common responses at all. 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 finally suggest 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 suggest 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

Each of the groups is further detailed. For example, the proposed articulation of the person items includes: descriptive data (if the person is other than the driver and/or the pedestrian); place occupied in the vehicle; physical consequences (superficial wounds, serious wounds, death); and reference number to hospital case.

They propose that detailed injury data should be obtained from medical sources, and that such data would probably not be a part of the survey phase of the accident data collection.

It was found that, in 24 survey topic areas, 1,364 different response specifications were given in these countries. Of the 1,364 specifications, 930 were found in only one form, 222 in two forms, and 97 in three forms. Time and date were the only items in all forms. A summary of the eleven major categories is given in Table 7 (Nilsson 1985, Ercoli and Negri 1985).

TABLE 7

SUMMARY OF ACCIDENT REPORTING DATA CATEGORIES
OF A SURVEY OF ELEVEN EUROPEAN COUNTRIES
(Nilsson 1985, Ercoli and Negri 1985)

Item	Data Category Description	Recorded in Accident Forms
1	Date and time	All countries
2	Location definition by graph or location coding	All countries
3	Roadway category, usually road classification according to importance	
4	Pavement information (material, surface, characteristics, condition, etc.)	Not recommended in many countries
5	Roadway characteristics recorded, but specification differences in, for example, traffic regulations, curves, etc.	Most countries
6	Obstacles in the roadway	One country
7	Weather conditions recorded	All countries
8	Vehicle type specification	Most countries
9	Safety and/or mechanical deficiencies in vehicle, and extent of impact	Most countries
10	Persons involved: Many aspects are recorded, varying from country to country. (Examples: driver age, sex, driving experience, driver license category, drunkenness, trip purpose, travel time, profession). Further recorded are injuries and fatalities, and in some cases, injury type and severity using hospital documents.	Varies from country to country
11	Recording of accident type varies from graphical presentation to accident-type coding.	Varies from country to country

Comparison of Accident Reporting in Nine European Countries. Andreasen (1975) compares the accident reporting forms of the nine European EEC member countries with respect to the three following categories: availability of data on accident factors, unit factors, and human factors.

Table 8 on accident factors contains six items: time of accident, year, type of area (urban, other), visibility (poor, normal), road condition (poor, normal), and accident type (ten accident types according to ECE classification). Andreasen states that, for accident

BACKGROUND AND HISTORY

TABLE 8

AVAILABILITY OF DATA ON ACCIDENT FACTORS
IN THE EEC IN 1975 (Andreasen 1975)

Item	Country*								
	B	FRG	DK	F	I	IRL	L	NL	UK
Time of Accident	x	x	x	x	x	x	x	x	x
Year	x	x	x	x	x	x	x	x	x
Type of Area									
Urban	x	x	x	x	x	x	x	x	x
Other	x	x	x	x	x	x	x	x	x
Visibility									
Poor	x	x	x	x	x	x	x	x	x
Normal	x	x	x	x	x	x	x	x	x
Road Conditions									
Poor	x	x	x	x	x	x	x	x	x
Normal	x	x	x	x	x	x	x	x	x
Accident Type**									
0	x	x	x	x	x	x	x	x	x
1-2	9)	1)	9)	2)	9)	9)	1)	9)	1)
3-4	9)	1)	9)	3)	5)	9)	1)	9)	1)
5-6	9)	1)	9)	4)	5)	9)	1)	9)	1)
7-9	9)	9)	9)	9)	9)	9)	9)	9)	9)

NOTE: An x indicates that data are recorded in the accident forms; 1) to 5) indicate that accident types are combined with the same number indicating one accident type. A 9) indicates that accident types are defined separately.

* B=Belgium, FRG=West Germany, DK=Denmark, F=France, I=Italy, IRL=Ireland, L=Luxembourg, NL=Netherlands, UK=United Kingdom.

** All accident types according to ECE regulation.

factors, "the factors of time, nature of area, visibility and road condition are already described in such a detail in national systems [of the EEC member countries], that consideration can be given to provide further breakdown of the categories of visibility and road conditions." It can be noted that 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. Also, other European countries, e.g., Finland (VALT 1984), have adopted the ECE accident-type categories in a slightly modified form, as will be described in Appendix H.

BACKGROUND AND HISTORY

Table 9 on road and unit factors depicts two items: type of unit (private motor cars, light goods vehicles, heavy goods vehicles, public services vehicles, motorcycles, mopeds, bicycles, and pedestrians) and road type (motorway, roads with more than two lanes, roads with two lanes, and other types of roads). Andraesen states that, for unit factors, the categories *are almost complete*, the only unclear issue being the criteria for differentiating between light and heavy trucks. A 3,000 kg gross weight as a limit is proposed. He points out that only two countries record the road type, and that this of primary importance for international comparisons.

TABLE 9
AVAILABILITY OF DATA ON UNIT AND ROAD FACTORS
IN THE EEC IN 1975 (Andraesen 1975)

Item	Country*								
	B	FRG	DK	F	I	IRL	L	NL	UK
Type of Unit									
Private Cars	x	x	x	x	x	x	x	x	x
Light Trucks**	(x)	x	x	x	(x)	(x)	1)	1)	1)
Heavy Trucks**	(x)	x	x	x	(x)	(x)	1)	1)	1)
Public Vehicles	x	x	x	x	x	x	x	x	x
Motorcycles	x	x	x	x	x	x	x	x	x
Mopeds	x	x	x	x	x	x	x	x	x
Bicycles	x	x	x	x	x	x	x	x	x
Pedestrians	x	x	x	x	x	x	x	x	x
Road Type	(x)	x	x	x	(x)	(x)			(x)
Motorway			x	x					
>Two-Lane Roads			x	1)					
Two-Lane Roads			x	1)					
Other Roads			x	1)					

NOTE: An x indicates that data are recorded in the accident forms; 1) indicates that the respective categories are combined in the country. An (x) indicates that the recording is done but not in accordance with the ECE regulations.

* B=Belgium, FRG=West Germany, DK=Denmark, F=France, I=Italy, IRL=Ireland, L=Luxembourg, NL=Netherlands, UK=United Kingdom.

** Light truck, gross weight <3,000 kg; heavy truck, gross weight >3,000 kg.

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Table 10 contains five items: seating position in vehicle (driver, front-seat passenger, other passengers), age (00, 01, ..., 99), sex (male, female), degree of intoxication (0.00, 0.01, 0.02, ... in %), and injury (death, serious injury, minor injury, uninjured). Andreasen states that, for human factors, "all the listed items are included in the national systems [of the EEC member countries], and all of them are well covered."

TABLE 10
 AVAILABILITY OF DATA ON HUMAN FACTORS
 IN THE EEC IN 1975 (Andreasen 1975)

Item	Country*								
	B	FRG	DK	F	I	IRL	L	NL	UK
Seating Position									
Driver	x	x	x	x	x	x	x	x	x
Front-Seat Passenger	x	1)	x	x	1)	x	1)	x	x
Other Passengers	x	1)	x	x	1)	x	1)	x	x
Age									
00,01, ..., 99	x	x	x	x	x	x	x	x	x
Sex									
Male	x	x	x	x	x	x	x	x	x
Female	x	x	x	x	x	x	x	x	x
Degree of Intoxication									
0.00,0.01,0.02, ... (%)	x	x	x	x	x	x	x	x	x
Injury Severity									
Death	x	x	x	x	x	x	x	x	x
Serious Injury	x	x	x	x	x	1)	x	x	x
Minor Injury	x	x	x	x	x	1)	x	x	x
Uninjured	x	x	x	x	x	x	x	x	x

NOTE: An x indicates that data are recorded in the accident forms; 1) indicates that the respective categories are combined in the country.

* B=Belgium, FRG=West Germany, DK=Denmark, F=France, I=Italy, IRL=Ireland, L=Luxembourg, NL=Netherlands, UK=United Kingdom.

III. 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, particularly with regard to representativeness, of in-depth accident investigation programs, 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. Two-thirds of all pedal-cyclist casualties attending hospital had not been officially reported.

By contrast, recent work in the Netherlands [D.20]¹ 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 KABCO, in which *K* is killed, *A* indicates that the person was incapacitated, *B* a visible but non-incapacitating injury, *C* a complaint of pain, and *O* uninjured. (See Chapter IV for details about injury scales.) 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

¹Numbers in brackets indicate personal contact, trips, or visits. A listing is included at the end of the text.

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have only one code, and some have several. Analyses of U.S. data lead to the conclusion that the *A* injury tag of the KABCO scale is not a very good indicator of hospital admission, and indeed, that there are many persons with *A* injuries whose severity are far from serious. Further, because of variations in training or policy, the distribution of *A*, *B*, and *C* injuries varies markedly from one jurisdiction to the next. In a study conducted by Scott and Carroll (1971), in which state-to-state variation in injury distributions was considered, it is suggested that either reporting is inconsistent or that the populations are much different—the former being the most likely.

There are similar variations in vehicle damage scales at the police level. The TAD (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.

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 trees and utility poles. Another region may identify them separately. Such variations again make it difficult to aggregate the data across jurisdictions. It will be noted below that the Australian national file was able to identify only two types of accidents, single or multi-vehicle, although every state form provided much more detail than that.

In this section of the report, information about the present police accident report system (and some extensions of these in a number of countries) is presented. Completeness of coverage has not been investigated, nor in general, have we looked at misreporting or missing data rates. Information about these topics is certainly important to an understanding of the data for international comparisons and for determining the representativeness of samples used in in-depth studies.

As a part of this program, a number of accident report forms have been acquired, and these are provided as appendices to this report.

STATE REPORTING SYSTEMS IN THE U.S.

This topic is addressed mainly as a reference point for the observations from other countries. In the years since the federal highway safety establishment came into existence, each state in the U.S. has (1) adopted common form for reporting throughout the state, and (2) put the resulting data into a computerized form for use by various state agencies concerned with operation and planning.

While there is still much variability in the actual reporting forms and in the threshold for inclusion of an accident in the official statistics, the influence of both the National Safety Council (in compiling national statistics) and the ANSI D-20 committee efforts (American Association of Motor Vehicle Administrators et al. 1980) have led to common coding protocols for many data elements.

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 some 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 collect 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 in the FARS, gather pertinent data, and code the data onto three forms: the accident level, vehicle/driver level, and person level forms (see attached versions of 1983 coding forms). The data are then forwarded to NHTSA's National Center for Statistics and Analysis in Washington, D.C. 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*. This manual is 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. The system allows the analyst to update the data at any time. While the data are being entered, an edit check in two parts is carried out. The first part, a range check, looks for invalid code numbers, and the second part, a consistency check, reports discrepancies such as coding time as 1:00 pm and light conditions as "dark" (Sebastian 1981).

Effort is placed on consistent, complete and accurate reporting, recording, coding, and analysis of the data. Unknown data are often not compensated for in the annual report. Various mathematical and statistical methods are used to detect errors in coded data and to estimate missing data. The Chi-square analysis method and pilot studies are applied to coded data to detect errors, and the EM algorithm method is used to estimate missing data.

Chi-square analysis (Dougan et al. 1980) of the 1978 FARS analytical file indicates possible coding errors in the individual states. The distributions for coding variables were determined for the entire country, and then compared to distributions of the variables for individual states. A large Chi-square value on a variable indicates that the state deviates from expected levels. One concern of particular importance is the completeness of coding. By use of this statistic the number of blank responses for each variable in each state was calculated. This information is useful, since the number of analysts in each state are assigned according to the expected number of fatal cases. There were 63 analysts in 1978, one analyst in most of the states, and two or more in a few states. Any detected coding errors can therefore be narrowed down to a personal level, and needed improvements in coding can be implemented by interaction with one analyst in most of the states.

Pilot studies are another method of determining error rates in coding of FARS files. The general method involves selecting a group (usually states) that will be representative of the nation as a whole, and compare coded cases from these groups to control cases. Comparisons of results may indicate specific areas of coding problems or inconsistent coding among the different groups (Dougan et al. 1980).

Two general methods are used for missing data estimation. One is based on regression analysis when data are continuous, the other is the EM algorithm for discrete data. The EM algorithm readily lends itself to computer applications. The EM algorithm has two main steps (see Dougan et al. 1980 for details of the EM algorithm):

1. E - Expected Step: A current estimated model is used to predict missing data.

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2. M - Maximum Step: "Maximum likelihood" estimation of cell probabilities, using predicted missing data from the E-step, along with all other data.

The data exist in the data bank in three forms: the master file, the analytical file, and the annual report. The master file consists of data as submitted by the analyst, and it is updated with new information weekly. The analytical file contains reformatted data, with identifying information such as names, addresses, and social security numbers omitted. The annual report contains the highlights of the previous year's data and is divided into eight sections: Fatality Trends, Alcohol: Safety Belt Factors, Fatality Profile, State Statistics, Accidents, Vehicles, Occupants, and Non-Occupants. Both the analytical file and annual report are available to the public (NHTSA 1983).

To qualify for inclusion in FARS, the fatal accident has to (Sebastian 1981)

1. involve a motor vehicle while in transport on a roadway customarily open to the public,
2. have resulted in the death of the injured occupant within 30 days of the accident date, and
3. not have been the result of a natural disaster.

While there may still be some uncertainties in the FARS data, it is accepted by most in the U.S. as being a rather 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 rather complete coverage because fatal accidents are well investigated and reported in all states, and provides a level of detail useful to national planning.

Copies of the present FARS report forms are shown in Appendix J.

ACCIDENT REPORTING SYSTEM IN 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 by the officer and reported in dollars in all five provinces.

The Quebec report form is quite different from these first five. Aside from using the French language, the injuries are coded in just four levels (dead, major, minor, and no apparent injury). There is a twelve-level pictorial selection of accident configuration, but the codes are quite different from those discussed above. The officer is asked to show the vehicle damage—areas by shading a picture of a car and to estimate damage in one of three categories: less than \$250, \$251-\$499, and \$500 or more. Pre-crash direction of travel is to be reported on an eight-point compass rose.

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 codes are all different, and could not be easily combined with those of the provinces discussed above. Injury status in Ontario is coded in five levels: none, minimal, minor, major, and fatal. In addition to these, two codes are added: drowning and asphyxiation. In the present form, vehicle damage is coded on a twelve-point compass rose.

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.

Injury severity in Alberta is coded as minor, major, and fatal. Manitoba codes minimal (no hospital treatment), minor (treated and released), major (admitted), fatal, and injured extent not specified.

Vehicle damage is reported in dollars in Manitoba, in dollars with a pictorial description in British Columbia, and on an eight-point compass rose in Alberta.

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). Vehicle damage is reported as disabling, functional, none, or other; and repair cost is to be estimated. The Northwest Territories seem to be unique in including both a vehicle identification number (VIN) and an odometer reading. Injury codes are not indicated on the form, and an instruction sheet was not immediately available to the authors of this report.

The threshold for reporting accidents in Canadian provinces varies. It is evidently legitimate to complete an accident report form for a non-reportable accident. British Columbia provides a code on the report for "non-reportable under \$400, no injury or death." Manitoba has a statute that requires reporting of an accident causing injury or death, or property damage in an amount apparently exceeding \$500. The report may be made by the driver if an officer had not attended the scene.

Transport Canada [D.7] has concluded 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.

Copies of the Canadian provincial and territorial accident report forms are included in Appendix K of this report.

ACCIDENT REPORTING IN 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

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capability to aggregate the reported data at the federal level with the kinds of detail available locally. Copies of police accident-report-forms from South Australia, Queensland, Tasmania, Western Australia, Victoria, and one other with the jurisdiction not indicated on the form, are provided in Appendix E.

Briefly, they are so different that it is very difficult to combine data from various states in a useful file. The Australia Bureau of Statistics has long had a national accident file, but because of the different codes used, they wound up with only two accident types: single vehicle and multiple vehicle.

Individual states had much more detail available, both on the report form and in the computer files. For example, Queensland's code 1 is "hit parked vehicle;" Victoria's code 1 is "collision of vehicle with other vehicle (include bicycle);" South Australia's code 1 is "rear end;" Tasmania does not provide an accident type coding, but the officer is required to draw a diagram of the situation and code what each unit was doing. In the computer files, Victoria at least uses a version of the road user movement (RUM) code as described by Andreassend (1983). A somewhat different version of the RUM coding is used in the Australian Fatal Accident file, necessitating a recoding of Victoria's data for that file.

Injury coding in Australia varies slightly from state to state. Western Australia codes in three levels: admitted to hospital, required medical attention, and did not require medical attention. Victoria's codes are similar, but provide for fatal and uninjured. South Australia codes the part of the body injured (head, chest, multiple, internal, shock, limbs, neck, other), and five levels of treatment (not treated, treated by private doctor, treated at hospital, admitted to hospital, and fatal).

As regards vehicle damage reporting, South Australia estimates the cost of repair in dollars, codes damage as slight, moderate, or extensive, and records whether or not the vehicle was towed from the scene. Queensland does the same, but adds a diagram indicating location of damage. Victoria has a different diagram for recording damage area, and also estimates damage in dollars. Western Australia provides for a description of the damage (in one line about 2-inches long), estimating the dollar cost of the damage, and reporting whether the vehicle required towing. Tasmania reports only whether the vehicle was towed from the scene.

Individual states have a variety of remarkably useful information. Victoria, for example, is presently coding geographic location into an x-y coordinate system based on the popular Melway Guide, and probably has the best geo-coding of accidents extant. Western Australia has long had excellent coverage of fatal accidents. Members of a five-person state-police fatal squad devote about one man-week to the investigation and reporting of each fatal accident.

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).

Data collection was accomplished in somewhat different manners in the individual states because of local procedures. In New South Wales, for example, coroner reports are retained at the local courthouses, and arrangements had to be made to borrow such reports (by mail) for analysis. In Victoria, copies of the coroner's reports were attached to

the police reports in a centralized file in Melbourne, and nearly all data could be acquired at one site. In Western Australia, the data forms were completed by personnel in the police department because of the state's confidentiality procedures.

Data are recorded on three card types: one for the accident variables, one for the vehicle variables, and one for the person variables. Complete forms and coding instructions are contained in the referenced document. Some coding difficulties have resulted from differences in coding in the original state/territory reports. For example, the road user movements code (RUM) is generally derived from reading the report, but the State of Victoria assigns the RUM coding in their basic form. However, the Victoria RUM codes are somewhat different from those used in the fatal accident file, and it was necessary to translate these carefully by hand.

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 are in preparation by a contractor as of this writing.

A road accident is defined in the Australian fatal accident reporting system as follows:

Any apparently unpremeditated event reported to the police or other relevant authority, and resulting in death, injury, or property damage attributable to the movement of a road vehicle on a road (Scott and Furphy Engineers 1985).

For inclusion in the fatal accident reporting system the event must result in death within 30 days of the accident. Data elements in the fatal accident report forms are presented in Appendix E.

ACCIDENT REPORTING IN THE UNITED KINGDOM

Traffic accidents are reported in the United Kingdom by police officers filling out a form known as STATS-19. This form has been modified from time to time, but the current version is in use throughout the U.K. [D.8].

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 where ICDA (Public Health Service 1962) codes are used 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.

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The active analysis program with the STATS-19 data at TRRL helps to discover shortcomings of the data. Several years ago 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.

A copy of the STATS-19 forms is contained in Appendix F.

ACCIDENT REPORTING IN DENMARK

The traffic accident reporting system was revised in Denmark during the 1970s (Andreasen 1975) and a new system came into effect in January 1976. Most of the data are collected using police reports. Expert opinion is used to obtain specific information, e.g., injury severity, etc. 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 four forms was introduced in order to satisfy the needs and requirements of the above data supplier, data processor, and data-user groups. The four forms and their use are:

1. PRELIMINARY REPORT FORM: This form is prepared by police and is sent to the Department of Statistics (Danmarks Statistik) 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.

For inclusion into the official statistics the report should be:

Restricted to such minor injuries, as seem [at least] to indicate that the injured person will be totally, or partially, incapable of carrying out his/her ordinary work until the day following the accident at the latest; ordinary work is defined as going to work, school, looking after home, etc. Accidents including a fire are always included.

In all forms the goal has been to use extensive coding, providing separate coding instructions, and attempting to minimize verbal descriptions. The coding of the forms is

done using coding instructions and a code sheet. The code sheet is divided into two main categories: description of locality and description of accident (Appendix G). The first one of these is divided into seven groups describing various aspects of the accident location such as development of the area (urban, rural, residential, etc.), intersection, road condition, weather condition, light condition, and illumination. The second, description of accident, is divided into two groups describing the vehicle(s) and persons involved such as vehicle information, road obstructions and type, pedestrian crossing, presence of traffic signals, estimated speed, information on persons involved, injury severity, cause of injury, intoxication, use of seat belts, etc.

ACCIDENT REPORTING IN 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. Nilsson [D.3] reported that he had conducted a short study in one region of Sweden of accidents reported to three agencies: hospitals, police, and insurance companies. He concluded that the overlap in coverage of all three was relatively small, and that any one did not well represent the Swedish accident population. Serious injury was defined as an injury that would keep a person in the hospital more than overnight for observation.

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 level). This suggests either a much lower accident and injury frequency in Sweden, or a considerable amount of underreporting.

Nilsson has tabulated road-user accidents to include single-vehicle bicycle and pedestrian crashes as well as lone pedestrians (e.g., those who slip on the ice and are injured by the fall). About half of all persons hospitalized for serious injury were pedestrians who were not involved with a motor vehicle at all, and consequently did not appear in the police statistics for traffic accidents.

ACCIDENT REPORTING IN 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

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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). Three major accident statistics programs are outlined:

1. The Official German Road Accident Statistics (die Bundesstatistik der Strassenverkehrsunfälle) covering all accidents reported to police since 1953 (Bureau 1985, B.24).
2. 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 (Langwieder 1986, Nygren 1984, HUK-Verband/German Association of Third-Party, Liability, Accident, and Motor Traffic Insurers 1975, HUK-Verband/German Association of Third-Party, Liability, Accident, and Legal Protection Insurers 1978).
3. The BAST In-Depth Accident Investigation Program (Bundesanstalt für Strassenwesen-BAST: Erhebungen am Unfallort) operated in the Hanover metropolitan area since 1973 by the Road and Traffic Administration (Löffelholz 1986).

The first and second of these statistics are discussed in this chapter. The third, BAST in-Depth Accident Investigation Program, is outlined in Chapter IV.

Official German Road Accident Statistics. 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 and reported on standard forms:

- **GENERAL ACCIDENT DATA:** 50 data elements including time, date, place/location (road, intersection), type of road and code, condition of road, pavement type, weather, illumination, ten accident types, type of traffic control, possible accident cause (intoxication, etc.), hit and run, number involved, number of fatalities, severe and minor injured, estimated total value of property damage, sketch of accident.
- **INVOLVED PERSONS:** 20 data elements including name, age, address, profession, driver-license years, vehicle type and manufacturer, vehicle model, vehicle license number, weight, injury severity of involved persons (fatal, severe, minor), estimated value of property damage for involved vehicles, other property damage, witnesses.
- **INJURED PASSENGERS:** 3 data elements including age, sex, and injury severity.

The actual on-site accident data recording is done by police using the standard accident report forms (Bierau 1986). These forms are reproduced in Appendix I of this report.

Bierau (1986) mentions that important data elements are not included or are not detailed enough in the official statistics. More information is needed for such elements as type of driver license, degree of intoxication, description of injury severity and injury-type classification, vehicle description (engine size, vehicle color), and extent of vehicle damage. He further points out that the official data are not directly accessible to the public, but specific data analysis may be requested.

HUK-Verband Accident Statistics. 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, *Interior Safety of Automobiles* (B.22) in 1969, 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. Between 1969 and 1975, a total of more than 100,000 injury accidents were investigated (HUK-Verband 1978, 1975).

In 1974, the HUK-Verband (1978) collected data on 15,000 motor vehicle accidents which resulted in passenger injury. The 1974 accident data were recorded without any grouping, but the accident data for the years after 1974 is subjected to categorization into four groups: number of total accidents for cars in service three years or less, for belted drivers, for occupants killed in the accident, and for accidents with child occupants.

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."

As a result of two studies (B.22 and B.23 as reported by HUK-Verband in 1973), it was concluded that the evaluation approximately 10,000 accident cases is required periodically to make statistically significant conclusions from the accident data, and that the results differ little if it is extended to cover 30,000 cases. Reliable description of general accident factors using 10,000 cases was shown to be possible provided that the evaluation is based on a representative sample.

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. Examples of the three forms (accident form, vehicle form, person form) are shown in the Appendix I, Figures I.1, I.2, and I.3 (original Figures 1, 3, and 5 in HUK-Verband 1978). In addition to coding of the forms, site sketches were prepared by hand, photographs were taken, verbal description of the accidents were made, and accident reconstructions (based on site investigations) were carried out. 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. Figure 1 shows the flow chart for the evaluation procedure used in the data processing.

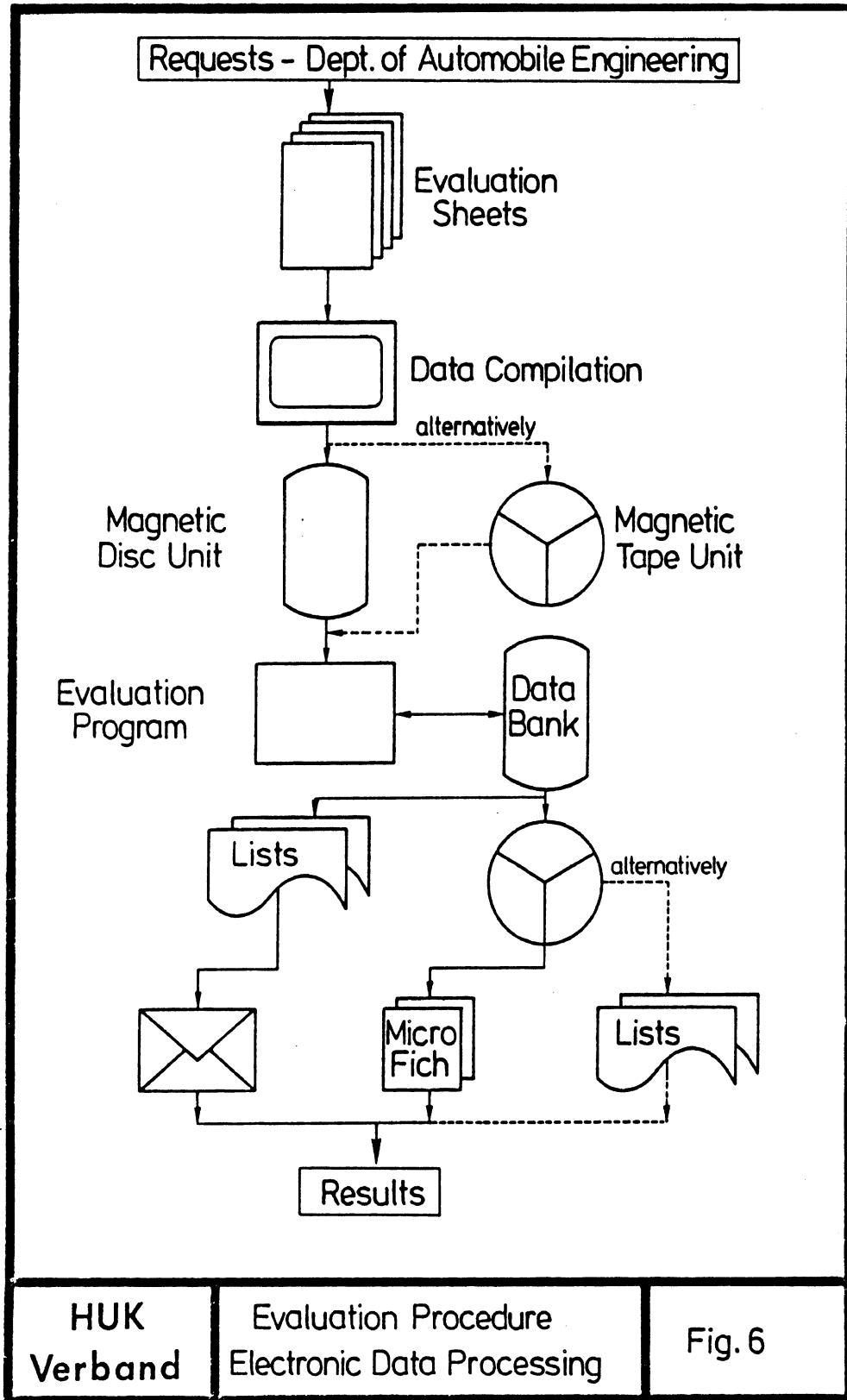


FIGURE 1. Evaluation procedure for data processing (HUK-Verband 1978).

The data were processed in three phases as follows:

PHASE 1: Data are taken from insurance files such as police reports, expert opinion, medical diagnoses, etc. evaluated by HUK engineers.

PHASE 2: Data are refined, consistency checks are performed, focus on main topics of the investigation, addition information is gathered if necessary.

PHASE 3: An in-depth case analysis is carried out: detailed accident reconstruction, photographic documentation, additional information by correspondence and/or interviews of involved persons, additional information from hospitals, police, experts, etc.

For selected accidents, additional information was gathered by interviewing persons involved, other experts, and/or medical doctors.

The accident data were divided into three groups: general accident information, vehicle-damage information (or description of object struck in case of single-vehicle accidents), and occupant information. Although detailed descriptions of injuries were gathered, the injury-data analysis was restricted to basic information such as injury severity, location, and type of injury.

A 1974 study included "accidents with at least one minor injury suffered by an occupant in one of the vehicles involved" (HUK-Verband 1978). This rule was adopted in order to include accidents involving car damage of great severity with no or minor occupant injury, and hence, to avoid the bias of looking only at accidents resulting in injuries. This rule is quite similar to the one used for case selection in the 1977-1979 U.S. National Crash Severity Study (NCSS).

Approximately 50,000 motor vehicle liability cases were chosen from the total accident information in the 1974 study in such a way that "they depicted road traffic accident totals in West Germany as completely as possible avoiding regional dependency." These data were further examined with respect to accident severity, and 15,000 accidents with occupant injuries were selected for final analysis.

ACCIDENT REPORTING IN 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. The tasks of the VALT-committee can be summarized as follows (VALT 1984, Finnish Motor Insurers' Bureau):

1. Develop traffic and transportation safety research.
2. Propose and initiate traffic and transportation safety improvements.
3. Maintain and create national and international contacts in areas related to traffic safety.
4. Serve as an information source concerning national traffic safety issues.
5. Release and make statements about national traffic safety issues.
6. Serve and assist the member insurance companies, and carry out other traffic safety related work.

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The 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. The 1983 report contains information on 82,767 traffic accidents, and data for injury and fatality cases combined totaling 13,168. Insurance companies have an obligation to report the number of traffic accidents reported to them (including the names of persons killed in these accidents) on a monthly basis to the Finnish Insurance Information Center. Data on reported traffic accidents is published monthly (Finnish Motor Insurers' Bureau).

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 law and regulations, to improve the safety of traffic and road environment, to improve the safety of motor vehicles, and the education, training, and enforcement of existing traffic laws, regulations, and practices. 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 in-depth program is discussed in more detail in Chapter IV.

The official general accident statistic is published annually by the government's Statistics Center, Tilastokeskus.

IV. 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 reasonable cost, and 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. But for several years thereafter, case selection was usually decided by the study's principal investigator with only general guidelines from the sponsor. At one time a NHTSA representative state that that agency fostered selection of unusual cases, e.g., cases of extreme damage to the vehicle with little or no injury, or the opposite. Collections of such case studies were of limited value in estimating the characteristics of the larger accident population, but were considered of value in identifying possible countermeasures.

In connection with a study of the 1974 introduction of ignition interlocks for restraint systems, 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 then in use.

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. In this chapter of the report, some historical information about in-depth investigation methodology is presented. In addition, present programs operating in various parts of the world will be discussed.

IN-DEPTH ACCIDENT DATA

A number of scales have been developed for recording both vehicle damage and occupant injury. Emphasis in many countries has been on determining a relationship between crash severity and injury. The scales that permit such analyses are discussed below.

DATA ACQUISITION AND SAMPLING

There are three major 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. As discussed in Chapter III of this report, samples chosen from an incomplete listing may have unknown bias in representing a total population. Many in-depth programs concentrate on the more serious accidents, and it is likely that these are more completely covered in the sampling frame.

Methods of choosing cases from a sampling frame vary widely. In the early 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. This topic will be discussed further in this chapter as activities in the various countries are described.

Data Sources and Acquisition. Andreasen (1975) discusses three somewhat different approaches to data acquisition for extended studies: parallel data acquisition, sequential data acquisition, and a combination of these two.

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 data collecting bodies.

Andreasen has defined sequential data collection as 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 involves a combination of these two methods and require considerable interaction and cooperation among police, hospital, and other agencies to produce accurate information. In describing the activities in various countries, the data acquisition methods will be discussed.

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 operating in other countries of the first type. These will be described below.

CRASH SEVERITY MEASURES

A meaningful collision (crash) severity measure would provide 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). Marquardt suggested that 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 meet some basic criteria (Kahane et al. 1978):

- The measure should portray a theoretically correct picture of the forces involved in the collision.
- The measure should be consistent and uniform so that the severity ratings may be used on all accidents.
- The measure should be easy to apply, calculate or obtain, and be quantitative in nature.
- The measure should be understandable and have meaning to nontechnical people.

No single measure can cover all collision variables, so specification of collision type and severity is needed to completely define a collision. Then within any *type* the severity level measures the contribution of the collision to injury. Types of collisions can be defined by damage location, direction of force, object struck, and time duration (Campbell 1974). The first severity measure to be discussed below was proposed by Campbell (1974) and involves relating vehicle damage to a so-called equivalent barrier speed (EBS). The second measured considered is called Delta-V (ΔV). It 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 ΔV 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 ΔV can be calculated. If information on a two-vehicle collision is available only for one vehicle, it is appropriate to use the EBS. Both the EBS and ΔV are described in the following sections.

Energy Basis for Collision Severity. Campbell (1974) provides a basic methodology to relate vehicle damage to energy absorbed by the vehicle in deformation. For this purpose he uses the so-called equivalent barrier speed (EBS) of the vehicle. 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. Campbell's data and development are only for frontal damage but can be expanded to include other types of damage.

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. Campbell uses a simple model of linear force-deflection characteristics of the vehicle's front structure. He assumes that characteristics do not vary across the width of the vehicle in cases involving non-uniform

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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.

Campbell also developed a pictorial representation of the energy absorbed by sections of the vehicle (see, for example, Figure 2). This facilitates the easy determination of EBS for more sophisticated models and for various damage patterns.

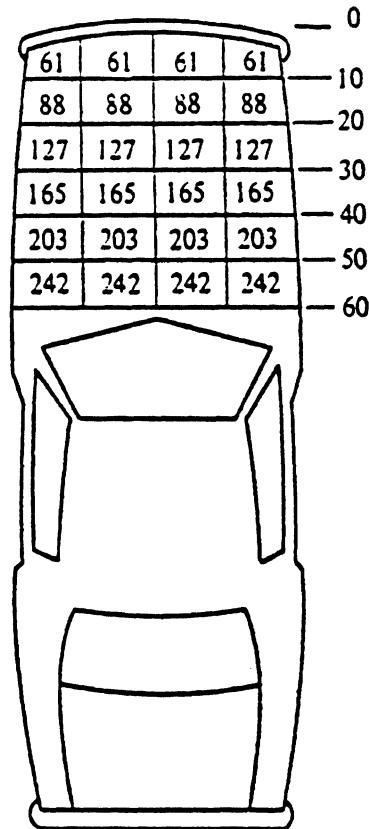
To use Figure 2 to get an EBS for a damage pattern sustained by a vehicle, the damage pattern should be sketched over the vehicle picture. The total energy absorbed is the sum of the *crushed* squares. Partial squares are allotted in proportion to area. The square root of the number is the EBS for that damage pattern collision (see Figure 3 for an example).

Campbell validated and showed the accuracy of his basic model to be ± 5 mph for any EBS measurement made in the field, for frontal as well as angle and offset barrier damage patterns. The basic model appears valid as long as at least 25% of the vehicle width is contacted. The limiting factor in determining the EBS is only the effort expended in determining the vehicle force-deflection characteristics and recording the field-vehicle deformation.

Volvo Car Corporation (Nilsson and Ehle 1982) has refined Campbell's basic model for their cars. Their refinements include an energy matrix (such as Figure 2) for underride situations, and the incorporation of a *shear* energy present in pole-type impacts. Volvo's test results confirmed the accuracy of Campbell's method for full frontal collisions with no override. Additionally, Volvo performed both vertical and horizontal half-barrier tests on several vehicle types. From these tests a more complete frontal energy distribution was determined. In Figure 4, the energy distributions for upper and lower segments of the front are shown. It can be noted that the lower segment requires a greater amount of energy to deform the section by a constant length. This may be because more of the frame is involved in a collision that affects the lower portion of the vehicle. The center section of the lower segment had originally energy values lower than respective sides for an equal deformation. This is expected since the center area does not contain any structural members. However, as the engine is moved back toward the firewall of the vehicle, the energy levels increase substantially. With this somewhat more sophisticated model the laboratory-tested ΔV s agreed by an error of less than 6%. It would appear that as more developed models of energy distribution are obtained for particular vehicle types, more accurate approximations of ΔV can be expected. It must be noted that both Campbell's (1974) and Nilsson and Ehle's (1982) models considered barrier collisions only.

EBS may not be the same for different types of collisions. Once a type of collision can be specified, then EBS within that type would be an appropriate measure of collision injury potential. Development of this potential as a measure of the probability of injury is discussed in a later section.

Crash Severity Measurement by Delta-V. ΔV 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). Marquardt regards ΔV as the closest approach to the ideal measure of collision severity that can be made with a single parameter. An early, and evidently independent, work about ΔV was done by Prost-Dame (1973).

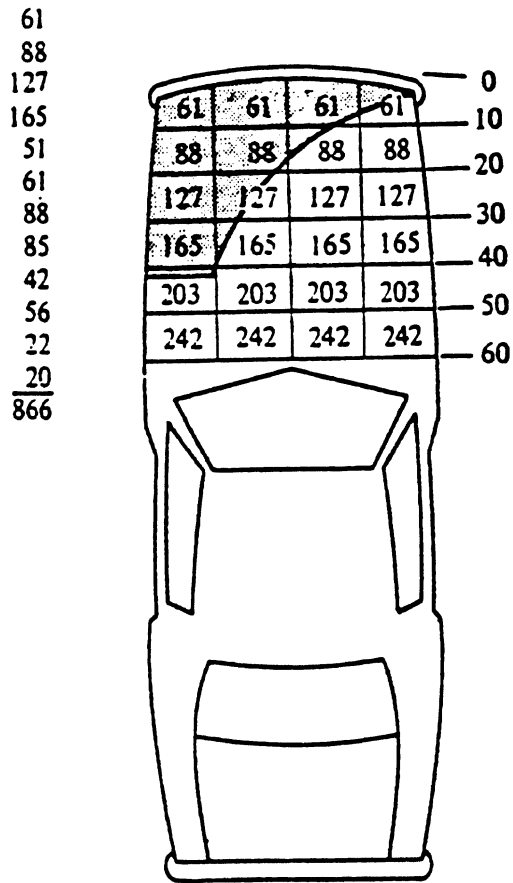
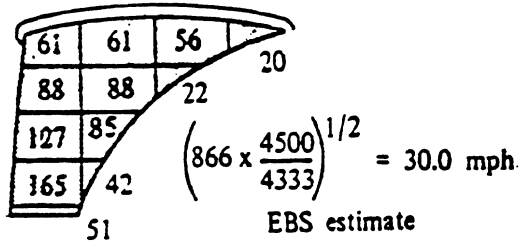


CRUSH (inches) vs (EBS)²
 71-72 FULL SIZE CHEVROLET
 12 O'CLOCK DIRECTION OF FORCE
 >25% CONTACT
 W = 4500#

FIGURE 2. Pictorial representation of crush versus EBS for 1971-1972 full-size Chevrolet (Campbell 1974).

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Impact Speed = 30.6 mph
 W = 4333#



CRUSH (inches) vs (EBS)²
 71-72 FULL SIZE CHEVROLET
 12 O'CLOCK DIRECTION OF FORCE
 >25% CONTACT
 W = 4500#

FIGURE 3. Application of pictorial approach to 30 mph offset barrier impact (Campbell 1974).

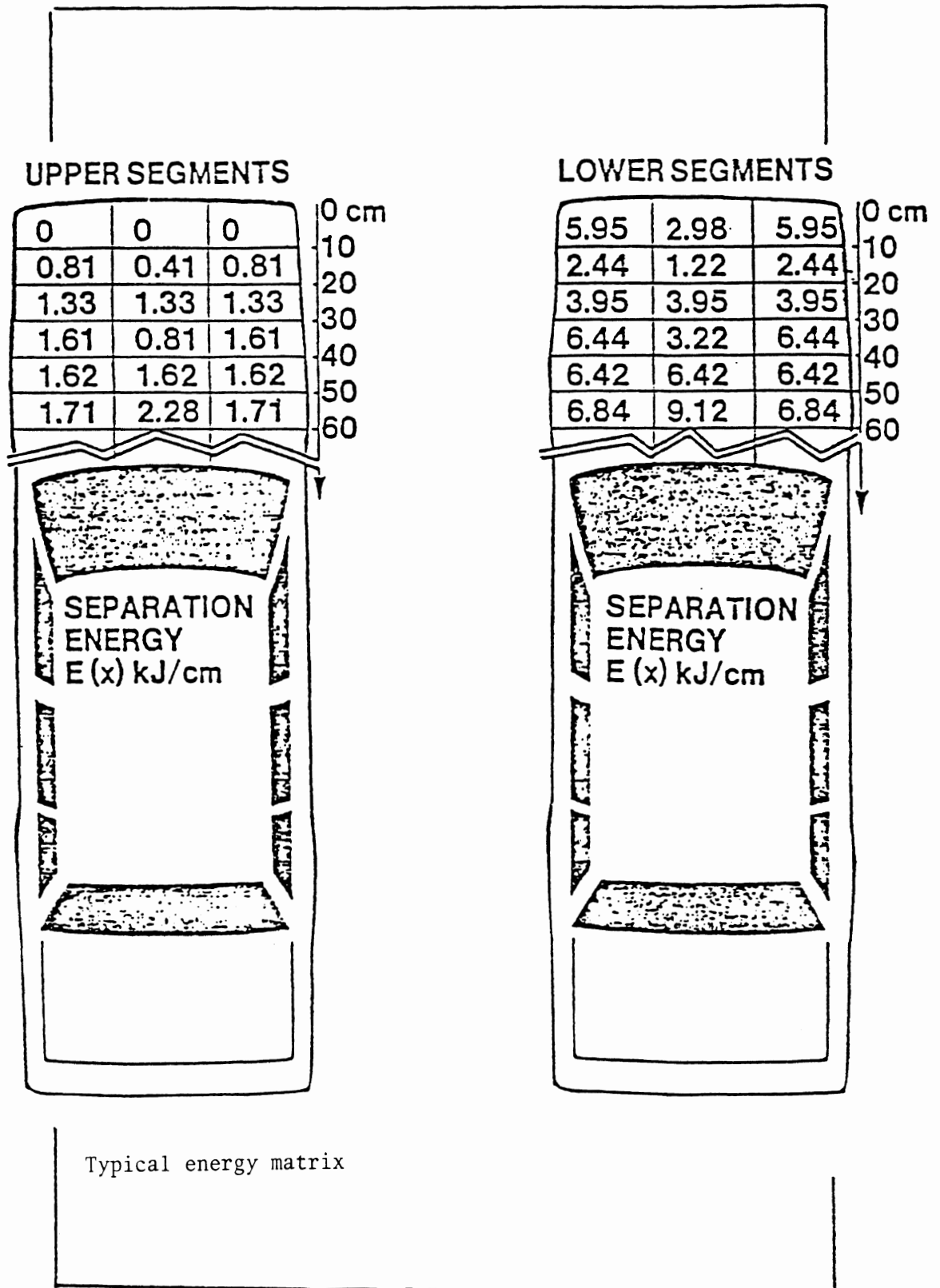


FIGURE 4. Typical energy matrix (Nilsson and Ehle 1982).

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Marquardt describes the suitability of ΔV 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. Figure 5 shows the velocity versus time relationship for a collision of cars of equal mass. 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 (ΔV 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. ΔV is then the maximum velocity with which an unrestrained occupant can contact the vehicle interior (Marquardt 1974).

ΔV can be found from conservation of momentum assuming an inelastic collision and no friction. In a more general non-collinear case velocities have to be treated as vectors. It can be noted that ΔV is only a function of the closing speed and the weight (mass) ratio of the vehicles involved. ΔV experienced by a vehicle is essentially the same if it strikes a fixed object, another vehicle, or a movable object subject only to the secondary effects of impact-duration differences. ΔV does not depend on vehicle structural or crush characteristics. This means that ΔV should be the same for the same closing speed V_c (where $V_c = V_a - V_b$), and V_a and V_b are velocities of vehicles a and b involved in the crush, and the same weight ratio, whether two heavy cars or two light cars are involved. However, in reality heavier cars have longer crush distances, which means that the duration of impact of two heavier cars is longer than for two light cars, causing a secondary difference between the impact of two heavy cars as compared to the impact of two light cars.

ΔV for vehicle a with a mass m_a in a collision with vehicle b with mass m_b can be written as (Marquardt 1977):

$$\Delta V_a = \left(\frac{1}{1 + m_a/m_b} \right) V_c$$

where $V_c = V_a - v_b$

An example of unequal weight vehicles is given in Figure 6. As can be seen, the smaller car has a larger ΔV , thus the smaller car experiences a more *severe* impact than the larger car, which has a smaller ΔV . The sum of the ΔV 's is the closing speed V_c . In Marquardt (1977) an example on how to extend ΔV calculations to angular collision is shown.

In the field it is relatively easy to determine the weight ratio of the vehicles involved in a collision. However, the the closing speed is more difficult, if not impossible, to determine. If the necessary data are available, for example, it is believed that accident reconstruction using the CRASH3 program can be employed to obtain speed values with an accuracy of about $\pm 15\%$. CRASH3 is a useful tool but must be applied with caution (Hight et al. 1985).

Since the damage to the vehicle is the primary evidence remaining after a collision, energy absorbed in crush, and hence the EBS, can be used to determine ΔV .

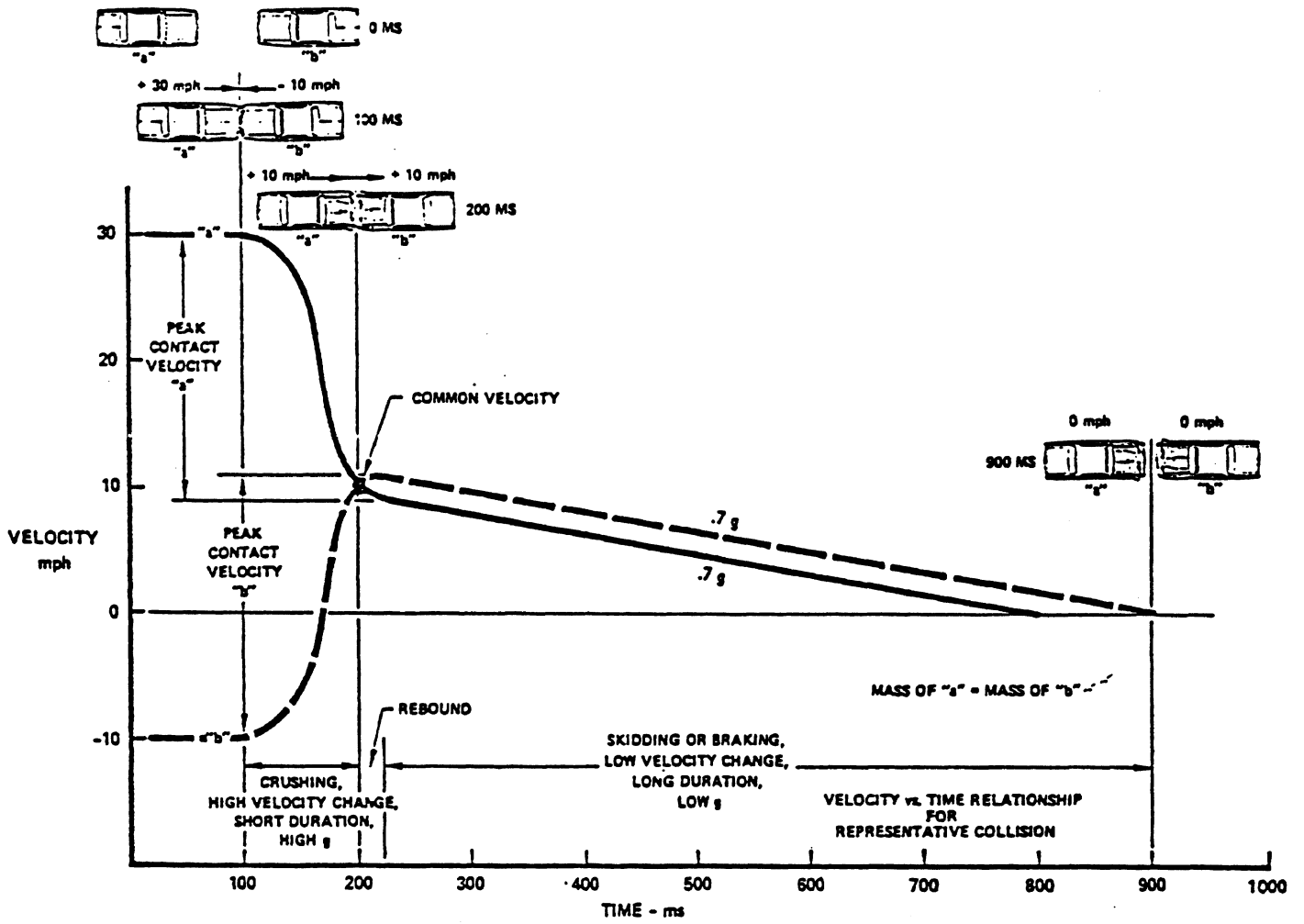


FIGURE 5. Velocity versus time relationship for representative collision for vehicles of equal mass (Marquardt 1974).

CLOSING SPEED = 120 MPH

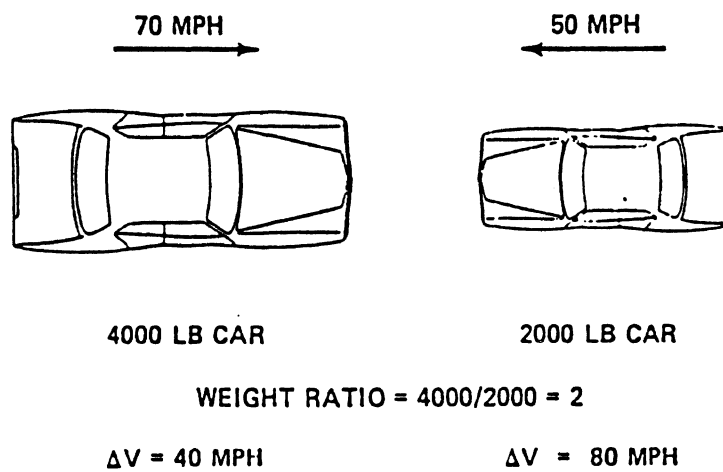


FIGURE 6. Effect of unequal weight (Marquardt 1977).

In practice, the heavier and stiffer vehicle has a much lower EBS than the opposing lighter vehicle that sustains greater crush. Without some knowledge of the damage to the lighter vehicle it is difficult to develop accurate assessment of ΔV and V_c for the heavier case vehicle when relying only on EBS for the heavier vehicle (Hight et al. 1985). It should be noted that for an accurate calculation the crush of both vehicles involved has to be determined reliably, and/or there should be an accurate methodology to determine both vehicle stiffness for different types of collisions in addition to having to determine EBS of at least one vehicle.

The equations presented in Hight et al. (1985) are simplifications of reality. Friction and rebound have been ignored and the vehicles are assumed to have no energy-absorbing systems (e.g., bumpers, etc.). Rotation of vehicles during collision is not considered, though correction coefficients should be developed for cases of minor rotation. For cases of extreme rotation, rollover, and glancing or sideswipe collisions, the equations do not apply.

Delta-V Using the CRASH3 Program. The CRASH program (Calspan Reconstruction of Accident Speeds on the Highway), currently the version 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 utilized 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 (ΔV) in the NCSS accident data base. CRASH3 uses a model that relates ΔV to ten input parameters as follows (Woolley et al. 1986):

$$\Delta V = \sqrt{(2(E_1 + E_2) / [m_1(1 + (Y_1 m_1 / Y_2 m_2))])}$$

$$\text{where: } Y_i = k_i^2 / (h_i^2 + k_i^2)$$

E_i = energy absorbed by vehicles

m_i = masses of vehicles

Y_i = non-central impact factors associated with impact force moments about the center of gravity of vehicles

h_i = moment arms of average impact force about vehicle center-of-gravity

k_i = radii of gyration of vehicles

i = 1, 2 for vehicles 1 and 2, respectively

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 ΔV 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).

In Smith and Noga (1983) results from 53 vehicles in 27 independently staged collisions are reported. It was noted that CRASH3 underestimates ΔV in the range of 0 to 30 mph. They further reported that Volvo Car Corporation found that the CRASH3 program often predicted ΔV values higher than their laboratory-test ΔV values. Volvo

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attributed this to CRASH's vehicle-dimension-related parameter, which gave stiffness values 70% higher than the Volvo cars actually had. Thus, typical ΔV errors ranging from 9% to 25% can be expected from CRASH3.

Other automobile accident-reconstruction programs, as reported in Woolley et al. (1986), 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

The TAD scale for reporting vehicle damage, mentioned in Chapter III of this report, is sometimes employed by police agencies. 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. "Determined by the resultant of forces acting on the vehicle at the point of application." For direction, a clockface is used where 12 o'clock is the direction of an oncoming force and 3, 6, and 9 are right-side, rear, and left-side, respectively.
- 3: AREA OF DEFORMATION. "Defines broadly which projected area of the vehicle contains the deformation." A letter code is used for front (F), right side (R), left side (L), back (B), top (T), undercarriage (U), and unclassifiable (X).
- 4: SPECIFICATION LONGITUDINAL OR LATERAL LOCATION OF DEFORMATION. A letter code is used to illustrate the specific areas in locating the deformation along both sides, front, and rear ends of the vehicle.
- 5: SPECIFIC VERTICAL OR LATERAL LOCATION OF DEFORMATION. As 4, but locating area and height of damaged area.
- 6: GENERAL TYPE OF DAMAGE DISTRIBUTION. A letter code specifies the width of the impact area, rollover, sideswipe, etc.
- 7: EXTENT OF DAMAGE. Residual damage is classified using a nine-zone extent system.

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 different 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). It shall be noted that the classification is comparable to the VDI with the difference that the HUK classification allows differentiation between the area of the main body deformation, and the post-crash overall degree-of-damage. The classification is used, for example, in Finland and West Germany. The scale is as follows (see Appendix I and HUK-Verband 1978):

- 1 = MINOR DAMAGE (scratches, small dents). No deformation of structural body parts.
- 2 = MODERATE DAMAGE. Minor deformation of structural body parts and possibly support and alignment of front and/or rear wheels.
- 3 = SEVERE DAMAGE. Minor deformation of structural body parts and support and alignment of front and/or rear wheels. Passenger compartment is not affected in rear and front impact, but passenger compartment is deformed in case of side impact.
- 4 = VERY SEVERE DAMAGE. Minor deformation of passenger compartment in rear and front impact, and, in side impact, passenger compartment is deformed almost up to vehicle center line.
- 5 = TOTAL DAMAGE. Deformation of entire front or rear including the passenger compartment in front and rear impact, and total deformation of passenger compartment in side impact.

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

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INJURY SCALES

Mattern et al. (1979) present a summary of eleven common injury scales. Table 11 shows the year, author abbreviation, and injury-rating scale used in fourteen injury scales: DeHaven's injury scale, ACIR, four versions of the AIS, CRIS, ISL, OIC, Gögler's injury scale, two versions of the ISS, KABCO, and OSI.

TABLE 11
SUMMARY OF COMMON INJURY SCALES

Year	Author/Used By	Scale*	Uninjured	No Life Threat	Life Threat	Fatal
1952	DeHaven		0	1 2 3	4	5
1956	Hasbrook	ACIR	1	2 3 4	5 6	7 8 9 10
1969	States	CRIS	1	2 3	4	5
1969	States	AIS	0	1 2 3	4 5	6 7 8 9
1971	States	AIS	0	1 2 3	4 5	6 7 8 9
1972	Patel	ISL	0	1 2 3	4 5	6
1973	Marsh	OIC	†			
1974	States	AIS	0	1 2 3	4 5	6
1974	Gögler		0	1(2) 3 4	5 6	sep. listed
1974	Baker	ISS	**			
1976	States	AIS	0	1 2 3	4 5	6
—	—	KABCO	0	C B	A	K
—	HUK	OSI	0	1 2 3	4 5	6

* Abbreviations: ACIR=Automotive Crash Injury Research, AIS=Abbreviated Injury Scale; CRIS=Comprehensive Research Injury Scale, ISL=Indice de Severite des Lesions; ISS=Injury Severity Score; OIC=Occupant Injury Classification, OSI=Overall Severity Index.

** $ISS = \Sigma(AIS_I^2 + AIS_{II}^2 + AIS_{III}^2)$ with rating scores from 0 to 75.

† OIC uses a letter scheme for four facets and adds the injury severity using AIS. See a later section.

The Abbreviated Injury Scale. This scale is used for coding injuries incurred in traffic accidents, except for burns and general pain. The AIS should be used by specially-trained research teams that obtain medical, vehicle, and environmental data on traffic accidents.

In the developmental stages the AIS scale concerned 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 (Nygren 1984).

The code numbers of AIS and their description as well as body regions addressed in the definitions are given below (AAAM 1980):

- 0 No injury
- 1 Minor
- 2 Moderate
- 3 Severe, not life threatening
- 4 Serious, life threatening
- 5 Critical, survival uncertain
- 6 Maximum, currently untreatable (fatal within 24 hours)
- 9 Unknown

AIS Description of Body Regions:

General (Any body region, external or surface)

Head (Head, face, eye, ear)

Neck (Cervical spine, throat)

Chest (Thoracic organs, thoracic spine)

Abdomen (Abdominal/pelvic organs, lumbar spine)

Extremities (Upper extremities and lower extremities)

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 occupant injuries. 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. Mattern et al. (1979) recommended that the OAIS should be determined by a physician who is experienced in the treatment of trauma. It involves careful clinical evaluation of overall effects of individual injuries for the body as a whole (Mattern et al. 1979).

Injury Severity Score (ISS). The ISS was proposed by Baker et al. (1974). The ISS is a method for describing the overall severity of injury, using a numerical scale to more than one area of the body as well as of isolated injuries by rating each injury, and then adding 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. 1978). The ISS takes into consideration the combined effects of multiple injuries. It was found (Reinfurt et al. 1978) that the prediction of threat-to-life was improved when the ISS method was used along with the AIS (see B.30 and B.35 as reported in Reinfurt et al. 1978).

The ISS is defined as "the sum of squares of the highest AIS grades in each of the three most severely injured areas," or

$$ISS = \Sigma(AIS_I^2 + AIS_{II}^2 + AIS_{III}^2)$$

with rating scores from 0 to 75.

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The six body regions used in the ISS are:

- 1 = Skull/brain or neck
- 2 = Face
- 3 = Extremities or pelvic girdle
- 4 = Chest
- 5 = Abdominal or pelvic contents
- 6 = External

The first category, skull/brain or neck, includes the brain or cervical spine, skull, and ears. Facial injuries include the mouth, eyes, nose, and facial bones. Injuries to the extremities or pelvic/shoulder girdle include sprains, fractures, dislocations and amputations, except for the spinal column, skull, and rib cage. The chest and abdominal and pelvic contents include internal organs in the respective cavities. The chest also includes the diaphragm, rib cage, and thoracic spine. The last category, external, includes external injuries, lacerations, contusions, abrasions, and burns, independent of their locations on the body surface (Nygren 1984).

Occupant Injury Classification (OIC). The vehicle OIC scheme was developed by Marsh (1973a, 1973b) at The University of Michigan. The coding convention was derived from the CPIR (Collision Performance and Injury Report) of General Motors Corporation (B.42), and the NATO Collision Analysis Report Form (B.43). 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). 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. The OIC coding for these five categories is employed using a letter (or number of AIS) scheme and is presented on the following page.

As an example (Marsh 1973), the OIC coding of an accident with a description, *laceration of left eye from contact with broken windshield with an AIS 2*, would be FLLE-2.

THE OCCUPANT INJURY CLASSIFICATION SCHEME

1. Body Region

F Face	B Back, Thoracolumbar Spine
H Head/Skull	P Pelvis/Hip
N Neck/Cervical Spine	Y Lower Extremities (Legs)
X Upper Extremity (Arms)	T Thigh
A Arm (upper)	K Knee
E Elbow	L Leg (lower)
R Forearm	Q Ankle/Foot
W Wrist, Hand	O Whole Body
C Chest	U Unknown, Unclassified
M Abdomen	
S Shoulder	

2. Aspect

R Right	L Left
B Bilateral	C Central
A Anterior/Front	P Posterior/Back
S Superior/Upper	I Inferior/Lower
W Whole Region	U Unknown

3. Lesion

L Laceration	C Contusion
A Abrasions	F Fractures
P Pain	K Concussion
H Hemorrhage	V Avulsion
R Rupture	S Sprains
D Dislocations	N Crushings
M Amputation	B Burn
X Asphyxia	O Other
U Unknown	

4. System/
Organ

S Skeletal	<i>Cardiovascular</i>
V Vertebrae	A Arteries, Veins
J Joints	H Heart
D Digestive	Q Spleen
L Liver	G Urogenital
N Nervous System	K Kidneys
B Brain	R Respiratory
C Spinal Cord	P Pulmonary, Lungs
E Eyes, Ears	M Muscles
	I Integumentary
	U Unknown, Unclassified

5. AIS

An AIS number is assigned according to the AIS scale presented earlier.

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KABCO Injury Scale. A widely-used injury scale in the U.S. has been the KABCO scale along with the AIS 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):

- K = Fatal
- A = Incapacitating Injury. Includes severe lacerations, broken or distorted limbs, skull fracture, crushed chest, internal injuries, unconscious when taken from scene, unable to leave scene without assistance.
- B = Non-Incapacitating Evident Injury. Includes lump on head, abrasions, minor lacerations.
- C = Possible Injury. Momentary unconsciousness, claim of injury (not evident), limping, complaint of pain, nausea, hysteria.
- 0 = No Injury.

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. The KABCO injury scale is shown here as presented in the *Manual on Classification of Motor Vehicle Traffic Accidents*, 1970 (B.33 as reported in Reinfurt et al. 1978); extension as presented in NASS and FARS *UMTRI Data System Codebooks*, 1984 (UMTRI 1985a, 1985b).

Other Injury Scales. Reinfurt et al. (1978) developed two threat-to-life scales. The first, 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 second, 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.

The New York State Injury Coding Scheme (NYSICS) was developed with the intention to improve, and possibly replace, the by-the-police used KABCO injury-coding system. The code consists of three components: the location of the victim's most severe injury, its type, and the victim's physical/emotional status. Baum (1978) evaluated the NYSICS as an alternative to the KABCO coding scheme.

The Comprehensive Injury Scale (CIS) was developed by the American Medical Association (AMA) and published in 1972 (B.34 as reported in Reinfurt et al. 1978). 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 et al. 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 et al. 1978).

INJURY SCALES USED IN DIFFERENT COUNTRIES

The AIS and the modifications thereof 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:

- 1 Fatal
- 2 Serious Injury
- 3 Minor Injury
- Uninjured

Under this injury scheme the nature and location of the injury is coded as follows:

- 1 Concussion, fractured skull, facial lesion, lesion of the eye
- 2 Thoracic and/or abdominal lesion
- 3 Lesion of the vertebral column and/or pelvis
- 4 Fracture/dislocation or severe spraining of the shoulder, arm, or hand
- 5 Fracture/dislocation or severe spraining of the hip, leg, or foot
- 6 Serious injury to several parts of the body
- 7 Burns
- 8 Superficial injury only
- Blank if 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, uses the revised AIS as presented in the 18th Conference of the American Association for Automotive Medicine, 1974 [B.25] 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. The OSI injury-severity categories, which seem to be equivalent to the older versions of the AIS, are as follows:

- 1 Minor
- 2 Moderate
- 3 Severe
- 4 Life Threatening, survival certain
- 5 Life Threatening, survival uncertain
- 6 Fatal

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In Sweden, the Folksam Insurance Group uses the AIS with the ISS. In the reviewed five-year study (Nygren 1984), car occupants were divided into four groups:

1. SLIGHTLY INJURED
ISS 1-3 and AIS = 1
2. MODERATELY INJURED, ISS 4-10
 - (a) One injury with an AIS = 1 or AIS = 2.
 - (b) One or more injuries in two different body regions with the combinations AIS = 3 and 1; or AIS = 2 and 1; or AIS = 2 and 2.
 - (c) One or more injuries in three or more different body regions where the AIS combinations could be AIS = 1 and 1 and 2; or AIS = 2 and 2 and 1.
3. SERIOUSLY INJURED, ISS ≥ 11
 - (a) One injury with an AIS = 4-5.
 - (b) Two or more injuries in two or more different body regions with AIS ≥ 3 combined with AIS ≥ 2 .
 - (c) Three or more injuries in three or more different body regions with AIS ≥ 2 .
4. FATALLY INJURED

In Finland, the 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 for five body-region categories: general, head and neck, chest, abdominal, extremities and/or pelvic girdle. The scale for the modified AIS is:

- 1 No Injury
- 2 Moderate Injury
- 3 Severe (not life threatening)
- 4 Severe (life threatening, survival probable)
- 5 Critical (survival uncertain)
- 6 Fatal within 24 Hours. Fatal lesions of single region of body plus injuries of other body regions of ISS = 3 (injury severity code), or less; fatal from burns regardless of degree.
- 7 Fatal within 24 Hours. Fatal lesions of single region of body plus injuries of other body regions of ISS = 4 to 5.
- 8 Fatal. Two fatal lesions in two regions of body.
- 9 Fatal. Three or more fatal injuries; incineration by fire.
- 99 Severity Unknown. Injured but severity not known.
- 98 Presence of injury not known.

IN-DEPTH PROGRAMS IN SELECTED COUNTRIES

Australian In-Depth Programs [D.12, D.15, D.16]. Australia has had a variety of in-depth accident investigation programs over a period of more than 15 years. These included 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 is engaged in a study of pedestrian and bicyclist accidents, and it is expected that the study will result in records of about 300 pedestrians and 150 bicyclists. Sampling is done of 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 current study at TARU is concentrating 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 [D.18]. Canadian in-depth programs began in the 1970s in a manner similar to those of the U.S. A number of 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 pickup trucks and vans was completed about two years ago, and presently the activity is concentrating on passenger-car involvements [D.16].

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 Abbreviated Injury Scale and the Occupant Injury Classification 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 [D.6]. 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.

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Fatal accident investigation is carried out by special accident investigation teams. In general, a team 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 (Appendix H) for reporting. A brief description of the duties of each team member follows.

The *police member* heads the investigation team and serves as a contact person with local officials. He/she informs the other members of the team about an accident, and delegates each member a particular role and assignment. He/she makes the basic on-site investigation, interviews the witnesses, and later interviews relatives of persons involved in the accident. Also, police and official records are checked for other essential information such as information concerning driver license, previous convictions, etc. He/she combines all information (forms) from other members of the team into a final report. For recording, standard forms PK-85-1 to PK-85-9 (9 forms) are used.

The *vehicle engineer* investigates deformations of the involved vehicles and any skid or other marks on the road surface. The engineer then attempts, with the road and traffic engineer member, to reconstruct the sequence of immediate events that preceded the accident, and the accident itself. He/she investigates and clarifies with the medical doctor any cause relationships between the vehicle or vehicle-safety devices and the sustained injury. Any additional inspections of the vehicle or its parts are carried out in a repair workshop or facility. For reporting standard forms PK-85-10 to PK-85-15 (six forms) are used.

The *road/traffic engineer*, with other members of the investigation team, examines the road/intersection design and geometry, sight distances, traffic signs, type of traffic control and traffic-control devices, speed limits, hourly traffic volume and mix at the time of accident, weather, lighting conditions, visibility, pavement-surface condition including friction, features of the immediate accident proximity (structures, illumination, cut, ditches, slopes). Also, a maintenance evaluation is made of the road section where the accident occurred and conclusions and safety recommendations are suggested.

The *medical doctor* may participate in the actual accident investigation or may merely serve as an expert witness in the final hearing. In the investigation, the medical doctor along with the police member investigates the physical, psychological, and other related conditions of the involved persons. He/she determines the injuries and injury severities using the AIS scale and the ISS. Five body regions are considered: general, head and neck, chest, abdominal, and extremities and/or pelvic girdle. With the medical doctor, the vehicle engineer also examines possible relationships between injuries and vehicle safety devices and other vehicle structures.

To qualify for inclusion in the VALT, the fatal accident must:

1. Involve at least one motor vehicle while in transport on a roadway or area open to the public, and
2. Have resulted in the death of at least one person within three days of the accident date (VALT 1984).

The accident investigation committee may, on a case-by-case basis, include accidents resulting in a death within 4 to 30 days of the accident date.

BASt in-Depth Accident Investigation Program (West Germany). The BASt in-Depth Accident Investigation Program (Löffelholz 1986) has its roots in the NATO-CCMS program. This program operated for three years in the early 1970s, and was concluded at the International Accident Investigation Workshop held in Brussels in 1973. The BASt 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.

Sampling is actually of time periods, so that all times of the week are ultimately covered. Professor Hautzinger [D.11] was responsible for the new sample design. He has recently compared the actual sample against a census of police-reported injury accidents, and has determined the kinds of biases that result from practical implementation of such a sample.

Swedish In-Depth Programs [D.5]. 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 ensures 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.

This latter scheme was developed by a medical consultant working with the Volvo accident-investigation team, and most notably expands the detailed injury information of the OIC. For example, where a facial fracture would be coded in the original OIC simply as a *skeletal system* involvement, in the present Volvo work it would be possible to differentiate the forehead bone, the temple bone, the occipital bone, the maxilla, the mandible, etc. This capability is made possible by introducing a new two-digit code to replace the fourth letter of the Marsh version of the OIC, and seems to have the potential to provide detail in computer form for more sophisticated analyses. There are a few other changes from the Marsh version that also seem useful, and it is judged that these

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modifications might be considered for the U.S. programs. Most of the in-depth investigative programs, of course, record detailed injury information in written form so that it can be subsequently retrieved manually, but the Volvo adaptation seems to be a large step forward in the computerization of such data.

Volvo data, then, 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.

Currently, the U.K. classifies an injury as *serious* if the victim is hospitalized overnight or, in certain cases, if an occupant has sustained a fracture. This *fracture* addition is evidently a change from previous practice so that the police officer is able to complete his record without a follow-up visit to a hospital.

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.

Copies of the U.K. in-depth data forms are available in Mackay (1985). They have been developed over a long period of time and bear some resemblance to the GM Long Form, particularly in the level of detail for vehicle damage. This is quite different from the current NASS practice in the U.S., but more like the older MDAI work. Injuries are recorded using the AIS and the Injury Severity Score. Details of the injuries are recorded on a pictorial representation of the human body and also in text. The AIS extent for each identified injury is recorded, along with probably vehicle contact points. The maximum AIS in each body area is carried forward so that the Injury Severity Score (ISS) may be computed at the bottom of the injury form. In addition, the maximum AIS (MAIS) is recorded. Vehicle damage data are recorded as a VDI. Data enabling the future running of the CRASH3 algorithm to compute Delta-V are recorded.

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 data base 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

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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.

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V. SUMMARY AND CONCLUSIONS

The purpose of this project has been 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. Greater consistency in the data would limit the uncertainties in such applications. In addition to collecting and reviewing a considerable amount of literature, direct contact was made with government, industry, and academia concerned with accident investigation and data processing in America, Europe, and Asia. Although the emphasis in these interviews was on in-depth methodology, there has been some information collected about police reporting methods in a number of countries.

This report presents background and history of worldwide experience in accident data collection and processing. Police accident data characteristics in various countries are addressed, and a discussion of fatal accident reporting systems in several countries, in which special files are developed for this, is presented. A number of in-depth efforts are reviewed here.

Several international organizations have been involved in road accident standardization efforts for many years. From these can be mentioned the World Health Organization (WHO), the United Nations Economic Commission for Europe (ECE), the European Economic Community (EEC), and the NATO-CCMS.

MASS ACCIDENT DATA CONSIDERATIONS

In order to aggregate traffic accident data over two or more jurisdictions (or 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. We might consider two data sets to be equivalent if

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 any injury or property damage exceeding a certain amount, another may require at least one vehicle towed from the scene, etc.

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2. **RULES FOR REPORTING ARE APPLIED IN THE SAME MANNER.** There is considerable evidence that the actual reporting practices vary with local interpretation. While 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 is able to attend the scene. In many jurisdictions drivers are supposed to make their own reports, but are evidently less likely to do so.
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 differ because hospitals are less available in one region than another.

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.

Previous Standardization Efforts

Various international and national efforts in accident investigation and standardization have been discussed, including the 1969 WHO survey of all WHO member countries concerning the status of accident reporting, involved agencies, data collection, and some accident terminology definitions in use by the member countries.

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

QUALIFICATION OF DATA

We have not adequately investigated completeness of coverage, nor in general, have we looked at misreporting or missing-data rates. Information about these topics is certainly important to an understanding of the data for international comparisons, and for determining the representativeness of samples used in in-depth studies.

SUMMARY AND CONCLUSIONS

The users of accident data lie on a kind of belief continuum. At the one end are those who analyze and use the data without concern for possible biases, missing data, or recording errors. At the other end are 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.

In this report there are a number of examples of efforts to better understand traffic accident data. The World Health Organization has conducted a survey to provide 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 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 death certificate and police-reported traffic fatalities in a number of countries. Among non-European countries there were large differences in both directions. Columbia, in 1977, reported 3,676 certificated deaths, 69% more than the 2,172 reported by the police. Sri Lanka, in 1978, reported 411 certificated 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.

Hutchinson notes 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 in this report 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 countries is displayed in Table 12, where many differences can be observed. For example, the ratio of injuries to fatalities 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 countries, but without further information it would seem dangerous 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. This is a potential topic for the communication program discussed below.

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TABLE 12

ACCIDENT STATISTICS FOR SWEDEN, MICHIGAN, AND THE U.K.

Country	Population	No. Accidents	No. Fatalities	No. Injuries	No. Vehicles
Sweden	8 M	70,000	800	16,000	3.5 M
Michigan (1984)	9 M	335,193	1,550	150,740	6 M
U.K.	56 M	350,000	5,934	328,000	17.5 M

SOURCES: Swedish data from D.5, United Kingdom data from International Road Federation (1984) and D.8, Michigan data from state police accident records and Verway (1985).

IN-DEPTH STANDARDIZATION ACTIVITIES

The 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.

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.

Most in-depth programs report injury using the AIS coding as published by the AAAM (1980). A number of users calculate the Injury Severity Score (ISS) and use it in their analyses, but some do not. Many, but certainly not all, programs use the Occupant

Injury Classification coding scheme. In Australia, only a portion of these codes are used; and in Sweden, Volvo personnel have expanded these OIC codes to provide for more detailed injury descriptions.

Most in-depth programs emphasize some measure of crash severity so that injury potential may be compared on accidents of similar severity. In the U.S., the CRASH3 program has been used to develop ΔV ; this has also been used in Australia. Volvo has further developed Campbell's method which estimates an equivalent barrier speed of a crash and has found this to be useful in their analyses.

Sampling for in-depth case selection is accomplished in many different ways. The U.S. NASS program uses a random national sampling procedure. The Hanover (West Germany) program employs a time sampling technique to assure representativeness, but is restricted to one region of the country. Victoria (Australia) uses a strict random sampling of hospital cases in a current study of pedestrian injuries. In the U.K., there are two large in-depth operations, one sampling in a rural and the other in an urban area, and these are combined to represent the entire country much as was done in the National Crash Severity Study (NCSS) in the U.S. The Canadian in-depth program is similar, using teams and areas which had been selected non-randomly but employing random selection procedures within these areas; it too might be compared with the NCSS design.

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.

Communication Needs. Communication among in-depth investigators (or the designers and managers of such programs) has been accomplished through the technical literature and through such public forums as ESV conferences, SAE meetings, and various international technical meetings. References to many of these reports and meetings are given in the bibliographic section of this report. All of these media of exchange have been productive, as evidenced by the similarities in the present programs.

But much material of importance winds up in what librarians call fugitive literature, and it is often not easily found. In Australia the OIC form used for their

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reporting (in 1986) came from Marsh's paper in the Brussels conference in 1975. The Volvo form of the OIC constitutes a major extension of Marsh's work, but it is little known elsewhere in the world. There have been other changes (in U.S. usage) which, for example, have never gotten to Australia.

The general purpose scientific computer at the University of Michigan is presently hosting a conferencing program (known as CONFER) which provides a basis for people with common interests to communicate with each other. Many such computer conferences are in existence, but most involve only domestic (i.e., U.S.) users. Present overseas packet communication is relatively inexpensive, and is possible for people in many parts of the world to be in communication with each other using this kind of program.

With the idea of fostering more frequent communication among the various persons concerned with in-depth accident investigation, such an electronic conference has been established on this computer. For the next year the computer time can be made available so that users' costs will be limited to the communication expense.

Discussions carried on in the forum are intended for the benefit of all participants, are not expected to be published unless the participants wish to do so. Suggested topics for continuing discussion include injury scales, sampling procedures, vehicle-damage scales and measurement, and exposure methodology and practice. The initial intent of the electronic conference is to foster communication about methodology rather than substantive analysis.

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DATA CONTACTS, TRIPS, AND VISITS

- D.1 November 21, 1985. Attended Frankfurt conference concerning West German accident investigation programs. Conference sponsored by VDA.
- D.2 November 25, 1985. Professor Hans Georg Retzko, Darmstadt University of Technology, Darmstadt, West Germany. (Two graduate students were present at our meetings, Mr. Bolze and Mr. Schlabbach.)
- D.3 November 27, 1985. Goeran Nilsson, Swedish Traffic Research Institute in Linköping, Sweden.
- D.4 November 28, 1985. Bertil Aldman, Chalmers University, Gothenburg, Sweden. (Janusz Kajzer was also present at the meeting.)
- D.5 November 29, 1985. Hans Norin, Volvo, Gothenburg, Sweden. (Others at the meeting included Christer Gustafsson who is responsible for on-the-spot investigations, and John Korner who is concerned with statistics and computerization of data.)
- D.6 November 30, 1985. Professor Sulevi Lyly, Department of Civil Engineering, University of Technology Helsinki. (Others present at the meeting were Mr. Jyrki Nuotio, Roads and Waterways Administration Traffic Division, and Dr. Markku Salusjärvi of the Government Technical Research Center, VTT.)
- D.7 December 1, 1985. Professor Heikki Summala, University of Helsinki. (Others included Mr. Lasse Hantula, Secretary General of the Traffic Safety Committee of the Finnish Insurance Companies, and organizer and general supervisor of the accident investigation teams which operate throughout Finland; and Dr. Valde Mikkonen, Professor of Psychology, University of Helsinki.)
- D.8 December 6, 1985. Barbara Sabey and Ian Neilson, TRRL, Crowthorne England. Others present included Bob Stone and Julian Everest (of Barbara Sabey's staff) and Martin Renouf and Jeff Meades (of Ian Neilson's staff). Martin Renouf is responsible for the computerization of the in-depth case reports produced by Birmingham and Loughborough.
- D.9 December 7, 1985. Telephone conversation with Murray Mackay, Birmingham University, Birmingham, England.
- D.10 February 24, 1986. Gordon Symmonds, Ford of England. Discussed the UK in-depth accident investigation program.
- D.11 February 28, 1986. Professor Heinz Hautzinger, Heilbronn University, Heilbronn, West Germany.
- D.12 March 13-14, 1986. Ian Johnston and Max Cameron, Victoria Road Traffic Authority, Melbourne, Victoria, Australia.

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- D.13 March 13, 1986. Max Lay, David Andreassand, John McLean, Australian Road Research Board. Others present included John McLean.
- D.14 March 14, 1986. Telephone conversation with Carol Boughton, Australian Federal Office of Road Safety, Canberra, Australia.
- D.15 March 17-18, 1986. Jack McLean, Accident Research Unit, University of Adelaide, Adelaide, Australia.
- D.16 March 14, Telephone Conversation with personnel at the Traffic Accident Research Unit in New South Wales (TARU).
- D.17 May 1986. Telephone conversation with Robert Clark, Canadian Department of Transportation, Transport Canada, Ottawa, Canada.
- D.18 May 1986. Telephone conversation with Lloyd Thompson, McGill University, Montreal, Canada.
- D.19 December 8, 1986. Professor Richard Alsop, Director of the Transportation Studies Group at University College, London, England. Also present was Dr. Richard Heydecker.
- D.20 December 9, 1986. Steven Harris, SWOV, Ad Leidshendam, Netherlands. Also present was Boudewajn van Kampen.
- D.21 December 12, 1986. Robert Zobel, Volkswagen, Wolfsburg, West Germany. Others present at the meeting were Mr. Sinnhuber, Mr. Simon, and Mr. Fehrmann of the Volkswagen staff.

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