RESEARCH REPORT

01509

Experimental Case Studies of Traffic Accidents

by
J. Stannard Baker

PUBLISHED BY THE TRAFFIC INSTITUTE, NORTHWESTERN UNIVERSITY
S.N.-1113

EXPERIMENTAL CASE STUDIES OF TRAFFIC ACCIDENTS

A General Discussion of Procedures and Conclusions

by

J. Stannard Baker

Prepared as Part of a Project Supported by
National Institutes of Health, U. S. Public Health Service (RG-5359)
U. S. Bureau of Public Roads (CPR 11-5981)
Automotive Safety Foundation

TRAFFIC INSTITUTE, NORTHWESTERN UNIVERSITY
Evanston, Illinois
1960

FOREWORD

This is general discussion of what was done and what was learned in Experimental Case Studies of Traffic Accidents and is a report on the entire project. It contains information not to be found in the score of reports on specific aspects of the project and serves to tie together these associat-reports and fill informational gaps between them. For sake of brevity, mention of material in the other reports is limited to that necessary to show relationships between them.

This is a guide to the other reports rather than a summary of them. In it are frequent references by title and superscript number to the other reports and to reference publications. These are identified in References[28] which is published separately rather than with each report.

In addition to reports on various aspects of the Case Studies, a separate case report was prepared on each accident studied. These case reports total about 3000 pages and are therefore too voluminous for publication but it planned to make them available on microfilm.

The entire collection of reports on the Case Studies is concerned with three general subjects: first, ideas about accidents and their causes; second, problems of studying accidents to try to discover their contributing factors; and third, what was learned about the accidents that were studied and how they might have been prevented.

The traffic accidents which are described in these reports are only a few of the thousands of such accidents which occur daily. All happened in a local area. Therefore it would be presumptuous to generalize about all accidents from this minute sample. Yet examinations of these few can give us better ideas about accidents than we had before, just as meeting a score of people in a foreign land will give the traveller abroad a new insight into the affairs of its inhabitants.

This general report was prepared after the others had been written and the interdisciplinary investigating team which worked on the Case Studies had disbanded. It reviews exploratory steps taken and difficulties encountered. Therefore, in effect, it is the report of the project director as chairman of the Operating Committee.

None of the four other members of this committee appears as an author of any of the reports. Yet every report reflects the influence of these four Northwestern University Professors, not only as general guidance for the project from its inception, but also in very specific contribtions to preparations of the reports, a fact that is not separately acknowledged in the other individual reports.

Operating Committee
J. Stannard Baker, Project Director
Robert B. Banks, Ph. D., Professor of Engineering Science
Edward S. Petersen, M. D., Asst. Professor of Medicine
Robert I. Watson, Ph. D., Professor of Psychology
Robert F. Winch, Ph. D., Professor of Sociology

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Robert B. Mack, M.S., Engineering Scientist
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Introduction

Need for Better Information about Traffic Accidents

Obvious measures to prevent traffic accidents are being taken widely and effectively. Further achievement in accident reduction will require discovery of less obvious measures which means solving more complex problems, especially if accident prevention is not to be increasingly expensive and unnecessarily restrictive in use of highways.

Scientists, who have considered the matter of trying to find more effective ways to prevent accidents, conclude that we have too few reliable facts about traffic accidents, and especially about their human causes, to attack the problem effectively.

Although many traffic accidents are not officially reported, in general they are now reported well enough by drivers and police to tell us where and when they happen, who and what was involved, the intended movement of vehicles and pedestrians before the accident, and something of other circumstances. Such information indicates whether accidents are increasing or decreasing and what places and individuals need attention because of unfavorable experience; but these routine reports give very little information about how and almost nothing about why accidents occur. Hence the need to try to find methods of getting better information about traffic accidents and factors contributing to them.

At the heart of the difficulty of obtaining information about traffic accidents is the fact that they do not lend themselves readily to observation. No one knows where or when the next accident will occur People involved are not prepared to note the circumstances of a series of complicated events compressed into a few confused seconds. Information about the accident must therefore be derived from its results and such fragmentary recollection as the surprised participants and witnesses may have. This is a much different situation from that related to disease, for example. The ailing patient presents himself to a physician to study the phenomenon as it gradually develops. Medical observation and study may be carried on in a hospital with equipment and personnel for special tests and records. The study of accidents has none of these advantages.

Previous Attempts to Secure Better Information

Attempts have been made from time to time to secure more information about accidents and these have taken several forms.

The first is to attempt to glean additional bits of data from the conventional police traffic accident reports. These data are to be found in descriptions of the accidents on report forms and sometimes on supplementary sheets. Such accident descriptions usually involve a primitive sketch (rarely to scale) and a hundred words, more or less. The phraseology used, points selected for emphasis, and degree of certainty of conclusions expressed are matters of inclination or even whim of the officer making the report. They are not specified in instructions or training; consequently, completeness and uniformity of described material cannot be expected. Two major efforts have been made to utilize such "spontaneous" comments by the reporting officer: Accident Causation[209] and Cause Factors in Highway Accidents: A new Methodology[204]. Both of these were constricted by stereotypes of accident factors used by reporting officers and by the limitations of these officers in deductions based on information available to them.

The second approach to the problem has been made from time to time by supplying police with supplementary forms to gather factual information for a limited time in a limited area about subjects of special interest. Some of these have been quite successful. The most extensive of such approaches is that of the Automotive Crash Injury Research of Cornell University which has been gathering data for a number of years on the injury-producing aspects of motor-vehicle traffic accidents.

The third method is to supplement police investigation of accidents with special technically trained investigators. This is often done by plaintiffs' and defendants' attorneys when they employ engineers and physicians to study the results of accidents which are involved in liability litigation. But it has rarely been done for research purposes. Nearly 25 years ago an experiment of this kind was reported to Congress in Motor-Vehicle Traffic Conditions in the United States-Part 2, Skilled Investigation at the Scene of the Accident Needed to Develop Causes.[208]

In 1956 the Sub-committee on Forms and Statistical Procedures of the National Conference on Uniform Traffic Accident Statistics, reviewed the status of accident data collection. The committee adopted a policy of distinguishing between accident reporting and accident investigation. Reporting was recognized as a means of getting the minimum amount of data needed for administrative purposes for the maximum number of accidents. This information was limited to objective factual data routinely obtainable. Investigation, on the contrary, was considered to be obtaining maximum information on a minimum number of accidents for special purposes such as enforcement. At the request of the Committee, a special

Supplementary Field Data sheet was designed for recording factual information collected during investigation. The committee also suggested that an experimental form, limited to a single sheet, be designed for recording opinions and conclusions of the investigator about how and why the accident happened. Such a form for "Direct and Mediate Causes" was developed. Experiments were made with it in a few cities and states; but even with special training in its use, the reliability of conclusions seemed to be low and tended to be stereotyped.

Character of This Report

The Experimental Case Studies of Traffic Accidents was an attempt to secure more data from accidents by having scientifically trained people study them as soon and as fully as possible. A similar subsequent project at Harvard University has been investigating fatal accidents.

In this report on the Case Studies of Traffic Accidents, the first section discusses the plan of giving an interdisciplinary team of scientists an opportunity to study traffic accidents intensively as they occur without limitation as to time. General objectives of this fresh approach are described and the kind of accidents selected for study are specified.

The second part of the report reviews problems and experiences of data collection and especially of trying to discover causes of the accidents from the information obtained about them. It is background information for the subsequent parts of the report. This part also considers the functioning of the interdisciplinary team and the fruitfulness of the fresh approach.

The third part is devoted to a discussion of results: a new operational concept of accident causes; a more comprehensive procedure for determining factors which combine to cause accidents; a more effective evaluation of problems and limitations of forming judgments about accident causes; more complete data collection forms; and a review of the factors considered to have contributed to the accidents studied.

The final part of the report suggests some possible future developments.

Two facts must be kept in mind in reading this report. First, it is only one of a number of reports resulting from the Case Studies and although it is the only one which could be considered an introduction to or a summary of the others, its main purpose is to supply supplementary information. Second, neither this report nor any of the others pretends to "reveal the secret" of accident causation. The Case Studies were only one more step toward better knowledge of how and why traffic accidents happen.

Considerations Involved in Design

Statistical and Clinical Approaches

Whatever method is used to attempt to gather more and better information about accidents to determine how and why they happen, there are two general approaches to the study of these data which must be considered.

Statistical method. For this approach, certain information is sought concerning circumstances or factors which are supposed to contribute to accidents. The circumstances might relate to the road, to some characteristics of the car, or to the driver in terms of age, sex, personality or any of many other characteristics. An attempt is made to secure precisely the same kind of information for each traffic unit involved in an accident. Then these data are manipulated statistically to determine which of the factors are present in accidents under certain circumstances and possibly what combinations of factors.

A special kind of statistical approach compares accident experience of roads, drivers, or vehicles having certain characteristics with similar control groups not having these characteristics. The purpose is to determine which group has more frequent accidents. Studies of this kind suggest conditions which might be changed to prevent accidents.

Clinical method. The other approach is clinical. It involves studying the individual accident to determine how and why it happened and to draw conclusions from this particular event as to how such accidents may be prevented. This approach must be used when the accidents are extremely rare as in the case of marine disasters, mine explosions, and major aircraft crashes. We cannot wait for large numbers of these to occur to study them by the statistical method. The clinical method is not often used formally in traffic accident study. Most of the accidents are too minor to warrant such expensive investigation. But occasionally individual traffic accidents are technically investigated, for example, the crash in 1950, on South State Street in Chicago between a gasoline tank truck and a streetcar, which killed 34 persons. The coroner assembled a "blue ribbon" grand jury composed of scientists and experts to make recommendations for legislative action which might protect the public from future disasters of this kind. The Interstate Commerce Commission, Bureau of Motor Carriers, also selects certain kinds of very serious accidents involving interstate trucks and buses for study of this kind.

The statistical method requires large amounts of highly standardized data which is a search for relationships by mathematical methods. The clinical method seeks special relevant data in a smaller number of cases and searches for relationships by interpretation of the data.

The Case Studies project was not conceived as being strictly limited to either statistical or clinical methods. It was planned to attempt to gather much more systematic factual data than had heretofore been available on accidents. Such data might be treated statistically if enough cases could be gathered to warrant such treatment. However, it

was also planned to go as far as possible in deducing from the information on each accident how and why it occurred which would be a clinical study of the individual accident. If such conclusions could expressed in sufficiently standardized terms, they might be classified and summarized.

Objectives

When the Experimental Case Studies of Traffic Accidents was proposed as a project of the Traffic Institute and Transportation Center of Northwestern University, a number of objectives were stated:

> Develop procedures for collecting information about individual traffic accidents, the roads, vehicles, and especially drivers involved which will yield case data suitable for use by medical scientists, engineering scientists, and social scientists inquiring into causes of traffic accidents.
>
> Devise a system of forms, indexing, coding, and filing factual information on intensively investigated accidents to provide effective recovery for clinical studies and statistical treatment.
>
> Examine the data gathered to determine what tentative conclusions may be reached about the nature and causes of the traffic accidents studied.
>
> Try to develop some new techniques of evaluating the road, the vehicle, and especially the people involved which might be useful in interpreting the accidents that they have.
>
> Study the problems of drawing conclusions concerning how the accidents occurred and why.

In planning to reach these objectives, a number of decisions were made with respect to organization and operation of the project. The more important of these will be outlined here and in a later section of this report there will be observations on how these plans worked out.

Interdisciplinary Operation

Experience in the armed forces and in industry, where interdisciplinary "teams" had tackled complex problems with conspicuous success, suggested exchange of ideas among several disciplines might prove fruitful in the Case Studies of Traffic Accidents.

Therefore, a special feature of the Case Studies was the interdisciplinary team used as the investigating unit. These specialists, from different technical fields, were expected to bring knowledge and skills of their disciplines to a first-hand study of accidents.

Disciplines represented. The first problem in the interdisciplinary approach was to decide how many and what specialties would be best. Highway transportation and accidents arising from it involve an extremely broad range of technologies. Several kinds of engineering, for example, are applicable; automotive and traffic engineering of course, but also highway, mechanical, civil, electrical, illumination, safety and other kinds. In aircraft and marine disasters, often a score or more of specialists bring their talents to bear on trying to find out what happened. That many specialists for Case Studies of Traffic Accidents would be unthinkable for two reasons: first, the cost; and second, the probable detrimental effect on relations with participants and police if such a crew were to swarm over a relatively minor accident on a busy thoroughfare. Practical considerations dictated a team of two, three, or four. Three was the number chosen as the most promising compromise. This small number precluded having more than one representative of any one discipline. On the contrary it required that each team member be responsible for a considerable span of technical knowledge.

The elements of the system to be studied by the team were the highway, the vehicle and the people involved. Because the highway and vehicle are both devised by engineers, it was felt that one engineering scientist could cope with them. He would have to extend attention to civil and traffic engineering for the road, to mechanical and automotive engineering for the vehicle, and to illumination problems for both. The driver is considered the key to most accident situations. It is generally what he does that creates hazard or manages escape from it. Hence it was felt desirable to have two of the team members study the part the driver or pedestrian plays in accidents, one with medical and one with behavorial interests. The former would consider the various medical and physiological aspects of the case and the latter psychological and sociological aspects. There would inevitably be some overlapping between the medical and the psychological fields in such matters as vision and mental condition.

Having an attorney as a member of the team, or at least having the legal viewpoint represented, was suggested, even urged. It was not done for a number of reasons. First, was the practical limitation on the number of people who could be on the team and the difficulty of discovering a scientist with enough legal background to consider legal problems as well as those of his own specialty. Second, it was objected that the law is not a scientific discipline. Third, and perhaps most cogent, it was felt that factors contributing to accidents should be sought outside the frame of reference of traffic law so that as few barriers of conventionality as possible would be met in the effort to achieve new concepts.

With a small team, outside scientists and technicians must be used for many cases. Thus in the case studies a skilled automobile mechanic inspected the cars and supplied data on their mechanical condition and the services of a psychiatrist were enlisted to interpret data gathered on personality. Teams with fewer members would have to refer more cases to consultants or technicians.

<u>Selection of personnel</u>. Because the broad range of capabilities and interests required when the number of team members is only three, there is considerable freedom for selection. Each member of the group will have to span several

allied technologies, and so might be found with any of several specialties. Any of several engineering specialties, for example, would be suitable. Nevertheless, finding people proved to be more difficult than expected mainly because so few promising people were willing to detach themselves from careers for which they had prepared or in which they were engaged. Special inducements had to be offered in the form of opportunities to study, teach, or work in a clinic. These were inevitably an inconvenience, although no insurmountable obstacle, in arranging investigation and interview schedules. From the time the project was approved it was nearly eight months before the team complement was complete. After resignation of one member, six months were required to secure a replacement.

The medical representative on the team, a woman, was not a specialist but had more than usual interest and training in psychosomatic medicine. The engineering scientist was a civil engineer. The first behavorial scientist was a psychologist with special experience and training in human engineering problems; his replacement was a sociologist with special interest in neighborhoods and their development.

<u>Fresh Approach</u>

First-hand information. It was decided not to have the scientists study material gathered by police or others, but rather to have the scientists themselves collect the data from the beginning. By this means they could try to secure whatever information they desired, could have first-hand knowledge of the problems of getting the information, would avoid delays of training special personnel to secure what information might be needed, and would be able, during a developmental period, to modify the kind of data gathered and the methods of gathering it as their study of the data progressed.

<u>No indoctrination</u>. At first it was proposed to train these investigators in the methods of accident investigation developed for police at the Traffic Institute over many years; but these methods were for enforcement rather than scientific purposes and contained much dogma of questionable validity. Therefore it was felt that the possibilities of fresh approaches to the accident investigation problem would be more likely to develop if the investigators were not indoctrinated but rather permitted to observe the phenomenon as closely as possible without guidance. Then they might, so far as time would permit, develop original methods of data collection, observation, and recording.

<u>Ordinary Accidents Selected for Study</u>

For several reasons it was decided not to select special types of accidents for study. For one thing, at an early stage of development it seemed to make little difference in terms of developing study methods whether the accidents observed were urban or rural, serious or minor. Accessibility to accidents was considered more important than selecting accidents by type or location. It was recognized that most of the ordinary accidents involve relatively minor property damage but Dunman's studies of the "<u>Economic Cost of Traffic Accidents in Relation to the Human Element</u>"[424]

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indicate that these produce the major economic losses. For the year 1953 in the state of Massachusetts 362,280 drivers and passengers were involved in motor vehicle accidents. Of this number only 0.1% were fatally injured while 12.4% were non-fatally injured. The remaining 87.5% were not injured at all. In terms of accident costs the total estimated for fatal accidents was $1,642,000 while the accidents involving only property damage cost a total of $17,926,000, or approximately eleven times as much. Such figures clearly indicate that it is the minor accidents involving only property damage which constitute the great bulk of motor-vehicle accidents and are responsible for most of their economic cost.

A further consideration in choosing ordinary accidents as contrasted to the more serious ones was the feeling that it was important to be able to talk fully and soon with those involved. Where the driver is killed outright, other than post-mortem examination of him, is impossible. When he is seriously injured or when the accident involves great damages, by the time it is possible to talk to him, his memory of the events may be distorted by trauma or clouded by apprehensions with respect to his responsibility.

In planning the project, which was intended to be completed in less than three years, it was not expected that enough cases would be studied to permit much generalization about the causes of accidents. In commenting on the observations made in connection with the 68 people involved in accidents studied there is no implication that these few people and their experiences are representative of all of the people involved in all of the accidents everywhere.

<u>Review of Problems and Experiences</u>

<u>Interdisciplinary Operation</u>.

The comments that will be made here relating to the interdisciplinary approach are based only on the experience in this project. Under other circumstances and with other people, results might have been different. Yet knowledge of this experiment with the interdisciplinary approach should be useful to those contemplating similar activities.

<u>Problems of discipline orientation</u>. When brought together in a joint work situation, people, trained in such different disciplines as those required to study traffic accidents, cannot be expected to merge instantly into a smoothly functioning team. This is especially true when the group has a general objective such as the study of accidents as compared to a specific objective such as designing an automobile. Even with inherent good will, it takes time to understand each other's technical language. Such words as perception, illusion, norm, and efficiency have enough differences in meaning for people with different backgrounds to be a source of confusion and sometimes misunderstanding. Moreover each member of such a team has somewhat different ideas of research and the form that the results of research should take. Eventually they exchange ideas, but such learning to communicate takes time and the production of the "team" falters until it is accomplished.

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The academic climate is perhaps less favorable for interdisciplinary teamwork than industrial, military, or governmental environments. The great emphasis put on individual achievement, the premium placed on authorship of frequent publications, and the real or imagined constrictions placed on procedures and presentation by specifications for dissertations and professional papers all tend to make each member of the interdisciplinary group seek material in the project for studies and reports which will contribute to the "literature" of his specialty and to his professional stature. Thus, to begin with, each member of the team in addition to bringing the techniques of his discipline to bear on problems of the joint project, tends to adapt the opportunities of the project to the uses of his discipline. It was apparently partly this situation that led team members to insist, for the first year -- as examination of the early reports will show -- that each should investigate and prepare a report on each case entirely independently. Other reasons for independent investigation and reporting were advantageous: it was a method of testing the team concept by noting the degree of commonality of the observations and conclusions among members of the team. Interests of team members in identifying their work with their respective disciplines was also a consideration in preparing a number of individual reports on the project rather than one joint report such as would have been expected from a consulting firm or governmental agency.

Traffic accident investigation is a new experience for all members of the team and tends to be disquieting to them. The operation of police, quick communication and transportation problems, seeking cooperation from people while they are still bewildered from an accident, the possibility (which never materialized) of being subpoenaed to testify about an accident in court, and lack of authoritative guides in the "literature," are new experiences to which adjustments must be made.

All these circumstances contribute to the time required for an interdisciplinary group to learn to work as a team with each member in a specific cooperative role. For the Case Studies this required more than a year. Perhaps less time would have been required if a "fresh approach" had not been attempted and the team members had been given some systematic advance training.

Need for "instruments". An interdisciplinary problem quickly became apparent in the Case Studies. The physician had reasonably adequate methods and instruments for measuring the physiological capabilities and condition of the people studied and to classify their physical limitations, for example an Ortho-rater for measuring various aspects of vision. The engineer also had methods and equipment for measuring the road and the vehicle to evaluate their capabilities such as the friction grip of tires on the road surface. But the behavorial scientist lacked equivalent methods and instruments to evaluate attitudes, emotional stability, skill and knowledge of people. Some tests seemed to measure extreme degrees of attitude, for example, that might tell why a person could not get along with others, but not reveal the very slight degree of a quality which would make the small difference between having an accident and not having one for an apparently normal person. Perhaps requirements for personality tests would be less erecting in communities with more heterogeneous population than that in which the Case Studies were conducted.

Consequently both the behavioral scientists on the project--first the psychologist and later the sociologist--felt the need for new and more specialized instruments for evaluating personality. This need was vigorously expressed in proposals to try to develop such instruments. Several interesting special tests were, indeed, experimented with during the last phase of the project. They wre briefly described under the subject of data gathering methods.

The impression to be noted here is that although none of the disciplines have fully developed techniques available for accident investigation, the behavioral sciences are less well equipped than the others to measure accident conditions in which behavioral scientists are interested. Consequently the psychologist or sociologist more frequently than the other team members feels the need to pause and try to invent new devices to help in the investigation. This tends to disturb the functioning of the team toward its assigned objective although it does have the compensating advantage that it stimulates progress in development of more useful instruments.

Evaluation of interdisciplinary approach. At this point there is likely to occur to the interested reader a question beginning, "If you had it to do over again . . ." This is not an easy question to answer because so much depends on the particular individuals who compose the interdisciplinary team, the physical facilities available to them, and the intellectual climate in which they must work. However some observations may be useful.

Technical coverage. The greatest lack in disciplines represented by the three team members seemed to be that related to knowledge and skill of the driver. Among the classifications of derived accident factors developed in the first part of the project, knowledge and skill do not appear atho experience, as represented by years of driving does. At this stage, little attention was given to whether the driver could make his car do what he wanted it to, how well he inhibited distractions, or what his attention habits were. The factor "habit patterns" was derived in only three cases, all in the last third of those studied. "Proficiency" appeared as a factor six times in the first half of the cases studied and 11 times in the latter half. Toward the end of the project, as greater skill developed in trying to account for behavior in the accident, knowledge and skill began to be regarded as more important and there was some talk of a knowledge test and a driving demonstration, but among the 20 forms developed for recording data none was for evaluation of driving ability. This would probably not have happened had a driver educator been a member of the team.

Of the technical areas represented on the team, the medical seemed to be the least significant in explaining the accidents studied. This might be due in part to the method of selection of cases studied. In any case it

is no reflection on the physician member of the team who conscientiously examined every driver for conditions which might have contributed. There were just not many such conditions. The physician's greatest contribution was an as interviewer who not only could elicit information on attitudes and emotions but was also adept at encouraging, casual remarks which would throw light on how the accident happened. Were a two-member team to be used, the engineer and psychologist would be retained rather than the physician especially because competent physicians to whom certain cases could be referred are more readily available.

Number of people on team. Except for the lack of someone to give special attention to driver skill, which has been noted, the three-person team appeared to be successful. But for three months, while 22 cases were studied, the team was without a behavorial scientist with the result that the engineer and physician had to carry on as a team of two. Both had the benefit of having seen the psychologist work and could use the long lists of questions which he asked. So far as data collection does, these two could fill in well for the third. Case reports prepared during this period are not conspicuously different in content or quality from those in previous or subsequent periods. Hence, if team members had the benefit of training and structured forms, it seems likely that two could accomplish almost as much in data collection as three. This is not to say that disciplines could be dispensed with for development of methods, training, investigators or analysis of data.

One scientist for data gathering. It is quite likely that one person could successfully gather all needed data. This is common in police and insurance investigations of accidents. Such a person would require considerable special training in the viewpoints and needs of other disciplines to be able to do more than ask questions which had been prepared by others and record the answers. If there were only one person, an engineer might be the most suitable. It would probably be easier to train him to seek information for medical or behavorial sciences than it would be to train a physician or psychologist to make the time-space diagrams and other calculations for accident reconstruction.

An interdisciplinary approach to the study of accidents is required because of the great diversity of scientific and technical problems presented by highway transportation. But this does not mean that all the data have to be collected by scientists. To continue indefinitely to use highly trained personnel for this purpose would not only be expensive but would probably be uninteresting as permanent occupation for the scientists. It seems likely that gathering large amounts of accident case data would have to be by specially instructed technicians collecting information specified by scientists, and supported by specialists to whom unusual cases can be referred. Then the role of the scientist in one or more disciplines is to interpret the data collected.

This would put the scientist in the position of a consultant rather than one who routinely gathers data. It is possible that one or more consultants might be used on each case.

Exhibit 1

POLICE AND TEAM DESCRIPTION OF ACCIDENT
EARLY IN CASE STUDIES
(No. 33.2)

Research Team	Police Report
General Description	
Vehicle 1, westbound on main street Veh 2, southbound on intersecting side street, intending to turn right and proceed west on main street. Veh 2 came to stop at stop sign, then turned right into intersection, and was struck on left front by Veh. 2.	Veh 1, westbound collided, right front end with left front side of Veh 2, southbound and in act of making right turn to go west. Point of impact was in northwest quarter of intersection.
Statement of Driver 1 (Intoxicated)	
Had difficulty standing and gave incoherent story.	Westbound at 25 mph. Otherwise gave incoherent story. Stated she saw Veh 2 go through the stop, then stated that she didn't see him at all until impact. Might have had left turn signals on by accident.
Statement of Driver 2	
"Stopped for sign. Looked both ways. A car on my left (Veh 1) at about 75 ft with left blinker on. Car opposite me coming from south just sat there. Started my turn. Looked to left again and she was about 20 ft away. Next thing I knew she done hit me."	Southbound. Stopped for stop sign. Looked both ways and saw Veh 1 about 75 ft to left with left turn signal on. Started to make right turn to go west and did not realize Veh 1 did not make the signaled left turn until the impact.

The technicians would require considerable training. The diversity and complexity of the phenomena to be observed and recorded is such that mere completion of a series of self-explanatory forms would be insufficient even if such forms had been designed. The training required would be as much, probably, as that of a medical laboratory technician: a year or possibly more. The amount of training would depend somewhat on how far the technician carried the data collection and study before more highly trained scientists took over its analysis. But the technician would have to do more than fill in answers to factual questions on a report form; he would have to be able to recognize and act on subtle clues that developed in the course of investigation.

Fresh Approach

The fresh approach was intended to afford an opportunity for original ideas about accidents and accident investigation to develop. Would more be gained by letting the team start from the beginning without preconceived notions or by teaching them customary methods so that they could begin where others had left off? Had all members of the team been ready to begin at once, all would have started without studying what has been written on the subject. As it was, during several months between the time when the first team member and the last one was available, considerable study was done which resulted in two preliminary reports: Intensive Investigation of Behavioral Aspects of Traffic Accidents[1] and Medical Approach to Intensive Investigation of Motor-Vehicle Traffic Accidents.[2]

However team members did not refer to such how-to-do-it publications as the Traffic Accident Investigator's Manual for Police[115], the model matched forms for traffic accident investigation, Uniform Definitions of Motor Vehicle Accidents[108], or other accident investigation training material available at the Institute.

The fresh approach yielded fewer new ideas than hoped. Perhaps it was expecting too much that even scientists, from outside the field of highway transportation should, within a year after entering it, have taught themselves enough so that they might significantly augment or amend existing knowledge. But failure to develop wholly new concepts and techniques has a conforting aspect: it shows that the thinking done on the subject of accident investigation before was probably not far wrong.

Police practices. There was an interesting result of putting the team to investigating accidents with the police after so little preparation. The team, new at investigating, picked up many ideas from the police, who were old hands at taking charge and getting information at the scene of an accident. Perhaps the team was unaware of how much police technique "rubbed off" on them, but it was reflected, for example, in the manner in which they described accidents as illustrated by the comparison in Exhibit 1 from an early case.

Narrative reports. The team understood, from Air Force reports, for example, that often much more was to be learned about the accident from the part of a report following the heading, "Describe what happened" than from the marked boxes and filled-in lines of a form. Furthermore, a narrative report is the customary way of recording information resulting from clinical studies. Hence the first reports of investigations were entirely in narrative form with a complete and independent report by each of the three members of the team.

But the number of items about which each member of the team wanted information for his discipline and also for his general report of the accident was large. To avoid forgetting to find out about some item for which information was wanted systematically for every case, each team member prepared a lengthy questionnaire or form. This also simplified recording the data gathered. Information from these structured working forms was then rewritten in narrative for the case report.

The three separate reports served a useful purpose at the beginning. They enabled each team member to see what observations others had made which he had not and led him to strive to anticipate the observations and comments of those studying the accident from the viewpoint of another discipline. This experience was valuable during the period when the physician and engineer had to carry on for all disciplines. But as the resulting three-fold reports began to reflect the broadened scope of competence of each member, they became increasingly alike, repeating the same information.

The attempt to extract similar information for each case from three narrative reports to be tabulated in the first progress report proved tedious because the narrative form provided no regular place to look for the required facts. Hence at the beginning of the third phase of the project, after 54 cases had been studied, the individual narrative reports were abandoned in favor of 18 one-page data sheets. These were an elaboration of the Traffic Institute's two-page form for Supplementary Field Notes[115] recommended to police.

Independent derivation of contributing factors has already been mentioned in connection with disciplinary orientation. This served a useful purpose at first in showing how much difference there was among the team members of the conditions they thought of as contributing to the accidents. Later, the factors were determined in a joint conference of the team. Even so, the general method was to accept factors which were obvious from the circumstances of the accident, and also consider as factors any unfavorable conditions of roads, vehicles, and especially those of people.

In the early stages of the project, little thought was given by the team to an operational analysis of the accident, but during the last phase, this was called to their attention and time-space diagrams began to be used. These were improvements over those described in the Traffic Accident Investigator's Manual for Police.[115]

A systematic "operational analysis" for determining related behavior and condition factors contributing to an accident was developed during the project but too late to be used on more than a very few cases. This analysis will be described later. Had the Case Studies continued, it would have been systematically applied and thoroughly tested.

Evaluation of the fresh approach. The investigating team felt its way for about a year, investigating a series of accidents and then pausing to take stock of techniques and consider revisions. It is probable

that this learning period could have been shortened had the team had several months of training in existing techniques to begin with. However, Concepts and Classification,[11] Limitations on Accident Reconstruction[19] and the data sheets which were developed during the project, were not available then and so the training would have been in more primitive methods and there might not have been the same inducement to develop better methods.

Certainly if technicians, as contrasted to scientists, were to do the data gathering, there should be months of intensive training, much of it by scientists, in procedures which would have to be rather fully developed beforehand.

Data Collection

Reasons for the paucity of basic data on accident causes are not obscure. None of the three major sources of information about traffic accidents is intended to produce such causal information. They are designed only to yield information for certain administrative purposes.

Driver's reports are on simple forms designed to meet legal reporting requirements. The forms provide only a very small space for describing how the accident happened and rarely suggest attempting to report why it happened. Furthermore, drivers involved can scarcely be expected to supply reliable information. Often they simply do not know what happened or why; but even when they do know, their stories are usually strongly biased even though their reports are legally confidential.

Police reports are little better than those from drivers because most of the information on them is obtained from the drivers and is therefore subject to the same limitations. The report forms used are almost identical. Information in addition to that appearing on the police traffic accident report obtained by police accident investigations is usually collected to prove that a law has been violated. It may shed light on circumstances surrounding the accident, particularly on the physical results of the accident; but police investigation reports rarely record in a systematic way any conclusions as to reasons for the occurrence.

Records of insurance companies provide data for determining possible negligence and amount of liability. Beside a report form which is much like that which the driver makes to the state, material collected varies enormously from one accident to another in completeness and so is of little value for broad statistical treatment. Furthermore, it is almost never organized or stored in such a way as to permit systematic study without immense labor in sorting out relevant from irrelevant material and discarding large numbers of cases which fail to provide desired information.

Three kinds of information appear on reports of traffic accidents:

1. Identifying data such as names, addresses, location, and time.

2. Factual data about circumstances. These are what the investigator can see, hear, measure, photograph or obtain from matter-of-fact statements of people. They are determinable conditions at the time and place of the accident or as soon afterward as the investigator can examine the accident situation. In reporting these conditions, no question is raised as to whether they contribute to the accident.

3. Conclusions concerning events or conditions contributing to the accident. These are opinions of someone concerning circumstances which were not observed and perhaps could not have been.

The nature of the report determines the proportion of these three ingredients that it contains. The driver's report of his accident is mostly No. 1 with some of No. 2 and possibly a little of No. 3; the report of a Case Study on the other hand might be mostly No. 3, with some of No. 2, and practically none of No. 1.

For purposes of investigating accident causes, the identifying material is purely incidental. It will be considered no further here. The factual data will be recognized as material for the statistical approach, some of which might be useful also in a particular accident for clinical study. The third kind of information is the result of the "clinical" study, however feeble and misguided it may be in a particular case.

Factual data of some kinds are very easy to get. Such things as the type of vehicle, kind of road, and sex of the driver are readily determinable from simple observation and as much of such data as might be required could easily be obtained. Other kinds of factual data are more difficult to get, for example, the quality of brake fluid, amount of illumination on the road, and especially the skill and attitudes of drivers. These require measurement rather than simple observation and therefore special instruments and skill in the use of such instruments. Not all data which can be obtained by observation and inquiry can be obtained equally well by all investigators. Much skill is needed to gather some kinds of information. One must learn to recognize the meaning of skidmarks, scuffs, gouges in the pavement, furrows in the roadside, collapse of car structure, and shattering of glass just as archeologists recognize the tell-tale signs of kitchen middens and burial mounds or the nature of pottery shards and pictographs. Furthermore, one must be able to pursue lines of questioning that will bring out unsuspected facts and to recognize clues as to the informant's certainty in the way that person speaks. These skills develop with study and experience.

Reliability of factual information is high. Conditions are generally reported without prejudice. There may be errors in observing or clerical mistakes in recording and there may be inadvertant omissions; but by and large, objectively determinable information such as age, time, weather, type of vehicle, and so on are well reported.

Existing police and driver reports are limited to the two sides of a

single sheet. Much of this is required for identifying information. Approximately a score of factual items are regularly called for. A few more are usually supplied by the general description but not systematically for all accidents. The ordinary police report, therefore, is of little help in answering most of the questions which are being asked today. For example, someone wants to know whether substandard brake fluid is a factor in accidents. To find this out, one would like to know, among other things, how many cars in accidents had substandard brake fluid. To get this systematically, the brake fluid in each car in an accident would have to be tested. Or suppose that one wanted to know how drivers in accidents had learned to drive. Several questions would be required on an accident report to establish useful data for this purpose. Police are reluctant to add items to their accident reports, especially if these serve no immediate purpose. The tendency in recent years has been to reduce rather than increase the data routinely collected by police relating to accidents.

Statistical requirements. To find out by statistical analysis what factors contribute to accidents involves amassing enough data so that factors which only occasionally contribute will appear in tabulated results. Data relating to anything that might conceivably contribute to accidents in any way could be collected. Because highway transportation is complex and diverse, and because accidents involve many aspects of it, the amount of possibly pertinent data is immense. Usually data are required also for non-accident situations for comparison. If there are 500 items about which information is wanted, that is 500 variables that might contribute to accidents, all the data have to be searched for each of these 500 variables. If, then, one of these variables appear in only one accident in a thousand, a thousand cases will have to be collected to get an even chance of finding one case of this condition contributing to an accident and perhaps a hundred times this many to have it appear frequently enough to be established as a contributing factor through statistical processes alone. Many factors apparently appear infrequently. Hence the strictly statistical search for contributing factors promises to be an enormous undertaking.

Statistical analysis is quite different from simple tabulation. The record of factual information about accidents without statistical study of extremely large number of cases, tells little about how and why accidents happen. Mere tabulations of such data lead the naive to assume incorrectly that all the reported unfavorable conditions had causal connections with accidents. But the reported fact that it was raining, for example, does not mean that had it been dry there would have been no accident.

Whether any observed or reported circumstance did or did not contribute to an accident would be a conclusion and therefore the third kind of information that might be in an accident report. Because this is a special subject of inquiry in the Case Studies, the next section will be devoted to it.

Determining What Factors Contribute

Not all the information called for on accident reports, is factual and objective. In the hope, of getting at factors which contribute to accidents, questions asking for conclusions concerning causes have been put on accident report forms for many years. These call for information about law violations, speeds, mechanical defects, and other matters which are rarely observed accurately and are often the subject of extremely biased statements. The lack of reliability is often obvious when comparing reports of two drivers for the same accident. Each, for example, may report that he entered the intersection with a green light. Nearly every driver reporting shades his estimate of his own speed downward at least to the speed limit. Conclusions with respect to tire failure and mechanical defects are so suspect that they are no longer provided for on the Standard Summary of Motor Vehicle Accidents. More than two decades ago the author, searching for signs that drivers explained falling asleep accidents by blaming mechanical defects, tabulated by hour of day all driver-reported steering-gear failures occurring in Massachusetts for a year. These failures should occur roughly in proportion to volume of traffic, giving the greatest number at the peak hours between five and six in the evening. The driver reports showed nearly 60 per cent of "steering gears" failing between ten P.M. and two A.M.

Police reports are doubtless more reliable than driver reports, but police rarely witness accidents and therefore obtain most of what they report from drivers involved. They usually accept any uncontradicted driver statement which is not preposterous.

Not only are conclusions concerning contributing factors unreliable, but they are also incomplete. Rarely is more than one condition--the most obvious--reported as a contributing factor in an accident. Many conditions and actions which are difficult to detect go unmentioned, for example, driver attitudes, driver skill, and delayed perception. With such unsatisfactory conclusions tabulation of "contributing factors" from ordinary police accident reports is unwarranted. Such data should be rejected. It might be misleading and so do more harm than good. To secure conclusions concerning contributing factors in individual accidents that would be worth tabulating, much more refined methods of forming these conclusions would be required. This would be the clinical approach.

The objective of case study of an accident is to identify for the case studied the combination of contributing factors which caused the accident. To achieve such an objective is difficult and requires intensive investigation.

History of a few seconds. Intensive investigation of accidents such as that in Case Studies is the careful study of a minute segment of history, a matter of a few seconds in which the series of events that we call the accident takes place. As in any attempt to explain history there are vestiges of the events remaining. In the case of accidents these are the damage, injuries, final positions of vehicles, and marks on the road or roadside. There are also recollections of those who were there. Because such people were unprepared to note what happened, their observations may be fragmentary or even illusory. Their recollections may be confused, or what they say may be designed to shift blame for what happened. Like the historian, the accident investigator must gather what information he can about the period. He

must try to separate fact and truth from misinformation and unwarranted assumptions in statements of drivers and other participants. Then comes the most difficult and important step. He must patiently go as far as he feels he safely can in deducing from the facts he has what must have been the nature of events of the accident and conditions which would produce those events. These are the contributing factors being sought. In coming to these conclusions the investigator must stay clear of outright speculation or if he does speculate, he must state that he has done so and label speculative conclusions as such. All this is no easy task.

Data in the form of systematic or specialized observations is the necessary basis for either statistical study of large numbers of accidents or the cause analysis of an individual accident. Both techniques are limited by the quantity and quality of the facts available. We are concerned here however, mainly in the problems of drawing conclusions from whatever data have been collected, for this is the point at which ideas concerning contributing factors emerge.

In the first phase of Case Studies, each member of the investigating team independently drew his own conclusions as to what conditions of the road, driver and vehicle contributed. The contributing conditions seem to have been derived in two ways:

1. By considering what conditions would be likely to produce an accident of the kind.

2. By noting unusual or abnormal conditions and considering how they may have possibly contributed.

The first of these derives from circumstances of the accident; the second from examination of road, car and driver.

A comparison of conclusions developed by each of the three team members working independently is interesting. In the first 32 cases 93 factors were noted by only one or another of the three; 44 were noted by two; and 15 conditions by all three[22]. With independent consideration of essentially the same circumstances, the fact that all three came up with the same factor only 15 times and quite different factors 93 times has several implications. It might be due in part to expressing the same idea in slightly different terms which would cause them to be separated in classification. This probably accounted for some of the difference, but most of the "factors" were chosen to fit a previously prepared "Classification of Elements Characterizing the Human Factors Aspect of the Accident Process,"[1/] and so the tendency was to use the same basic terminology and groupings. The difference therefore suggests also that different members of the team looked for and recorded different types of factors, and that the report of each member was likely to represent a different combination of factors as causes of the accident.

If, under these favorable conditions, dependability and completeness of determining factors is low, what must it be in the casually recorded opinions of ordinary accident reports? And how much can we trust tabulations of that such opinions?

Later in the Case Studies, independent derivation of factors by team members was superseded by group discussion but the methods of approach seemed to be essentially the same. As skills increased, there was probably somewhat higher concurrence. In general, any factor was then included if it was suggested by any team member.

The problem of deriving contributing factors becomes complicated when one "expert" believes that a factor contributed and another disagrees. This issue was rarely raised among team members in the Case Studies, but it frequently comes up in litigation arising from accidents. One case (No. 120.1) will illustrate the problem.

A woman parked on a narrow street just beyond an alley which did not continue across the street. She discovered that she was in a no-parking zone and decided to turn around and go back in the direction from which she came. To do this she proposed to back to her left across the street and then go forward into the alley. She backed and turned but bumped into a retaining wall behind her on the opposite side of the street. Then she drove forward, but instead of turning into the alley as planned, ran into a building at the entrance to the alley. Here is what she said about the accident.

". . .Before I had a chance to get my wheel around to run down the alley I was into the corner of the building. As I pulled forward the gas pedal seemed to stick. I'm sure I didn't step on the pedal as I would have no reason to. Any the engine roared and in the space of about eight feet I slammed into the building.....Just after I had gotten into drive I stepped on the gas a little bit, ahd wham!.....I just didn't do anything, I sat rigid, really. I just remember this one little thing. I thought - my left foot - it had to go that fast, you see. My left foot, what can I do? You see that's a kind of holdover from the old way when we used to brake with our left foot. Didn't we used to brake with our left foot? Before power steering.....but I just do remember that the car was roaring away, and I thought what did I do with my left foot and there I was. And why that left foot, I don't know. It was, as I said, a case of a - just panicking a bit, you see. Because the car roared--that was why I panicked."

Examination of the car at the scene showed that the accelerator push rod would not move freely up and down. Further examination at the garage showed that the push rod could be moved up and down but would remain in whatever position it was moved to. The accelerator pedal was bent down clear to the floor between the rubber bumper underneath it at the top and its hinge at the floor. The engine had been shoved back by the collision until the distributor made contact with part of the vertical shaft which links the push rod with the carburetor. When this contact was released and the pedal was straightened out, the accelerator push rod moved freely. There was no sign of binding. The return springs were in place and would close the throttle when pressure on the pedal was released. There was no

mechanical indication that the accelerator had stuck or would stick. The bend in the pedal indicated that it had been subjected to heavy pressure. There seemed to be no explanation for this except force on the pedal by the driver. This force would not have to be more than 115 pounds.

The issue here is simple. Did the accelerator stick, or did the driver press on the accelerator thinking she had her foot on the brake? If the former is the case, factors in the accident must be sought in design and maintenance features of the car, for the driver was a helpless victim. If the latter was the case, factors must be sought in the operating habits and skills of the driver and in the car only to the extent that arrangement of controls might not give the "feel" that would tell the driver whether her foot was on the brake or the accelerator. Accident factors derived, therefore, differ greatly depending on decision about this critical issue. Whether the decision be truth or false, resulting conclusions find their way through tabulations into statistics relating to causes of accidents.

The reasons for believing that the accelerator stuck were that the driver said, "The gas pedal seemed to stick" and that after the accident the accelerator push rod would not move freely up and down. To explain why the pedal was bent it was theorized that when the car hit the wall and stopped suddenly, the driver continued forward and so pressed down hard to brace herself.

There are equally good reasons for believing that the accelerator did not stick. After pressure on the linkage caused by engine displacement in the collision was released, the push-rod worked freely; there was no mechanical sign of sticking and repeated operation would not induce sticking. Normal pressure on the accelerator for the intended forward movement would not make the engine "roar" if the accelerator stuck at the point to which it had been depressed. Either there would have had to be pressure on the accelerator enough to "floor" it or something would have had to cause the accelerator by itself to open the throttle wide. If the driver had her foot on the accelerator when she thought it was on the brake, effort to slow the car would increase its speed, further attempts to "brake" would make the engine roar. Pressure for maximum stopping would, for this woman, provide up to 115 lbs. necessary to bend the pedal. The woman's own statement shows that she is a little confused about the pedal arrangements. The driver had about 2.4 seconds from the time she started forward until she hit the wall to take evasive action. This is enough under ordinary circumstances to apply the brake, and application of as much pressure on the brake as would be required to bend the accelerator pedal would have stalled the engine or at least substantially reduced its roar. The accelerator pedal in this particular car is nearly the same height as the brake pedal and is closer to it than on most cars; consequently the feel of the position would give the driver less clue as to where her foot was.

The engineer on the team offered the following as a factor in this accident: "The accelerator stuck with the result that the engine roared and the driver became panic stricken." Other members of the team deferred to his judgement and so that is how the matter stands in the tabulations of Derived Factors[22].

Statements of drivers and pedestrians. Participants in the accident must furnish much of the information about how the accident happened. Of this information some will be factual and some will be false. Sorting out the factors is extremely important and often difficult. This was the problem in the case in which the woman said "The gas pedal seemed to stick."

The problem becomes more complicated when two or more investigators interview the same driver and receive different stories. Which is to be believed? The accident factors derived by one investigator may differ from those of the other. This can occur even when the driver has every assurance that his statements will be held confidential and when interviewers are expert, as an example from the Case Studies will illustrate. In this case (No. 73.2.1) the driver explains what he did when he saw the car approaching from the opposite direction to make a left turn.

Statement to physician: "I travel that street every night. I didn't think she was going to turn. When I saw it, I put my brakes on. There's one thing I can say and that is I always have good brakes; but it was too late. After she struck my car . . . . . "

Statement to psychologist: "I was eastbound -- not very fast -- and I came to the intersection. I stopped because the other car stopped, and then I proceeded through because I noticed she was not going; and when I got three quarters of the way through, I got clobbered."

The above statements were made within an hour of each other in the same room. Did the driver stop and then go ahead, or did he not? What one concludes about how the accident occurred and why depends on this. In this case, there were physical signs in the form of skidmarks which, by accident -reconstruction methods, confirm the first statement.

Studying reliability of conclusions. If the objects of case study--derivation of contributing factors--is to be achieved, reasons for lack of reliability in the results must be sought and methods devised to improve this reliability. Because the end results are conclusions, we must consider how the conclusions are reached. This is not only a problem in Case Studies for research purposes, but it is also one which had been met before at the Traffic Institute and elsewhere in developing methods of determining law violations and negligence in connection with accidents. There is a difference, however. In the Case Studies, so far as they went, only conditions were derived as factors; whereas for law violations and negligence the conclusions relate largely to behavior.

In considering this problem both in connection with Case Studies and other work, a number of circumstances may have influenced the thinking processes which are involved in reaching the required conclusions.

1. Intuitive conclusions. These are ideas that pop into one's mind and are acceptable to the investigator himself and others with confidence in him because of his experience. These are not exactly off-the-cuff opinions but rather a form of "expertizing." They may be expressed

by anybody from taxi drivers to scientists. If one does this frequently, the ideas that come up become stereotyped or stylized at least for certain situations. Thus every right-angle collision at an intersection may be categorized simply as failure to yield right of way.

2. Seeking special factors. The investigator may have some special interest, it might be brake failure, defective vision or anything else. He seeks in each case any signs of factors that interest him and having discovered something neither inquires concerning its precise connection with the events of the accident nor seeks for any other conditions. The engineer in the case cited above was responsible for discovering deficiencies in vehicles that contribute to accidents. They do not occur often. So when a driver claims that an accelerator "stuck" it is something he has been looking for and without proving how and why it stuck or exactly how it related to the accident, he tends to mark it on his data sheet.

3. Accepting suggestions and irrelevant clues. When nothing comes to mind at once, the investigator may accept whatever someone suggests or is suggested by some circumstance. These may be strongly influenced by attitudes and prejudices of many kinds. Thus one car may be driven by teenagers. In the mind of the investigators teenagers are bad accident risks. Therefore, lacking more obvious influences, the investigator concludes that teenagers have done something wrong. This becomes a behavior factor and their immaturity becomes a corresponding condition factor.

No good proof of correctness of conclusion. A great difficulty in analyzing accidents for causes is that there is no easy way to know whether the conclusions reached are right. It is conforting when two or more investigators reach the same conclusion from the same facts. The agreement seems to confirm the conclusion. But when investigators disagree, one or both are probably wrong although sometimes disagreement may be due to reconcilable differences in understanding.

The clinical method of trying to find factors contributing to an accident is more complicated than one would think. Gathering data is not difficult. Drawing conclusions from them, especially without ways to verify the truth of the conclusions, is difficult.

Effect of Problems. We have reviewed the problems of the case approach to determining accident causes. There are many and they are complex. But realization and evaluation of these problems is progress.

These problems come to light in studying accidents intensively. The solutions proposed for them in Concepts and Classification[11] for example, were not of course available when the cases which showed need for these new methods were studied. This circumstance does not necessarily invalidate conclusions resulting from the cases studied. Hence Derived Factors[22] remains the most complete of its kind available up to the time they were worked out.

Review of Results

Concepts of Causes

From reflections on the problems of determining what factors contribute to a traffic accident, it is evident that one task of a group engaged in Case Studies as a pilot project should be to seek reasons for mistakes in conclusions about contributing factors. To "study the problem of drawing conclusions concerning how accidents occurred and why" has already been stated as one of the objectives of the project. Therefore, while the investigating team was studying individual accidents intensively, the author and others connected with the project were thinking about this problem.

The thinking followed several lines. On approach started with the realization that ideas about accident causes are not as clear as they should be. Just what are we looking for when we say we are seeking the causes of accidents? How do we know ehen we have found them? Are they behavior, such as law violation and negligence, or are they conditions of the road, the car and the driver such as those sought as derived accident factors by the Case Studies team? Another approach started with the observation that investigators, even such as the Case Studies team, tended to leap directly from the original data to conclusions about contributing conditions without intermediate steps. This would be equivalent to solving a problem in algebra or geometry by making a shrewd guess at the answer without intermediate logic. The results might be right intuitively, but one would be less sure of them than if a series of steps were taken. Results of thinking along both lines will be outlined in the next few pages.

Each of these levels has the same cycle of three operational phases.

Conditions. To explain the failure of an operation in any phase of any level, condition factors are sought. These are attributes or qualities of:

1. Trafficway environment including weather and light.

2. People as drivers or pedestrians.

3. Vehicles.

The attributes of each may relate to any of the three operational phases: recognition, decision or performance. For example an attribute of the road affecting its performance in slowing the vehicle is its friction characteristic. The basic or fundamental attributes describe qualities which may vary from time to time by modifiers. Thus, the friction characteristics of a road may be modified by many circumstances. These may be more or less permanent modifiers such as wear, or temporary modifiers such as snow and ice.

Classification system. The levels and phases of operation and the attributes and modifiers constitute a classification system which will accommodate both operation and condition factors.

Analytical system. This scheme of thinking also provides a precedural

basis for analysis of accidents to discover the factors which in combination constitute its cause. Starting by identifying the crucial event, one works back by determining what evasive action, if any, was possible and if evasive action failed whether it was in performance, decision or recognition. If evasive action was not possible, what strategy would have made it possible, and if the strategy failed did it fail in performance, decision or recognition of a situation requiring strategy. If evasive action failed because of bad performance, was it because of lack of driver skill, lack of braking ability or because of road surface conditions, and so on, step by step accounting systematically for the events of the accident.

Requirements for such step by step inquiry about the accident prescribe careful reconstruction and, perhaps more important, rigorous requirements for original factual information.

This procedure also develops a more complete list of factors contributing to the accident. For example, for one accident (No. 85.2.1) compare the factors derived by the original investigation and factors developed by following the procedure just outlined which forces more rigorous reconstruction:

Factors as originally derived (with code numbers)

1a. Road stable: Street was very narrow and with two cars parked opposite each other. Only one lane was available for traffic.

1b. Road variable: Ice covered street was extremely slippery and driver started to lose control as he approached parked cars.

Factors derived by revised method. (With code numbers in which a question mark indicates a questionable factor.)

115 Crucial event: Left available path.

21. Evasive action-performance. Evasive action failed because action was not what was intended due to over-steering and experimenting. Combination of contributing attributes:

21 T 3116 Alignment requiring sharp steering because of car parked on road.

21 T 3219 Surface icy reducing slip angle because of surface deposits.

21 T 3316? Path narrowed leaving small space for maneuver due to cars parked on road, possible.

21 P 3144 Lack of skill resulting in over-steering due to lack of training and experience in such a situation.

21 V 1917? Loose steering wheel due to loss of adjustment, possible.

22. Evasive action-decision. Failed, especially in second steering operation, which was wrong direction to come out of skid, due to:

    22 P 2144 Judgment about what to do, trial and error due to lack of training and experience.

33. Strategy-recognition. It is clear that the driver failed to recognize some of the situation confronting him. Just what this was was not determined. It is possible that it could have been determined by more careful inquiry of him during interview, but he may not have been conscious of his failure to recognize the situation. Looseness of steering wheel may not have been noticed and it if was, its significance probably was unknown. Also ice on the road may not have been noticed because of darkness or observation habits of the driver, and the significance may not have been known; these latter are driver attributes. None are more than possibilities:

    33 T 1112? Darkness obscures icy spot on road.

    33 P 1144? Observation habits: car check-out; look for ice. Both due to lack of training and experience.

    33 P 1544? Knowledge of significance of loose wheel knowledge of significance of ice-both training and skill.

43. Preparation-recognition. Problems possibly not fully understood. Weather apparently comprehended, but car condition not. Therefore, contributing attributes are possibly

    43 P 1144? Lack of search for vehicle defects; habits of observing need experience.

    43 P 1544? Lack of knowledge of effect of steering wheel play on ice due to inexperience.

Each traffic unit is treated separately in such an analysis. Thus, a case is a traffic unit in an accident. The usual case involved a car and a driver, but a pedestrian is also a traffic unit.

The operational approach to deriving accident factors which has been described was not completed until data collection in Case Studies was finished. Consequently it was not applied by the investigating team to the cases studied and therefore the factors reported for cases studied were not derived on this basis. Had the project continued, the more systematic approach would have been applied. The procedure was, however applied later to data obtained by the Case Studies for a number of accidents such as the one used in the example given. Otherwise, the operational concept of factors as a scheme for deriving factors in accidents has not been subject to empirical test. As a series of categories for classifying factors, however, it was subjected to test as will be described next.

Inventory of factors. While Concepts and Classification[11] were being developed, a list[13] of factors suggested by various sources as contributing to accidents was prepared. This list had four purposes:

1. To test the classification system developed by determining whether it would accommodate the suggested factors.

2. To get a general idea of how many different factors might be anticipated if case studies were extended broadly and how many items might have to be provided for on data sheets or tabulating cards for a broad statistical study of accidents by the case method.

3. To give investigators some idea of what they might be expected by others to look for.

4. To tell how many of the factors derived from Case Studies had not been suggested before.

The classification system was satisfactorily adjusted and expanded to take care of all suggestions except some which were really descriptions of accidents rather than contributing behavior or conditions.

Of the 180 Derived Factors[22] in cases studied, 50 were essentially the same as factors which had already been suggested by others and hence were not given a separate listing in the inventory. The other 130 appeared to be different at least to a degree, but nearly half of these merely represented different aspects of the same general idea. For example, "unfamiliar with automatic transmission" is a specific instance of "unfamiliar with operation of vehicle or its equipment."

Our inventory of factors included approximately 850 items. Although this listing was not exhaustive, it did incorporate suggestions from fourteen major sources and a number of additional minor ones. Any additional sources which might have been consulted would probably have repeated many of the ideas already listed and added comparatively few new ones.

The Inventory of Factors Suggested as Contributing to Traffic Accidents[13] is given in a separate report, together with a discussion of problems which arose in connection with attempting to fit the factors into a logical classification scheme.

Errors in Determining Contributing Factors

From experiences in trying to develop a method for deriving factors which contribute to an accident, one thing was clear. The conditions - attributes and modifiers - of trafficway, person and vehicle named as contributing factors must explain behavior which contributed to the accident. This was pointed out for the example in which the problem was to determine whether the accelerator stuck. Similar questions of how the accident happened are too numerous to be ignored. Thus the first step in determining why an accident happened is to determine how. There is little point in seeking explanations for behavior unless we know what the behavior was.

Accident reconstruction is the term used for determining from information available how an accident happened, that is, what events took place that led to the final damage and injury. Cause analysis has been used to signify the process of trying to discover conditions which will explain why the events took place as they did.

Certain techniques of accident reconstruction had been developed before the Case Studies began and were described in Traffic Institute publications[115]; but in the hope that better methods would develop from a fresh approach, the investigating team had not been introduced to them. When the first two series of cases were completed, deriving accident factors had become routine without recognition of the need for first clearly establishing how the accident occurred. Therefore, the team was introduced, by example, to methods of accident reconstruction, especially the use of time-space diagrams.

These diagrams were prepared for all of the last 25 cases studied. They were useful in evaluating ideas about the events of the accident and consequently about the contributing factors. To reduce time-consuming calculations necessary to work out time-space diagrams, a new transparent chart was developed to relate time, distance, speed and acceleration. This chart and examples of time-space diagrams appear in Engineering Science Techniques[17]; they will not be further described here.

Limitations on reconstruction. Skillfully done, accident reconstruction is a very useful technique in case studies and other accident investigations; but although it uses many scientific principles, it is no "cook-book" recipe for finding out how accidents occur. The procedure is easily bungled with disastrous effects on the resulting conclusion. To point out some of the pitfalls and suggest the extent to which confidence could be placed in this technique, a review of the Limitations on Accident Reconstruction[19] based partly on experience in Case Studies was prepared and published. It discusses four principal limitations:

1. Quantity and quality of available information with which to work.

2. Skill of the individual doing the work with respect to:

   a. Ability to recognize the significance of results of the accident.
   b. Ability to apply various scientific principles.

3. Need which may be limited for some purposes although it is unlimited for research Case Studies.

4. Time and money available.

The major emphasis is on the first two limitations.

Sources of error in conclusions. Because it is so difficult to determine whether one's conclusions are correct, and because there is good reason to believe that conclusions are often mistaken, attention was directed to how people solve problems of determining the manner in which accidents happen. This is a matter of concern not only to those making case studies for research purposes but also to those settling claims or determining law violations in connection with traffic accidents. Everyday such problems are presented to juries.

To learn something specific about this subject, an experiment was tried.[20] The story of an actual head-on collision was selected as the instrument for this study. All occupants of both cars were killed. Altho how it happened was obscure, the facts available were sufficient to resolve any doubts. All told 1214 people, ranging from professional investigators and engineers to college girls and housewives, were given the facts and asked to tell where in the road the collision occurred, which direction the cars were going (from what was known of the trips either could have been going either way) and therefore, who was at fault by being on the wrong side of the road. The information was supplied in a guileless or control form and also with added irrelevant information of one or both of two kinds:

1. Psychological in the form of descriptions of the occupants of the cars -- teenage boys who had been out all night, and a married couple starting a vacation after attending early mass.

2. Physical in the form of a scratch left on the pavement by one car after collision.

In its guileless form without irrelevant data only 54 per cent of those given the problem came to the correct conclusion, not many more than would be expected to get it right by guessing. Surprisingly, engineers and professional investigators did not do significantly better than college girls and housewives.

Emphasizing the scratch had a significant unfavorable effect on conclusions. The percentage of people with correct conclusions fell from 54 per cent when the scratch was not mentioned to 34 per cent when it was. Describing the occupants also made a difference. With the boys described as in the car at fault 57 per cent of replies were correct, when they were described as in the other car only 34 per cent were correct.

Many of those who had a right final conclusion were wrong about location of collision or direction of travel, especially the latter. They got a correct final result by making a second counteracting mistake. For the entire group only 38 per cent had the right conclusions for the right reasons.

The accident described for this experiment presented a problem with a clear-cut solution. the facts were ample, and they were presented in a pre-organized way. If there is so much trouble with a straightforward problem, what might be expected from the many more obscure problems with sketchy facts and fuzzy outcomes?

This experiment is described in detail in a special report entitled Sources of Error in Deciding How a Traffic Accident Happened[20]. It strongly confirms opinions expressed earlier about how accident factors are derived; it suggests that special training in accident reconstruction is needed if reliable conclusions are wanted and it emphasizes the need for systematic approach to the solution of problems of this kind.

Confidence in conclusions. With some understanding of the limitations on accident reconstruction and a knowledge of what apparently insignificant things can influence conclusions, the investigator may become diffident about expressing his opinions. The facts on which to base conclusions are always limited and so even the most throughtful analysis involves projection towards or into areas of speculation.

If facts are not good enough or are too few the investigator is entitled to decline to form an opinion. If he does express an opinion he should be permitted to express, at least in general, how confident he is. In Derived Factors,[22] the investigating team expressed confidence or lack of it in their conclusions by various modifiers such as "possibly" and "perhaps". In a more systematic reporting of conclusions, the estimated level of confidence may be indicated by symbols. In the example given earlier, the question marks show possibility rather than certainty. Three, four, or more degrees of confidence levels could be provided to show the investigator's appraisal of his opinion. Three, such as certain, probable, and possible, would be useful, but more would have little value because definitions that would make clear distinctions between them would be difficult.

Data Collection Methods

One result of the Case Studies was the development of more complete forms for data collection. These consisted of 18 one-page data sheets,[15] two for medical data[16], nine for engineering information[17], and seven for behavioral[18] information.

A problem confronting designers of accident-data collection systems is to know how far to go. In general standard police and driver reports contain little more data than that required for administrative purposes. This problem also confronted those working on the Case Studies. How much routine factual information should be gathered on each case for future reference in interpreting the case or for possible statistical purposes? An important factor in answering this question is the cost of the data. Some information is cheap and easy to get. For example, air temperature can be measured accurately with an inexpensive thermometer in a few seconds. On the other hand personality measurement of a driver might require hours by a highly skilled investigator. In general the question of how much data to gather routinely is given a practical answer: include expensive necessary data and inexpensive data of marginal usefulness.

Exhibit 2

NUMBER OF ITEMS OF INFORMATION PROVIDED FOR ON THE STANDARD POLICE REPORTS AND ON CASE-STUDIES DATA SHEETS

	Police		Case Studies
	Standard Report	Supplementary Field Notes	Data Sheets
Trafficway	5	46	95
Weather and light	2	0	6
Driver or Pedestrian	4	39	125
Vehicle	4	18	130
Environment	2	3	4
Trip	2	12	20
Total	19	118	380

Data become necessary if one proposes to make a special statistical or other study in which it will be needed. It is unnecessary if it is collected only for possible future use.

Item counts of recorded data. A comparison of the number of items called for by the Standard Specifications for Police Traffic Accident Report, those provided for on the Supplementary Field Notes[115] and those on data sheets for the Case Studies[15] is interesting. It is given in Exhibit 2. In neither case is strictly identifying information such as names, addresses, registration numbers and route numbers included. The number of items for the Case Studies data sheets includes only those scheduled and not unlisted observations made for a special case. It would not be difficult to double the number of items on the Case Studies data sheets without including a large number of hard-to-get items. For example, tire sizes, tread patterns and roadway surface material might be included; and many items of driver size and condition would greatly expand the data sheets. By including hard-to-get items such as tire composition, windshield glass distortion, and results of personality tests, the number of items could be still further expanded.

Not all of the items on such lists need to be filled out for each case. Some are eliminated under certain circumstances. For example, if the traffic unit under consideration is a pedestrian there is no vehicle and vehicle conditions are neither available nor applicable. During daylight hours, data on headlights and street lighting are generally obtainable but not applicable. All of the data required by the Police Traffic Accident Report form are supposed to be collected for each accident, but the Supplementary Field Notes are used only when enforcement action or litigation is contemplated. It is not intended for statistical summarization although much of the data on it could be summarized if systematically collected. The Case Study data sheets provide for all the information on the police reports although check lists are not provided as a means of recording the information obtained as is customary on police reports.

Additional data from reference sources. Some of the items in data sheets connect with other sources of information which could be referred to, and indeed were referred to when wanted for Case Studies. For example, information regarding the make, model and year of a vehicle makes it possible to get dimensions from manufacturers' specifications. Photographs also provide reference data for such things as damage to vehicles. Any of these reference data could be looked up and reduced to quantified information for statistical purposes. Hence the total possible systematic information available exceeds by a considerable amount that which is actually recorded on the data sheets at the time.

Statistical and Clinical applications. The case studies were slanted strongly toward the clinical approach. Therefore the data gathering methods were developed with that in mind, and the data systematically provided for on each case was less than it would be for strictly statistical interpretation.

The clinical and statistical methods are not totally incompatible. The results of any number of individual case studies may be examined by statistical methods--classifying, counting and comparing--to see what they have in common. Many of the circumstantial data which would be collected for a statistical study would be also collected as a basis for clinical conclusions. The investigating team and others working on the Case Studies, were not unmindful of the statistical approach. This concern is reflected in the development from the first by team members of detailed data sheets and lists of specific questions to ask in highly structured interviews. It is also indicated by the work done by others connected with the project in devising classification systems.

Too few cases were studied on the project to warrant refined statistical treatment, but the possibilities of it with more data were kept in mind.

Personality Tests can be considered a form of data collection and so will be mentioned at this point. As was explained in the review of experience with the interdisciplinary team, both behavorial scientists felt the need for more precise and specialized tests of personality. Although development of such tests was not an object of the Case Studies, several such tests were given a try. Some of these were developed especially for the purpose and are briefly described:

Driving Situations Test, an adaption of the projective technique of the Thematic Aperception Test to traffic situations. The person was shown a series of ten pictures of drivers in traffic situations and asked to tell about them. This test is further described in Appendix C of Social Science Techniques[18].

Personal Opinion Inventory, a list of 160 items with which the person indicates agreement or disagreement. The responses to selected statements give keys of 15 "scales," each purporting to measure an aspect of personality. Scales relating to aggression and authoritarianism seemed to be more promising than the others in connection with accidents. This test is further described in Appendix B of Social Science Techniques.[18]

An evaluation of law violations in which the person was given a list of about 20 common traffic law violations and asked to indicate for each what fine he would assess, where he a magistrate, as a penalty for a person convicted of the violation. This is not further reported.

Teen-age orientation. A study was made of high-school drivers to determine whether those who took their cues from adults (parent oriented) or those of their own age (peer oriented) were more likely to have accidents. This study is not yet further reported.

None of these instruments was fully tested and none seemed to be more than moderately useful in suggesting why a particular person had a particular accident.

The behavorial and medical scientists found that carefully conducted interviews, including detailed discussion of the accident, was the most useful technique available for assessing the contribution of personality characteristics to the accident.

Case Reports. When the investigating team was through studying a case, a report of it was prepared. This contained:

1. Measurements, observations and pictures made of the trafficway, the person, and the vehicle.
2. Summaries or transcripts of the statements of the person involved concerning the accident and himself.
3. Diagrams and results of calculations in reconstructing the accident.
4. Certain data from outside sources such as driver-license records.
5. Discussion by investigators of their observations.
6. Conclusions of the investigators concerning factors which may have contributed to the accident.
7. Other notes and data.

The case reports varied from about 25 to more than 75 pages in length. For reference purposes, a collectionof Synopses[21] of the accidents has been prepared; one for each report. This consists of a diagram, a description, some classifying data relating to type and severity of accident, and the Derived Factors.

Rate of Investigation

In a pilot project, a matter of considerable interest is the output of the investigating unit. How many accidents can be investigated in a month or a year by a team like that used for Case Studies working under the conditions of the project? How much could be done by different kinds of teams under different conditions?

Two kinds of activities involved in pilot projects. Pilot projects like the Experimental Case Studies have two functions: production and development. They produce case reports for a time, then shut down and develop new methods after which they work for another period with revised methods. To evaluate the rate of investigating, therefore, only the productive periods should be considered not the shut-downs for development.

Time distribution. The Case Studies project was begun July 1, 1957 and ended December 31, 1960, a total of three years and six months. Of course project proposals and much preliminary planning preceded "activation", and distribution of reports and answering enquiries will inevitably come after official termination. Nine months, from July to April, elapsed before the first "production" run was started. The last case was investigated early in February of 1960, more than ten months before the project terminated. Therefore of the 42 months the project was active, 19 were required for initial "acceleration" and final "deceleration." During the remaining 23 months production was not continuous but went forward in three phases with periods between for preparing progress reports, developing new methods, vacations, and so on. Even within periods, investigation was not continuous. For example, the last phase from September 1959 through February 1960 spanned six months but during this time only ten weeks were devoted to actual investigation.

Actual time investigating for each of the three phases is shown by "Weeks Active" in Exhibit 3. This is the number of calendar weeks during which the investigating team was on call to go to accidents, was following up, or writing case reports. Although records of team activity by hour which would permit detailed separation of development and production time were not kept, the number of weeks shown is considered a fair estimate.

Rate of investigation. For the time spent in production there was an overall average of 1.21 cases per week completed. This was lower in the second phase, probably because only two investigators were active during most of this time.

Hours available is the number of hours that the investigating team was

Exhibit 3

INVESTIGATIVE TIME AND RATE FOR CASE REPORTS

	First Phase Apr.-Sept. 1958	Second Phase Jan.-July 1959	Third Phase Sept.59-Feb.60	All Periods
Weeks active (a)	25	21	10	56
Hours available (b)	343	242	39	625
Runs to accident scene (c)	75	46	17	138
Runs to acceptable accidents (d)	23	20	8	51
Cases completed (e)	32	22	14	68
Hours available per week, active (b/a)	13.8	11.5	3.9	11.1
Cases completed per week (c/a)	1.28	1.05	1.40	1.21
Hours available per run (b/c)	4.58	5.26	2.29	4.52
Proportion of runs productive (d/c)	.30	.43	.47	.36
Cases per acceptable accident (e/d)	1.39	1.10	1.75	1.33

prepared to respond to a call to the scene of an accident. This corresponds roughly to the time waiting for an accident to happen. Actually during these hours, team members were writing up previous cases, keeping records, making appointments or doing other work which could be instantly dropped if an accident call came in. Sometimes to catch up on writing reports the team went "off call." Also during interviews and follow up at the scene, the team was not available.

Hours available per week, as will be noted by Exhibit 3, diminished substantially in the second and especially in the third phase. There were several reasons for this. In the first period, the police sometimes forgot to call the team when an accident happened and so it was missed. This situation was remedied by monitoring the police dispatcher's radio calls. Another reason is that the third phase was mainly during months of high accident frequency. Finally, in the later phases, particularly in the third, more time was spent in interviewing and especially more in analyzing the accident so that the team was more often not available because of need to catch up on report preparation.

Hours available per run represents average number of hours from the time when the team notified the police that they were available until they went to the scene. The reduction in the later phases is due to the first two of the factors mentioned as influencing the hours available per week.

Proportion of runs productive of acceptable accidents increased from 0.30 in the first phase to 0.47 in the third. The team was rejecting fewer accidents because of small damage and they were becoming more adroit in securing cooperation from accident participants. Even at best half of the runs resulted in no case. The main reason in the first phase was negligible damage; in the final phase it was involvement of commercial vehicles which were not included in the study. Further details on these rejections are to be found in the special report on Data Collection.[15]

Cases per acceptable accident is the number of traffic units on which reports were finally completed compared to the number of accidents which were investigated. A few accidents involved only one traffic unit and so could yield only one case for study. Most of the accidents in this urban area involved two traffic units and so should yield two cases. When they did not, it was usually because one of the drivers refused to cooperate or if he agreed to cooperate, failed to do so.

Total number of cases completed was 68 traffic units involved in 43 accidents out of 51 accidents accepted for study in 138 runs to accident scenes. These accidents were quite representative of those which happened in Evanston, Illinois. where the study was made, except for those occurring in the hours between midnight and seven in the morning or involving commercial vehicles. Reasons for not including these are given in the special report on Data Collection.[15]

Possible full-time production. Suppose a team of this kind were to devote full time to investigating accidents without pausing to improve. methods or without having to summarize the cases studied. Suppose that it were to prepare case reports of about the same scope as those in the last phase of the Case Studies, that it were to work in a city like Evanston, and were to exclude accidents involving commercial vehicles and those between midnight and seven in the morning. Then we might expect about 1½ case reports to be completed per week, or, allowing for vacations, etc., between 70 and 75 per year.

It should be noted that although the output suggested may appear small, it is a higher production rate than would likely be obtained by a lawyer in investigating and handling damage claims.

Effect on output of alterations in investigation methods would be expected to affect the rate of report production. For example, it might be desirable to increase the number of items of information gathered about each case. This would increase the time required to complete a case, especially because most of the easy to get information has already been included and any additional information would take more time per item to obtain. Also, if the analytical techniques improved, for example, if an operational analysis were to be made of each accident, the work of accident reconstruction and of deriving factors would be greatly increased, thus reducing the time available for data collection and number of cases that could be handled in a given time.

Selection of cases. Were commercial vehicles included, there might be a fifth more cases per run, but this would not increase correspindingly

the number of cases produced because more time would be "off call" to complete reports. Perhaps the gain in productivity might be a tenth. This would improve the percentage of runs that were productive. Were accidents to be investigated in night hours many more hours available would be required per run because the accidents are so infrequent during these hours. It is likely that there would be a considerable reduction in cases per week were these hours to be sampled because such night hours are not very productive for report writing and other interruptible activity. It is not unlikely that the team members would wish to follow the practice of fire departments for night calls and sleep until the call comes in.

Effect of other locations. Another location would effect the production of the investigating team because not all locations have the same frequency of accidents within a practical radius. More congested areas will reduce the time the team has to be available per run, but that might increase output very little because the time "off call" to complete reports would increase. Only when the time required by interruptible case work is less than the time available per run is there waste waiting time that would permit greater production if accidents occurred more frequently and the strictly waiting-with-nothing-to-do-time were reduced.

Studies on limited-access highways present particular problems because the accident frequency on these special highways is so low. The team would have to be located at a junction to have access to the greatest number of cases within a practical working distance on routes connecting at the junction.

The possibility of placing the research team on the Illinois tollway with headquarters at the O'Hare International Airport interchange was considered. The results which might be expected from such a move are given below, based on accidents for 1959:

Total passenger cars involved	647
Within 15 miles of O'Hare Interchange (approximately 50% of accidents)	324
Occurring during working hours (20 of 168 hours in week)	39
Involving drivers living within 150 miles (50%)	20
Drivers willing to cooperate (60%)	12
Weeks per year team available (47 of 52)	11

Increasing radius from 15 to 50 miles would enable team to cover practically all of the Illinois tollway system. However, this would substantially increase travel time and thus increase the frequency of arriving at the scene too late. It would also lead to the possibility of missing out on an accident "closer home" as a result of being so far afield. It is unlikely that more than 20 hours of a normal working week could be devoted to waiting for calls and visiting the scene of accidents. The remainder of the time would be needed for interviews, revists to the scene and other non-interruptible activity. It is also considered impractical to attempt to interview anyone who lives more than 150 miles from the base of operation. What percentage of the people would cooperate is problematical. The situation in

Evanston was almost ideal from that standpoint. On the Tollway not nearly so many could be expected to agree to interviews and tests. The figure might be well below the 60% used in the calculation above.

Concentrating the 'on-call' hours on Saturday and Sunday when the rate is higher would increase the number of accidents occurring during 'on-call' hours by perhaps 15%. This is a relatively insignificant increase and it might well be offset by a different pattern of driver distribution, perhaps more of the weekend drivers come from further away from home than is true at other times.

It would thus seem that a team could expect to get perhaps a dozen cases a year under the circumstances. This would mean considerable waste waiting time. This might be reduced by also accepting accidents in the surrounding area. But this would mean that the investigators would reduce greatly the likelihood of being available when a freeway accident occurred because of being tied up with an outside case.

Even at locations were accidents are more frequent within a practical working radius, it is doubtful whether a team could produce more than a score of case studies per year for freeways. With the variety of accidents to be found even on freeways, ten to twenty accidents is no very large specimen of the phenomenon to observe. More teams and longer time would be required to obtain significant data. In the Case Studies, of which this is the report, the desirability of seeing more accidents outweighed the desirability of including a small sample of those which occur on freeways.

Cost of case studies. The direct labor cost for a three-person team of scientists with clerical and part-time administrative help which would be needed to keep them producing is about $40,000 per year. To this must be added for transportation, supplies, special tests, and other expenses plus an overhead of about 50% giving a cost of $60,000 per year. To study 70 to 75 cases per year, this is a cost of between $800 and $900 per case completed. This would include nothing for study of the cases as a group, statistical summaries of them or publication. It would include nothing for further development. If the estimated expressway experience were to limit the output as indicated, to a dozen cases per year per team, the cost would be six times as great or something like $4000 per case. If techniques were improved to require more testing of cars and drivers and more time in analysis of the individual case, the costs would increase not only because of more time required per case but also because there would be a smaller proportion of those who would agree to cooperate in the more elaborate and time-consuming procedures.

Reducing cost by simplifying procedures does not seem to be feasible. If this much is to be put into the study of a case, all the data collected and probably more will be expected by those who want to study the case reports. It is more likely that the case study will become more rather than less complex. It might be possible to reduce costs to some extent by employing one well trained technician to collect data and do most of the fol-

low-up investigation including interviewing. There would have to be doctors, engineers and others on a part-time basis as consultants for special cases, and one analyst to reconstruct the accident and prepare the report. The technician might be had at $6000 per year, the analyst at $11,000. Consultants' fees, clerical help and the necessary overhead would probably cost about $40,000 per year or a reduction of about a third, more or less. If one scientist could work up the cases for two data-gathering technicians, the cost per case would be reduced about a half.

It is conceivable that the technician employed might be a policeman patrolling until an accident occurred and then following the case for the complete collection of data. This would have the advantage of economics of operation but there might be problems in getting cooperation of individuals involved and with respect to accessibility of data collected to attorneys for other than research purposes.

It must be remembered that the above estimates are only for the development of a "clinical" report on an individual involved in a traffic accident and not for study of the cases so accumulated. Furthermore, with respect to teams composed of technicians and scientists, it does not include costs of initial training of the technicians--there are none already trained--or for development of techniques.

Number of Cases to be Investigated. The total cost, of course, depends on the number of cases to be investigated. The 68 cases studied in this pilot project were enough to give some idea about how accidents happen--to show that some expected things do not appear often and that accidents seem to hinge on very great variety of inconspicuous circumstances. But for any real evaluation of the frequency with which circumstances contribute to accidents, the number of cases would have to be large enough to allow for the possible occurrence of the rare circumstances. This number would certainly be in the thousands, probably in the tens of thousands and possibly even more. Certainly to obtain enough data for systematic statistical treatment to discover more than the most common contributing factors, and many of the contributing factors are not very common, would take very large samples. At the cost per case indicated, one must think in terms of millions of dollars and a program of indefinite duration.

Cause of the Accidents Studied

This is the place to state again for further emphasis a conclusion that was repeatedly confirmed during the case studies: the causes of traffic accidents are combinations of contributing factors and not single acts or conditions. We have come to think of an illness as being caused by a disease, in many cases a specific micro-organism, but accidents are different. Except in rare cases, two or more factors must operate together to produce the crucial event resulting in injury or damage. The factors are equally important although some may be much more obvious than others and some much more amenable to control.

The study of a case, that is, a traffic unit involved in an accident, is

Exhibit 4

NUMBER OF ACCIDENT FACTORS DERIVED

FROM 68 CASES

	Stable	Variable	Total
Road	37	71	108
Vehicle	11	13	24
Driver	27	90	117
Social Situation	2	38	40
Total	77	212	289

intended to discover the combination of contributing factors for that accident. It has been pointed out that more systematic methods of doing this were developed at the end of the project than were available during the project for the cases studied.

Conclusions of the investigating team with respect to contributing factors are listed for each case and summarized in a separate report, Derived Factors.[22] These are classified according to the four categories listed in Exhibit 4 with the number of factors for each derived from the 68 cases studied. This is an average of 4.3 factors per case studied.

The factors derived are all conditions of the highway, the vehicle and the driver or pedestrian. They do not include action or operation factors which would reflect behavior such as violations of traffic laws. Had these been included, the number of factors would be substantially larger.

Conclusions are limited by number of cases. In considering what might be said about accident causes as the result of the Case Studies we must again warn that the small number of cases from one community will not permit conclusions about accidents in general. There was some question as to whether anything at all should be said on this subject because of the possibility of unwarranted inferences. However, for what they are worth, some of the impressions gained in studying those accidents will be summarized.

Chance. One of these impressions is that the circumstances of the accidents are extremely varied. True, eight of the 43 accidents studied were collisions between two vehicles moving in the same direction with neither turning. Police traditionally report the "cause" of such an accident as "following too close." Hence we seem to have 19 percent of the accidents of this kind. But this customary classification is by rule of thumb; it is made without consideration of how close the vehicles were, how fast they were moving or how close is

"too close." To say, after one car hits another, that they were too close is stating the obvious. On more careful examination of these cases, the superficial similarity begins to disappear. A number of them involved a third, non-contact vehicle; slippery surfaces contributed to some; and delayed perception, for a variety of reasons, was a factor in others. All could have been categorized "travelling too fast" as appropriately as "following too close," because it is the relation between speed, distance, perception delay, reaction time and decelerating rate that makes the difference between having an accident and not having one. These relationships vary greatly from one "following-too-close" accident to the next.

Another observation from these cases is the very narrow margins by which many of the accidents occur. A few inches difference in position, a fraction of a mile per hour difference in speed, a few tenths of a second less delay in perception and there would have been no accident or the accident would have been entirely different. Car A would have struck C rather than B, for example. In trying to find causes of accidents, then, we are seeking, in most cases, minute influences. This may in general be less true in more serious accidents. But it is not difficult to find fatal accidents with very, very small margins between happen and not happening.

This leads to consideration of chance. In the philosophical sense nothing happens by chance, everything is the result of causes or influences. But in practice we recognize that many of these influences are so minute and obscure that they cannot be observed and measured. When a tossed coin falls face up rather than the reverse, it is unquestionably due to its starting position and forces acting on it in tossing, moving through the air, and in landing on a surface; but these forces are too complex to be evaluated for prediction of which way the coin will fall. So we say the coin falls head or tail up by chance.

There is a series of events for each traffic unit involved in an accident that culminates in the crucial event resulting in damage or injury. Minute differences in influences and forces anywhere along this series could have meant that there would have been no accident--or a worse one. A slight difference in time of starting a trip or small variations in speed on the way would have meant no accident. These are matters of chance in the sense that there is no conceivable way up to a certain point of predicting the outcome as the events take place. In this sense it is chance, that two vehicles approach the same spot at the same time--on collision courses, we say. It is chance that at this particular moment, for one reason or another, neither driver happens to be looking where the other could be seen approaching; or it is chance that when the two come in sight of each other both happen to be going so fast that neither can take successful evasive action. Thus accidents occur when certain combinations of circumstances by chance occur at the same time to contribute to it. These ideas are developed in much more detail in the special report on Concepts and Classification.[11]

To prevent accidents, an effort is made to control or modify conditions in such a way that they will less frequently appear with other conditions in accident-producing combinations. If, for example, 1) an unskilled driver in

2) a car with unusual play in the steering wheel driving at 3) a speed just below the limit comes to a 4) icy spot where 5) two cars are parked on opposite sides of 6) a narrow street, (Case 85.1) these six conditions happen together by chance just as much as a combination of any six cards dealt from a well shuffled pack would come together by chance. Change any of these conditions--very little change would be enough for some--and the accident would have been averted: a more skillful driver, a car in better adjustment, somewhat less speed, less slippery surface, only one parked car, or two feet more street width.

Accidents are therefore a matter of chance combinations of circumstances. The diversity of the accidents suggest that the number of factors combining by chance is very large. The fact that so many accidents happen by narrow margins suggests that only slight modifications of factors will increase the chance of accidents or decrease it substantially.

Seeking the expected. As one goes through the case reports he naturally looks for what he has been led, for one reason or another, to believe are important contributors to accidents. For the most part he will be disappointed.

Accident-prone drivers, for example, did not appear. From their pre-accident experience with automobiles or otherwise, none of the 68 drivers, pedestrians and cyclists in these accidents would have been expected to have had the accident in which they were involved. There is a special report on the previous accident and traffic violation experience of these drivers: Record of Accident Involved Drivers[24].

The teenage "terror" did not appear. This does not deny the statistics and increased insurance premiums that testify to his existence. The investigating team for Case Studies was not angling in the right pond to catch this species of fish. A little study of reports of accidents for such drivers suggests areas and times where they might be found.

Poor vision. Although many of the people in the accidents studied "did not see" the hazard, it was rarely if at all because of poor vision. Half a dozen had some visual defect and although a number of these were listed as factors in accidents, this was done without a thorough analysis of the seeing requirements of the task to match with the vision level. Detailed data will be found in the special report on Medical Techniques.[16]

Discourtesy as such did not appear as a factor. A number of drivers moved from parking spaces in front of oncoming traffic or did other very annoying things but without realizing anybody would be affected; hence there was no intended social interaction which could be classified as discourtesy.

Emotional stress, is often mentioned as contributing to accidents. One is warned of the danger of driving, for example, after a quarrel with the wife, or a reprimand from the boss. It is extremely difficult after an accident to determine whether some such situation was in fact involved. There were no conspicuous examples of it. Some of the people in the accidents appeared to be the kind who might be upset easily but at the time they did not appear to be or have reason to be so. Failure to find an example in this sample does not, of course prove that emotional stress is never a factor.

Alcoholic influence was noted as a factor in four cases out of 68. Evanston (where sale of alcoholic beverages has been barred for many years) is not a place, and the hours sampled would not be times where driving under the influence would be expected. Hence this number of cases was not surprising.

For the most part the accidents seemed to involve ordinary people in ordinary vehicles on ordinary streets. The circumstances were so diverse that it is difficult to "single out" things that could be called the "most common causes."

That these circumstances were not found in the cases studied is not grounds for inferring that they never contribute to accidents. We can only say that they were not common enough to explain many accidents in this sample and therefore may not be so common as theorized by those who have been talking about them.

General observations. What, then, can be said about these accidents in general? In few cases was there anything like an unforeseeable mechanical breakdown. No vehicle suddenly gave out, no road collapsed under a car, no driver had a seizure at the wheel. All the conditions were as they had been for a while before chance brought them together in a combination which added up to an accident.

The streets contributed more factors than was expected. Few of these factors were conditions that hundreds of drivers who passed them successfully before and after the accident would think of as difficult situations. Indeed they became factors in the accidents studied only in combination with other driver and road conditions.

The most common of these street conditions was the view obstruction created by cars parked too close to intersections and alley entrances. For the ordinary alert and attentive driver at moderate speeds they are no problem, but when they combine with two drivers who are both a little careless in looking, they do contribute. The thirty-foot no-parking rule is quite well enforced in Evanston, but does not apply at alleys. It was adopted years ago when the speed limits and actual travel speeds in the city were less than now. To accommodate the present speeds, it is estimated that parking should be prohibited 60 feet from the intersection. A hundred feet would be desirable.

The cost of this in terms of on-street parking space would have to be weighed against the cost of the accidents.

Although signs and signals in Evanston are better than those in many if not most cities, many seemingly inconsequential things about them contributed to particular accidents. The green light remains on in the signals in this community when the yellow appears. This is contrary to the national standard[104]. In two cases the yellow light was not functioning leaving the green indication for the approaching driver. This was believed to have been a factor in the accidents. In other cases, stop signs were turned or placed so that some drivers to whom they did not apply thought they did with resulting difficulties. One of the few grades in the community is so arranged that it hides an approaching car for a few seconds while giving the illusion that there is nothing in the road. This difinitely contributed to an accident. Other street and car circumstances are described in the special reports on Engineering Science Techniques[17] and in Derived Factors[22].

None of these street conditions was the cause of an accident in the sense that it alone was sufficient to produce an accident for every car. They were only factors when they chanced to combine with other conditions. But had they not been as they were it is believed the accidents would not have happened.

The Suburban Matron. If the teenager did not appear as the "villain" in any noticeable number of the cases studied, was there any other kind of person who might be conspicuous. The cases were studied with this in mind by sociologists connected with the project. Nothing truly significant developed. The nearest approach to it was described by them as "the suburban matron." Evanston would be expected to be the habitat of such a "species," if one exists, as much as it would be an unlikely place to find the teen-age, high-accident stereotype. The suburban matron is likely to be both intelligent and courteous. Her deficiencies lie in other qualities. Although the car is a necessity to her and she drives considerably, mastery of its operation is nothing to give her satisfaction. Therefore she has never developed the skills in handling it that her husband or son would be likely to take some pride in. While at the wheel she is very likely to relegate driving to second place in her attentions when others are aboard especially her children or grandchildren. She tends to overlook the possibility of other vehicles especially when engaged in maneuvers such as parking, which requires concentration, effort, and skill. She tends to fluster in complex traffic situations with resultant inappropriate evasive actions. But the Case Studies suggests rather than identifies this personality type. To prove a connection with accidents would require study of many more cases.

Operational situations. It is extremely difficult to characterize kinds of operational situations which frequently result in accidents. There are so many different combinations that a very detailed study of many hundreds of cases would be required to identify and describe types. An attempt was made, however, to make a beginning at least in characterizing certain operational situations.

Competing hazards seemed to occur fairly often. This term, which may not be a very good name, does not refer to the forced choice between two evasive actions either of which may be unsuccessful. It refers, rather, to a situation in which the driver or pedestrian has several places to look for possible hazards, usually right and left, or ahead and behind; and these compete for his attention. Usually he quickly and superficially glances in the direction that seems to offer least hazard, and having disposed of that, turns his attention in another direction where a traffic unit of uncertain intent requires watching or where a view obstruction may hide a potential hazard. This situation occupies attention for several seconds during which

the driver has slowed or stopped to see that all is clear. Then, when the way does seem clear, he starts quickly without looking again in the original direction where another traffic unit in the meantime has approached and assumes that the slowing is to let him pass. The essential difficulty here is a multiple-hazard traffic situation for which the driver has not developed the necessary habits of looking. The other driver in this situation also contributes but usually for a different reason such as an unfulfilled expectation.

Ignorance of collision course[23] covers a number of rather common situations in which drivers make unwarranted assumptions about what some other traffic unit will do. These are the subject of a separate report and so will not be discussed here.

Recommendations for Reducing Accidents

Although it was not a purpose of the case studies to make recommendations for reducing accidents, the task of seeking contributing factors to specific accidents sets the machinery of imagination in motion toward that end. Hence, after listing the factors derived from the accidents studied, the investigating team continued and set down what seemed to be necessary to reduce the frequency with which those factors appeared in accident-causing combinations. Many of these suggestions are for activities which are already being done and so serve only to emphasize the need for continuing and possibly intensifying those practices. Other ideas would be so expensive to put into practice that there might be question as to whether the savings in accident costs would exceed the cost of preventive activity.

Some of the factors derived were such that no practical remedial action could be thought of. Accidents involving such factors must be contained by attacking other factors more amenable to control in the combinations which cause accidents.

These ideas about accident prevention are listed in detail in Recommendations to Reduce Accidents.[26]

Future Developments

This and other reports on the Experimental Case Studies of Traffic Accidents have been prepared to record experiences in this pilot project. The record has been made more complete than the reports of the few previous similar but less extensive projects. This was done so that in the future those who consider collecting and studying data on accidents may know of the problems encountered and ideas developed as well as the facts found about accidents studied.

The reader of these reports should, therefore, be able to draw his own conclusions from them as to the direction future accident data collection should take. Such a reader is entitled to modify his opinions according to his interests in and desires for data which might be accumulated by more elaborate study of accidents.

The conclusions of those who have worked on the program may be of some interest and will be briefly outlined here. These conclusions do not represent the thinking of all who participated in the project because a number left for other work before this was written. Nor do they represent policy of the Traffic Institute where the Case Studies were conducted.

Two Phases of Accident Study

To begin with, let us remember that study of an accident to find factors contributing to it has two phases:

1. Data Collection by observation, measurement, and inquiry. This includes recording data. The object is to get facts.

2. Interpretation of data which includes drawing inferences as to how and why the accidents happened. This includes accident reconstruction. The object is to form opinions.

Interpretation is definitely limited by the quality and quantity of the data collected. In other words, Phase 1 could be extensive without any of Phase 2, but none of Phase 2 is possible without some of Phase 1. This relationship is more fully described in a special report.[19]

Both phases may be done by the same investigator so far as he is able; each phase may be done by a different person, or there may be combinations. Either data collection or interpretation or both may be shared by two or more investigators. In the Case Studies, the same three investigators shared both data collection and interpretation.

An accident study may have any of many combinations of these two "ingredients". Standard police reports include a modest amount of data collection but little or no interpretation. The Case Studies included considerable amounts of both, but not nearly all that would be possible.

Possible Data Collection Systems

Assume that the object of accident investigation is to accumulate case reports for study purposes and that those reports may include interpretation as well as factual data. Much or all of the data collection could be done by technicians, depending on the complexity of the data. Some simple routine interpretation could be done by properly taught technicians, but beyond that all would have to be done by one or more scientists.

From these possible combinations, many different accident study systems could be planned. How far we go beyond present accident reporting depends of what is wanted in the case reports. A few possibilities for extended investigation are:

1. Expansion of all police reports to include additional factual information. This would be a return to methods of the past, although possibly with better planning for the additional data and its use.

2. Include interpretation on police reports. This is now done in some places. Its value depends on ability of the policeman to interpret. This ability is questionable.

3. Supplementary data collected on temporary forms by all police on a limited basis for special purposes. This has been done.

4. Assignment of selected police with special training to collect additional data.

5. Same with interpretation by police.

6. Extended data collection by police or technicians with interpretation by scientists.

7. Both data collection and interpretation by one scientist.

8. Data collection and interpretation by a team of scientists. This is what was done in Case Studies.

The above possibilities are arranged in order of increasing costs. The first and third of these will give additional useful data for statistical study. The second is not likely to produce very valuable conclusions unless the police have had much special training. The last is likely to cost too much for collecting cases on the scale necessary.

Practical considerations. Police are reluctant now and will probably become more reluctant to spend additional time on collecting accident data. They may be persuaded to do this if the data are useful and if it is on a temporary basis. On the other hand, police have the advantage of great accessibility to accidents, and they can do useful patrol when not engaged in accident investigation.

Scientists are not likely to be happy just gathering routine factual data. Nor are they likely to be attracted from other work to accident study projects which will last only a few years.

Sporadic efforts at studying accidents intensively are unlikely to amass sufficient uniformly collected data to evaluate the great number and variety of factors that contribute to traffic accidents.

Coordinated special studies within limitations of these practical considerations are possible. They seem to offer a practical means for obtaining more information about various aspects of accidents. This would involve cooperation between numerous agencies which, although uncommon, is not impossible. A continuing organization, probably attached to some parent organization rather than independent, would be required. This organization would be composed of representatives of police departments and others in a position to collect data about accidents and technical people who would use the data collected. The organization would require services of professional staff competent to specify exactly what data were needed, how it is to be interpreted, if all at, and how it should be recorded.

This organization would receive or generate ideas for special studies of accidents. It would carry out a continuing program of sampling for various studies. For this purpose it would supply auxiliary forms, instructions, and training aids. In some respects this would be like an opinion polling organization. It would serve as a clearing house for requests to police agencies for special data collection. it could combine and consolidate special data collection in an effective way, specify sampling methods, distribute forms and store the gathered data. The organization would make the data available to any who wished to study it or might summarize it directly. The program of data collection would be scheduled a year or more in advance so that there would be opportunity for collecting agencies to plan for it. Financial requirements for such a special study planning group would not be great, but continuity of activity over many years would be needed to make it a success.

Development of such a group need not stand in the way of continuing progress in analysis of individual accidents and of instruments and methods for evaluating all aspects of personality as it contributes to accidents.

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