Traffic and Safety Procedure: Project Report on the Safety and Accident Procedures

WA-RD 156.1

Final Report
April 1988

Washington State Department of Transportation
Planning, Research and Public Transportation Division

in cooperation with the
United States Department of Transportation
Federal Highway Administration

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
WA-RD 156.1		

4. TITLE AND SUBTITLE	5. REPORT DATE
TRAFFIC AND SAFETY PROCEDURE: PROJECT REPORT ON THE SAFETY AND ACCIDENT PROCEDURES	April 25, 1988
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
G. Scott Rutherford, Mark E. Hallenbeck, Edward McCormack	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Washington State Transportation Center The Corbet Building, Suite 204 4507 University Way N.E. Seattle, Washington 98105	11. CONTRACT OR GRANT NO. Y 3399, Task 27
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Washington State Department of Transportation Transportation Building, KF-01 Olympia, Washington 98504	Final Report
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

This report evaluates the existing procedures used by the Washington State Department of Transportation for collecting, storing and analyzing accident information. The report reviews published literature on accident analysis systems, reviews the proposed system design for accident analyses within the TRIPS computer system, and makes recommendations as to how WSDOT should alter their existing and planned systems to provide more appropriate accident analysis capabilities to the department.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
accident analysis, database systems, traffic accident data	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	116	

TRAFFIC AND SAFETY PROCEDURE: PROJECT REPORT ON THE SAFETY AND ACCIDENT PROCEDURES

by

G. Scott Rutherford
TRAC Director

Mark E. Hallenbeck
Research Engineer

Edward McCormack
Research Engineer

Washington State Transportation Center (TRAC)
The Corbet Building, Suite 204
4507 University Way N.E.
Seattle, Washington 98105

Washington State Department of Transportation
Technical Monitor
Kris Gupta
Transportation Data Office Manager

Final Report

Research Project Y3399
Task 27

Prepared for

Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

April 27, 1988

TRAFFIC AND SAFETY ANALYSIS PROCEDURES

INTRODUCTION

This technical summary describes the key findings of a WSDOT project that reviewed the Transportation Data Office's (TDO) procedures for collecting, storing, and analyzing its traffic and accident data. The primary objective of the study was to determine if the procedures currently followed are appropriate for inclusion in the TRIPS database design, or whether the procedures should be altered before or during the development, programming and implementation of TRIPS. This project is documented more fully in "Traffic and Safety Procedures: Final Report."

RESEARCH APPROACH

This project consisted of a review of the available literature; discussions of the needs and requirements of WSDOT's traffic and accident data users; a review of the needs of users external to the WSDOT; analysis of the potential methods for performing the identified data collection, manipulation, storage and analysis tasks; and recommendations for appropriate changes to existing WSDOT systems, procedures and documentation.

CONCLUSIONS AND RECOMMENDATIONS

In both the Traffic and Accident portions of the project, the existing WSDOT procedures were, for the most part, found to be consistent with the practices of most other state transportation departments. The majority of recommendations made by the project team concerned revisions to the preliminary description of data storage, flow and manipulation within TRIPS.

Improvements recommended for the Traffic portion of the project included the use of computers to reformat and summarize traffic data input into TRIPS to ease and speed the human review of those data for errors. Processing functions were also added to TRIPS to allow calculation and storage of seasonal factors for traffic volumes and vehicle classification data, axle correction factors, and summary sheets of permanent traffic recorder data. The study also concluded that improved communication between the TDO and other WSDOT divisions was necessary to improve the understanding and use of the data TDO maintains.

The conclusions and recommendations for accident data were similar in many ways to those for traffic data. The TDO would benefit from better access to some additional WSDOT data, particularly historical roadway information and appurtenance data. In addition, effort is needed (and resources committed) to ensure that the data stored in TRIPS are kept current. Changes were also recommended for the accident data storage, manipulation and reporting procedures performed within TRIPS.

Finally, the study recommended that WSDOT management review the goals of the Department's accident (safety) analyses. The project team believes that the current descriptive analyses TDO performs are sufficient to meet the Department's needs.

PROJECT CONTACTS

Mr. Mark E. Hallenbeck
Washington State Transportation Center
The Corbet Building, Suite 204
4507 University Way N.E.
Seattle, Washington 98105

Mr. Ed McCormack
Washington State Transportation Center
The Corbet Building, Suite 204
4507 University Way N.E.
Seattle, Washington 98105

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF EXHIBITS

EXECUTIVE SUMMARY

The Washington State Department of Transportation (WSDOT) is currently implementing the Transportation Information and Planning Support (TRIPS) data collection and analysis system. The objectives of TRIPS are

- to develop a central, integrated database of information about the state highways, and
- to provide a core around which an expanded road network database system can be built.

The primary impetus for the development of TRIPS was the need to replace existing databases, which where cumbersome and redundant, with a computer based system that could coordinate and integrate the majority of highway related databases maintained by the WSDOT. The TRIPS implementation process is oriented around a scope of work and development plan created by the consultant Arthur Andersen and Co.

As part of the implementation of TRIPS, the Transportation Data Office (TDO) asked the Washington State Transportation Center (TRAC) to examine the process the Data Office uses for collecting, storing, and analyzing its traffic and accident information as well as the information collected and procedures proposed in Arthur Andersen's TRIPS description. This report covers TRAC's evaluation of the accident data portion of the TRIPS project.

A review of the available literature indicated that most state highway agencies use accident information in order to

- identify hazardous locations,
- monitor accident frequency, rates, trends and severity,
- identify hazardous roadway elements, and
- evaluate the effectiveness of countermeasures.

The existing WSDOT analysis procedures that address these three areas were examined in light of other highway agencies' accident systems. For the most part, WSDOT accident analysis procedures were found to be good. However, TRAC also identified a number of limitations in the existing procedures. These findings led to a number of recommendations. Implementation of these recommendations should increase WSDOT's accident analysis capabilities and enhance the usability of TRIPS. The problems identified and the recommended changes are presented in the four areas as follows.

DATA COLLECTION

The existing WSDOT data collection procedures are for the most part quite good. Only a few weak areas were found, and TRAC does not recommend any major changes in the basic process.

Problem. The Washington State Patrol (WSP) collision report form does not collect all the data that could be used by the WSDOT.

Recommendation. With input from the WSP, additional variables such as the second harmful object struck and additional truck classification information should be added to the WSP collision report form.

Problem. Accident location information is not accurate.

Recommendation. A range of possible actions would help, including using TRIPS's capabilities to keep milepost information current, developing and consistently following a procedure to track milepost changes and update milepost signs, investigating the acquisition of accurate city maps, and maintaining the locator log used by SDB and WSP officers at a level of roughly $25,000 and 0.5 FTE per biennium.

Problem. Some information about the physical aspects of the highway system is not available.

Recommendation. The WSDOT should make highway appurtenance data available for use with accident data.

DATA STORAGE

The existing WSDOT accident data storage procedures are adequate but not optimal.

Problem. The existing file structure uses one large record which reduces the ease of data retrieval.

Recommendation. A three file structure including files for accident characteristics, vehicle characteristics, and occupant characteristics should be used.

Problem. Some information that is useful to the SDB is not stored in a manner that makes it easily obtained within the accident analysis process.

Recommendation. Historical roadway configuration data should be added to the accident characteristic record and that a procedure be designed so that new accident data variables can be added, as needed, at later times.

ANALYSIS TECHNIQUES AND CAPABILITIES

The existing WSDOT analysis system is on a par with, or better than, systems used by most other state highway departments. However, the WSDOT process does have limitations. These limitations relate to the "statistical validity" of many of the analyses performed as part of the routine analysis of accident data.

Problem. Most of the Department's analyses are oriented toward descriptive statistics, whereas the project team feels that in some situations analytical statistics are needed.

Recommendation. WSDOT should enhance its current analysis procedures with a number of short-term fixes designed to increase the usability of the descriptive statistics. In the long term, WSDOT needs to examine the true goals of its analysis methods. If they are needed, more analytical and statistically valid procedures should be implemented. The need for improved analytical techniques and the consequences of these techniques are described in detail in the main body of this report.

INITIAL TRIPS ANALYSIS REPORT

The project team reviewed the initial Arthur Andersen analysis report for the TRIPS accident section. TRAC felt that this report raises several concerns.

Problem. The Arthur Andersen report implies that TRIPS may reprogram a group of WSDOT processes that TRAC feels already operate well.

Recommendation. The WSDOT should attempt to use existing analytical software as much as possible.

Problem. The Arthur Andersen functional description of the system does not take advantage of the opportunity to make significant improvements to the existing accident analysis process by linking the accident information to types of highway data not currently included in safety analyses.

Recommendation. The accident data should be linked to historical highway appurtenance data, historical roadway data, and WSDOT cartographic data.

IMPLEMENTATION

Implementation of the above recommendations is divided into three categories:

- short-term action,
- important liaison activities, and
- long-term activities and reviews.

For the most part, minor changes are recommended for the existing analysis process. Other work requires short-term liaison with agencies such as the WSP and a number of WSDOT sections. Finally, some recommendations need not be acted on immediately and can be left for later action.

CHAPTER 1
INTRODUCTION

The TRIPS (Transportation Information and Planning Support) data collection and analysis system is currently being implemented within the Washington State Department of Transportation (WSDOT). The objectives of TRIPS are as follows:

- to develop a central, integrated database of information about the state highways, and
- to provide a core around which an expanded road network database system can be built.

The primary impetus for the development of TRIPS was the need to replace existing databases, which were cumbersome and redundant, with a system that could coordinate and integrate the majority of highway related data maintained by the WSDOT. The TRIPS implementation process is oriented around a scope and development plan created by a consultant (Arthur Andersen and Co.).

TRIPS is currently divided into three functional sections:

- roadway data, covering the physical aspects of the state's highway (which is essentially implemented),
- traffic data, dealing with elements such as vehicle volumes (the design and construction of which is under way), and
- accident data, which includes elements such as vehicle type, occupant information and accident details (which is scheduled to be implemented in 1991).

As part of the implementation of TRIPS, the Transportation Data Office (TDO) of WSDOT asked the Washington State Transportation Center (TRAC) to examine the processes the TDO currently uses for collecting, storing and analyzing traffic and accident information and those proposed in Arthur Andersen's TRIPS description. This document reports the project team's evaluation of the Safety Data Branch's (SDB) existing accident analysis procedures and the preliminary TRIPS accident database. The evaluation has included

- reviewing available literature,
- examining state-of-the-art procedures being used by other states,
- reviewing the Arthur Andersen TRIPS Analysis Report and other TRIPS documentation,
- evaluating existing WSDOT accident analysis and data storage procedures, and
- recommending changes to existing WSDOT procedures and proposed TRIPS functions.

This final report is structured in an executive summary and four chapters:

- Introduction,
- Review of Previous Work and Existing WSDOT Procedures,
- Evaluation of the Existing WSDOT Process, and
- Recommended Changes.

The contents of the executive summary and each of the chapters is discussed below.

The Executive Summary is a more concise version of this report. It summarizes the project's findings and the reasoning behind those findings.

The Review of Previous Work and Existing WSDOT Procedures chapter describes the findings of the literature searches performed as part of this effort. It also includes a discussion of the existing WSDOT accident analysis procedures and the Arthur Andersen plan for the TRIPS accident database system.

Within the Findings chapter is a detailed description of the project team's evaluation of the current WSDOT accident analysis process, and includes a list of problems with existing accident analysis procedures.

The Recommended Changes chapter discusses the project team's recommended actions concerning the existing accident analysis procedures and

TRIPS functions. It also discusses the implementation of the recommendations with existing accident analysis procedures in terms of specific actions that WSDOT should take.

CHAPTER 2
REVIEW OF PREVIOUS WORK AND EXISTING WSDOT PROCEDURES

This chapter is broken into three major sections:

- an introduction to highway safety record systems and accident analyses procedures,
- a review of existing WSDOT accident analysis procedures, and
- a discussion of the Arthur Andersen (AA) TRIPS Accident Database Analysis Report.

Information sources used to develop the data presented in this chapter include literature available through NTIS, on-going FHWA research into accident analyses, the Arthur Andersen TRIPS report, and discussions with a variety of WSDOT and other state agency personnel. Some of the most relevant pieces of accident analysis literature are listed in Appendix A of this report.

HIGHWAY SAFETY RECORDS SYSTEMS

This section provides background information on systems and procedures used to track and analyze highway accident and safety information. It describes the types of analyses performed and the means with which data relating to accidents are stored and retrieved. Specific WSDOT procedures are described later in this chapter.

Background

As the use of motor vehicles has increased, vehicle accidents have become a major cause of property damage, injury and death. In the early 1960s the federal government started actively developing programs to improve highway safety. With the passage of the 1966 Highway Safety Act, each state was required to maintain a record keeping system for safety data. This act institutionalized federal support by providing financial assistance and guidelines for planning, implementing and evaluating highway safety programs.

With the passage of the 1973 Highway Safety Act and the 1978 Surface Transportation Assistance Act, as well as the increased use of computers for data storage and analysis, the concept of a large, statewide, integrated safety system became common. In 1984, under provisions of Public Law 98-363, each state was provided with federal money for the establishment of statewide computerized safety record systems.

State Level Accident Systems

A Comprehensive Computerized Safety Record keeping System (CCSRS) is a state administered, multi-agency safety system. A CCSRS comprises computer files of data concerning motor vehicle accidents, vehicles, drivers, highways and other information, which are linked to compare data among files. Data files included in a CCSRS have usually been developed independently to support a variety of state and local programs, and in many cases, traffic safety is a secondary consideration in the development of these files. The CCSRS program combines these diverse files into a more integrated package.

While many states are working toward CCSRS few have complete systems. The state of New York's safety system, considered by many to be the best and most complete CCSRS in the nation, links driver information, vehicle registration, accidents, traffic law enforcement and adjudication, roadway environment, educational services, and emergency medical services. North Carolina, Utah, Idaho, and Kansas are to various degrees developing and using state level CCSRSs.

Another, more common, state level safety system is known as an Integrated Highway Information System (IHIS). IHISs arose from states' efforts to integrate and link their data files. The IHISs often overlap, are complementary to or are a component of CCSRS. The principal differences between a CCSRS and an IHIS is that while a CCSRS can support the needs of some highway agencies it also supports the work of traffic enforcement agencies, health agencies, motor vehicle administrations and other public groups. An IHIS, on the other hand, usually focuses on highway planning objectives. It is typically designed to meet the requirements of state agencies responsible for highway planning, design, construction and maintenance. Exhibit 1 illustrates the relationship between typical CCSRSs and IHISs. A typical IHIS is the state of Utah's Highway Information System. This system is used for linking accident files to geographic and traffic files.

Highway Accident Analysis Using State Level Safety Systems

Highway accident information stored in the various databases serves as the primary source for analysis conducted by state highway departments to determine and mitigate hazardous traffic conditions in the state. Highway accident analysis performed by the states typically attempts to

- identify hazardous locations,
- identify hazardous roadway elements, and
- evaluate the effectiveness of countermeasures.

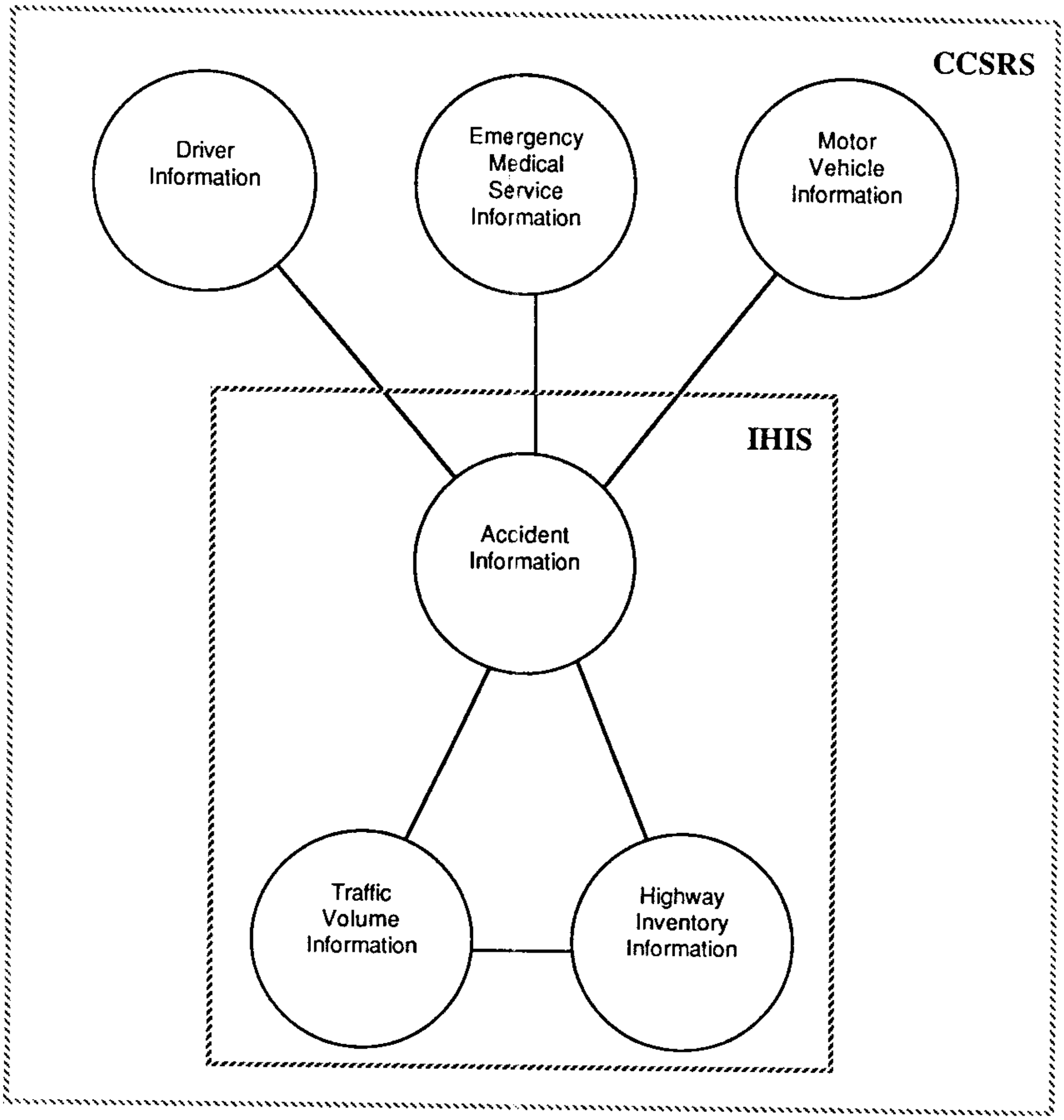
Such analysis can be completed at both the CCSRS and IHIS level but it is often the IHIS maintained by a state highway agency that is designed specifically to meet these objectives. A discussion of these analysis objectives is provided below.

Identify High Accident Locations

Since hazardous locations are a major cause of highway accidents, a comprehensive highway program requires identification of locations with high accident rates, frequencies and/or severity. Often this process is automated and requires the linking of accident, traffic and roadway files. There are a number of identification methods commonly used for this process:

- **Accident frequency method**. The accident files are searched using a set "floating roadway distance." For example, a severity spot on any portion of the highway may be defined as any 0.10 mile segment of roadway which has greater than a preset number of accidents. The accident data can be searched using the 0.10 mile segment incremented at .01 mile moving segments along the roadway.

Exhibit 1. Typical CCSRS and IHIS Systems



- Accident rate method. Accident rates are calculated for sections of a roadway (i.e., number of accidents per million vehicles), to get a frequency index. Those locations with the highest indices are singled out for additional study.
- Rate quality control method. This technique uses statistical methods to compare accident rates of locations with similar characteristics. If a location's accident rate is higher than a calculated critical value (based on rates at similar locations), that location will be singled out for additional study.
- Accident severity method. A formula is used to convert all accidents into equivalent property-damage-only values. This allows the comparison of accident levels at a variety of locations, with more severe accidents (e.g., accidents with fatalities) given more importance than other accidents.
- Relative severity index. Average accident costs based on accident severity for a particular accident type are computed. Using this information, a total accident cost can be calculated for different highway segments, with the highest cost locations singled out for additional study and improvements.
- Hazardous roadway features inventory. Roadway design is manually or automatically inventoried to look for sections that do not meet current MUTCD standards or configurations and that are an obvious hazard to traffic.

Using any of the methods above, hazardous locations can then be reviewed in more detail to determine probable accident causes and to recommend countermeasures. Locations can also be ranked or prioritized for improvement within a budgetary framework.

Identify Hazardous Roadway Elements

Highway accident analysis requires that accident records and highway data files be linked in order to detect undesirable features in existing roads. This requires the ability to relate highway accidents to different vehicle types, roadway geometric designs, roadside structures, road surfaces and many other factors. If a particular roadway feature is found to be hazardous, a survey can be conducted to locate similar features (hazards) on other roads. Once the locations are isolated, countermeasures can be implemented.

Evaluate the Effectiveness of Highway Safety Projects and Programs

The evaluation of completed highway safety projects and programs is important to determine if those projects are truly effective. Common methods usually involve a before-and-after accident rate comparison using a variety of statistical methods. However, research has shown that simple before-and-after studies often lead to erroneous results because of the infrequent nature of traffic accidents and the variety of variables that affect the number of accidents.

Current FHWA literature recommends a series of more statistically valid evaluation procedures. These statistical methods include the following.

- **Before and after designs with randomized control groups**. Candidate locations for a safety countermeasure are randomly assigned to either a treatment group or control group. This allows a researcher to more accurately measure changes specifically to the treatment being investigated, as opposed to factors extraneous to the investigation.
- **Before and after designs with comparison groups**. Control locations are sought that are as similar as possible to the location receiving the safety countermeasure. This accomplishes the same basic task as above but requires less forethought. It is slightly less statistically valid.
- **Time series design**. Numerous observations of a countermeasure are made over time (both before and after the countermeasure is applied)

to determine the stability of the accident rate associated with that countermeasure.

Effectiveness evaluations also involve analyzing quantitative information on the benefits and costs of a safety countermeasure. A proper evaluation of countermeasure programs will allow future funding to be more effectively allocated for safety programs. A complete discussion of recommended accident evaluations can be found in the FHWA report, "Accident Research Manual," February 1980, Report No. FHWA/RD-80/016.

Existing Accident Analysis Software

Examples of accident analysis software used by other states and national agencies are listed below. Each of these systems contains a specific data structure and set of programs designed to perform some subset of the analyses described above.

DART -- Data Analysis and Reporting Techniques

DART was developed by Genasys Corporation under a series of National Highway and Traffic Safety Administration (NHTSA) contracts. This statistical system was specifically designed to assist in the acquisition, selection and analysis of state level accident data. The program generates reports relating to problem identification and program evaluation.

RAPID -- Records Analysis for Problem Identification and Definition

RAPID was developed for identifying problems relating to highway safety and is oriented toward quick retrieval of data from computer files. The program can be used to find hazardous locations and can produce a variety of accident summaries. RAPID has been installed by Alabama, South Carolina, Kentucky, Tennessee, and Delaware.

MIDAS -- Michigan Dimensional Accident Surveillance

The Michigan State Department of Transportation has been developing MIDAS since the 1970s. The program currently identifies locations with a high number of accidents by comparing them to similar locations. MIDAS also can gather available information on a particular location and present it in a package of charts and tables.

CASESTUDY & TAP -- Traffic Accident Profile

These programs were developed by the Texas State Department of Highways and Public Transportation. CASESTUDY identifies problem areas while TAP integrates engineering, enforcement and education programs.

SAFE -- Safety Project Evaluation

SAFE was developed by Joseph L. Schofer. The program can analyze and evaluate proposed accident-reduction projects and can also compute accident rates. SAFE is used by various agencies in Illinois, Wisconsin, and Texas.

TARP -- Traffic Accident Report Program

This program was developed by Mole, Grover and Associates to generate collision diagrams and to assist in the surveillance of hazardous locations.

INTRACS -- Indiana Traffic-Accident Record System

INTRACS was developed to geographically locate accidents on road segments. The program was designed to analyze accident rates and their relationship to physical roadway conditions. The results can be used to identify hazardous locations and the conditions that have caused accidents.

Most of the above software is not readily transportable to Washington state. This is because the systems were designed with specific accident record structures and with specific highway systems in mind. For example, the WSP accident record form is substantially different from the form used in Michigan. A substantial amount of programming would be necessary to recode the data structure and reporting systems of these programs to account for differences in accident record formats and roadway records and to include access to the information that does not exist on the Michigan form. In addition, the need to maintain compatibility with the datasets and programs being designed for the Roadway and Traffic portions of TRIPS further limits the ability to "port" or move existing software to the WSDOT.

CURRENT WSDOT PRACTICES

Overview

This section describes the WSDOT's existing accident analysis systems. It includes discussions of the data collection procedures, how the information is coded, how the coded data are distributed, and WSDOT's existing analysis procedures.

Exhibit 2 is a flowchart that shows the flow of WSDOT's safety data and the relationship of WSDOT's accident data path to other agencies who use accident data. Currently the WSDOT system is functionally separate from other state agencies' safety data systems. The state of Washington may eventually have a CCSRS that will tie state traffic records together. In 1986, a consultant (National Con-serve) completed a report for the Washington Traffic Safety Commission that examined the state's existing traffic record systems (An Assessment of the Current Traffic Safety Records Systems in Washington State, Washington State Traffic Commission, February 1986). The recommendations of this report can be seen as the first step toward the creation of a CCSRS. However, the time table for the implementation of the consultant's recommendations and development of a CCSRS for Washington are uncertain at this time.

Work currently being done at the Traffic Safety Commission (TSC) will bring some additional computerized accident analysis procedures to that agency. These additional capabilities may reduce the need for TSC access to the WSDOT accident information. It may also require the periodic downloading of accident, roadway and traffic information to the TSC. The specific impacts of the TSC system are difficult to identify at this time, in that it is uncertain if the CCSRS system will be built, what the system might actually contain if it were built, and how that system would change the TSC's capabilities.

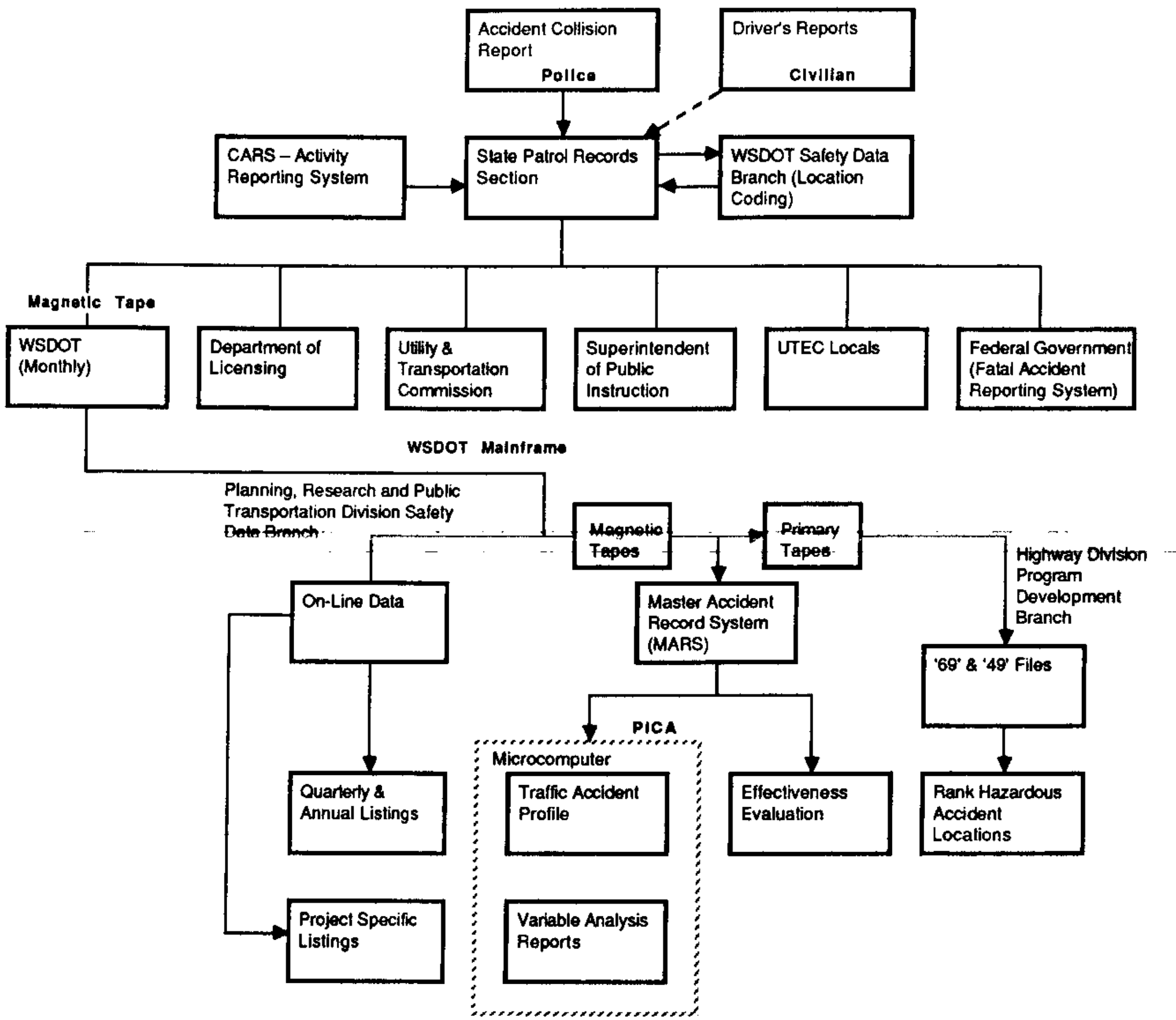


Exhibit 2. Current WSDOT Safety Data Flow.

Data Collection and Distribution

The Washington State Patrol (WSP) is the primary accident data source for the WSDOT because it has the statutory responsibility for the collection and distribution of statewide accident data. The State Patrol develops and maintains a standard Police Traffic Collision Report Form (Exhibit 3) and a similar civilian collision report form. All accidents that occur within the state that result in death or personal injury or at least $500 damage to any one person's property are supposed to be reported to the WSP. In practice, all major accidents are reported, but a large number of small, property-damage-only accidents are never reported to the WSP.

The State Patrol's records section receives completed collision reports from all Washington law enforcement agencies as well as any civilian Motor Vehicle Collision reports completed by individuals involved in an accident. (Insurance companies often require motorists to report accidents for which they are submitting claims.) As the system currently exists, the Washington State Patrol's records section collects the accident reports, matches civilian and police accident reports and microfilms the reports. The reports that detail accidents on state routes and city streets are sent to the SDB. The SDB manually codes the milepost locations and accident diagram information of each accident on state highways. Accidents that are not associated with state routes are marked as occurring under a specific jurisdiction (i.e., city or county road) and returned to WSP for submittal to that jurisdiction for coding. The completed forms are sent back to the WSP for final coding, entry into the WSP computer and preparation of a tape for distribution. In addition to the accident reports, the WSP also maintains an in-house data file known as the Computerized Activity Record System (CARS). This system tracks citation data and trooper activity.

Currently, six state agencies and one federal agency receive the monthly WSP accident file. Each agency processes the data and performs unique analyses using that information. For the WSDOT, the data are loaded into an IBM

Exhibit 3
Washington State Patrol Traffic Collision Report

ROADWAY SURFACE CONDITION (1)
1 DRY
2 WET
3 SNOW
4 ICE
5 OTHER *

WEATHER (2)
1 CLEAR, CLOUDY & OVERCAST
2 RAINING
3 SNOWING
4 FOG
5 OTHER *

LIGHT CONDITIONS (3)
1 DAYLIGHT
2 DAWN
3 DUSK
4 DARK-STREET LIGHTS ON
5 DARK - STREET LIGHTS OFF
6 DARK-NO STREET LIGHTS
7 OTHER *

TRAFFIC CONTROL (4 ①, 5 ②)
1 SIGNALS
2 STOP SIGN
3 YIELD SIGN
4 FLASHING RED
5 FLASHING AMBER
6 RR SIGNAL
7 OFFICER/FLAGMAN
8 OTHER TRAFFIC CONTROL *
9 NO TRAFFIC CONTROL

TYPE OF ROADWAY (6 ①, 7 ②)
1 ONE WAY
2 TWO WAY
3 REVERSIBLE ROAD
4 INTERCHANGE LOOP ROAD
5 ALLEY
6 CENTER LANE - TWO WAY LEFT TURN LANES
7 DRIVEWAY

ROADWAY STRUCTURE (8)
1 OCCURRED ON ROADWAY STRUCTURE (ON BRIDGE, OVERPASS, DOCK, ETC.)
2 DID NOT OCCUR ON STRUCTURE

CONSTRUCTION AREA (9)
1 OCCURRED IN CONSTRUCTION AREA (HIGHWAY, UTILITY, ETC.)
2 DID NOT OCCUR IN CONSTRUCTION AREA

ROADWAY CHARACTER (10)
1 STRAIGHT & LEVEL
2 STRAIGHT & GRADE
3 STRAIGHT AT HILLCREST
4 STRAIGHT IN SAG
5 CURVE & LEVEL
6 CURVE & GRADE
7 CURVE AT HILLCREST
8 CURVE IN SAG

ROADWAY SEPARATION (11 ①, 12 ②)
2 DIVIDED
3 UNDIVIDED

ROADWAY SURFACE TYPE (13 ①, 14 ②)
1 CONCRETE
2 BLACKTOP
3 BRICK OR WOOD BLOCK
4 GRAVEL
5 DIRT
6 OTHER *
0 UNKNOWN

SPECIAL HAZARDOUS DRIVING CONDITIONS (15)
(DUST, WIND GUSTS, SMOKE, ETC.) *
CHECK (✓) HERE AND EXPLAIN IN DESCRIPTION AREA

HAZARDOUS MATERIALS BEING TRANSPORTED (16 ①, 17 ②)
(IDENTIFY IN DESCRIPTION AREA)
1 FLAMMABLE LIQUID
2 CORROSIVE MATERIAL
3 EXPLOSIVES
4 RADIO ACTIVE MATERIALS
5 AMMONIA
6 CHLORINE
7 OTHER *

PEDESTRIAN/PEDALCYCLIST WAS USING: (18)
1 SIDEWALK
2 WALKWAY
3 SHOULDER
4 MARKED XWALK
5 UNMARKED XWALK
6 OTHER *
7 DESIGNATED BIKE ROUTE

PEDESTRIAN/PEDALCYCLIST CLOTHING COLOR (19)
1 DARK
2 LIGHT
3 MIXED
4 RETRO-REFLECTIVE
5 OTHER REFLECTIVE APPAREL - SHOES -PATCHES *

PEDESTRIAN/PEDALCYCLIST (CONTRIBUTING CIRCUMSTANCES) (20)
1 INTOXICATED
2 DISREGARDED TRAFFIC CONTROLS
3 FAILURE TO YIELD RIGHT OF WAY TO VEHICLE
4 INATTENTION
5 ON WRONG SIDE OF ROAD
8 HITCHHIKING
9 PEDALCYCLE NOT LIGHTED
0 FAILURE TO USE XWALK

CONTRIBUTING CIRCUMSTANCES (NOT MORE THAN TWO) (① 21, ② 22)
1 UNDER INFLUENCE OF ALCOHOL
2 UNDER INFLUENCE OF DRUGS
3 EXCEEDING STATED SPEED LIMIT
4 EXCEEDING REAS SAFE SPEED
5 DID NOT GRANT R/W TO VEHICLE
6 IMPROPER PASSING
7 FOLLOWING TOO CLOSELY
8 OVER CENTER LINE
9 FAILING TO SIGNAL
10 IMPROPER TURN
11 DISREGARD STOP & GO LIGHT
12 DISREGARD STOP SIGN/SIGNAL
13 DISREGARD WARN SIGN/SIGNAL
14 APPARENTLY ASLEEP
15 IMPROPER PARKING LOCATION
16 OPERATING DEFECTIVE EQUIP
17 OTHER * (LIST IN DESCRIPTION AREA)
18 NONE
19 IMPROPER SIGNAL
20 IMPROPER "U" TURN
21 LIGHT VIOLATION-NO LIGHTS/FAIL TO DIM
22 DID NOT GRANT R/W TO PEDESTRIAN
23 DRIVER INATTENTION

DRIVER/VEHICLE ACTIONS (ONE OR MORE) (① 23, ② 24)
1 GOING STRAIGHT AHEAD
2 OVERTAKING AND PASSING
3 MAKING RIGHT TURN
4 MAKING LEFT TURN
5 MAKING U TURN
6 SLOWING
7 STOPPED FOR TRAFFIC
8 STOPPED AT SIGNAL OR STOP SIGN
9 STOPPED IN ROADWAY
10 STARTING IN TRAFFIC LANE
11 STARTING FROM PARKED POSITION
12 MERGING (ENTERING TRAFFIC)
13 LEGALLY PARKED OCCUPIED
14 LEGALLY PARKED UNOCCUPIED
15 BACKING
16 GOING WRONG WAY ON DIVIDED HIGHWAY
17 GOING WRONG WAY ON RAMP
18 GOING WRONG WAY ON ONE-WAY ST. OR RD
19 OTHER *
20 CHANGING LANES
21 ILLEGALLY PARKED OCCUPIED
22 ILLEGALLY PARKED UNOCCUPIED

VEHICLE CONDITION (ONE OR MORE) (① 25, ② 26)
1 DEFECTIVE BRAKES
2 DEFECTIVE HEAD LIGHTS
3 DEFECTIVE REAR LIGHTS
4 TIRES WORN OR SMOOTH
5 TIRES PUNCTURED OR BLOWN
6 LOST A WHEEL
7 DEFECTIVE STEER. MECH.
8 POWER FAILURE
9 HEADLIGHTS GLARING
10 OTHER LIGHTS/REFLECTORS INSUFFICIENT
11 OTHER DEFECTS *
12 NO DEFECTS
13 MOTORCYCLE-LIGHTS OFF
14 EQUIPPED WITH STUDDED TIRES
15 MOTORCYCLE WINDSHIELD INSTALLED
16 TRUCK/TRAILER SAFETY INSPECTION

STATE OF WASHINGTON

POLICE TRAFFIC COLLISION REPORT

WSP 159 (REV. 1-79)

① UNIT NO. 1
② UNIT NO. 2 (VEH., PED., BIKE)
* DESCRIBE IN THE COLLISION DESCRIPTION AREA
\+ CODES DESCRIBED BELOW
SEE REVERSE SIDE FOR INSTRUCTIONS

DIRECTION OF MOVEMENT (① 27, ② 28)
(INDICATE BY NUMBER THE FROM AND TO MOVEMENT)
NORTH / WEST / EAST / SOUTH (compass points numbered 1–8)
9 VEHICLE STOPPED
0 VEHICLE BACKING

POSTED SPEED (① 29, ② 30)
MILES PER HOUR FOR EACH VEHICLE INVOLVED.

SOBRIETY (① 31, ② 32)
1 HBD ABILITY IMPAIRED
2 HBD ABILITY NOT IMPAIRED
3 HBD SOBRIETY UNKNOWN
4 HAD NOT BEEN DRINKING

CHEMICAL TEST (① 33, ② 34)
98 TEST GIVEN
99 TEST REFUSED

TEST RESULTS (① 35, ② 36)
LIST ACTUAL TEST RESULTS IN 100ths

VEHICLE LEGALLY STANDING (① 37, ② 38)
1 YES
2 NO

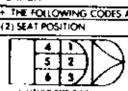
PEDESTRIAN ACTION (39)
1 XING AT INT W/SIG
2 XING AT INT AGST SIG
3 XING AT INT - NO SIG
4 XING AT INT - DIAG
5 FROM BEHIND PARKED VEH
6 XING NON INT - NO XWALK
7 XING NON INT - IN XWALK
8 WALK'G IN RDWY W TRAF
9 WALK'G IN RDWY OPP TRAF
10 WALK'G ON RDWY SHLDR WITH TRAFFIC
11 WALK'G ON RDWY SHLDR OPPOSITE TRAFFIC
12 STANDING OR WORKING IN ROADWAY
13 PUSH'G OR WORK'G ON VEH
14 PLAY'G IN ROADWAY
15 LYING IN ROADWAY
16 NOT IN ROADWAY
17 ALL OTHER ACTIONS *
18 FELL OR PUSHED INTO PATH OF VEHICLE

PEDALCYCLIST ACTION (40)
43 XING DIAGONALLY
44 RIDING WITH TRAFFIC
45 RIDING AGAINST TRAFFIC
46 FELL OR PUSHED INTO PATH OF VEHICLE
47 CYCLIST TURNED INTO PATH OF VEHICLE - SAME DIRECTION
48 CYCLIST TURNED INTO PATH OF VEHICLE - OPPOSITE DIRECTION
49 ALL OTHER ACTIONS *
50 XING OR ENTERING TRAFFICWAY

\+ THE FOLLOWING CODES ARE USED TO DESCRIBE THE DRIVER, OCCUPANT, INJURY CLASS, RESTRAINT SYSTEM, EJECTION AND MOTORCYCLE SAFETY DATA

(1) STATUS
2 PASSENGER
3 PEDESTRIAN
4 BICYCLIST
5 OTHER
6 WITNESS

(2) SEAT POSITION



7 OTHER POSITION
8 POSITION UNKNOWN
9 MOTORCYCLE

(3) INJURY CLASS
1 NO INJURY
2 DEAD AT SCENE
3 DEAD ON ARRIVAL
4 DIED IN HOSPITAL
5 DISABLING INJURY
6 NON DISABLING EVIDENT INJURY
7 POSSIBLE INJURY

(4) RESTRAINT SYSTEMS
1 NO RESTRAINT USED
2 LAP BELT USED
3 SHOULDER BELT USED
4 LAP & SHOULDER BELT USED
5 CHILD RESTRAINT USED
6 NON ACTIVATED AIR BAG BELTS IN USE
7 NON ACTIVATED AIR BAG NO BELTS USED
8 AIR BAG ACTIVATED BELTS IN USE
9 AIR BAG ACTIVATED NO BELTS USED
[illegible] RESTRAINTS UNKNOWN

(5) EJECTION
1 NOT EJECTED
2 TOTALLY EJECTED
3 PARTIALLY EJECTED
4 UNKNOWN IF EJECTED

(6) MOTORCYCLE SAFETY
[illegible] NOT STATED
[illegible] HELMET USED
[illegible] HELMET NOT USED

Exhibit 3
Washington State Patrol Traffic Collision Report (cont.)

WSP 159 (REV 1-80)

STATE OF WASHINGTON

POLICE TRAFFIC COLLISION REPORT

PAGE ___ OF ___

☐ TRAFFICWAY
☐ PRIVATE WAY

No.

POLICE COMPLAINT NUMBER

DATE OF COLLISION | DAY OF COLLISION | TIME (USE 2400 HOUR) | COUNTY

COUNTY NO. | CITY NO. | FHWA ☐ URBAN ☐ RURAL

☐ N ☐ E ☐ IN | CITY OR TOWN | NAME & NO. OF STREET OR HIGHWAY

MILES ☐ S ☐ W ☐ OF

ON

FCT CLS | ADM CLS | PREFIX | ROUTE OR STREET CODE | SECTION

INTERSECTING WITH STREET OR ROAD | NON INTERSECTION

BETWEEN ___ STREET & ___ STREET

PREFIX | EQ | MILE POST

DISTANCE & DIRECTION FROM REFERENCE (CROSS STREET OR NEAREST MILE POST) | ACCIDENT MILEAGE CODE

RAMP | DIAGRAM DATA

TOTAL NO. OF VEHICLES | SEVERITY: NO. KILLED ___ NO. INJURED ___ ☐ PROPERTY DAMAGE ONLY | ☐ FIRE RESULTED | ☐ STOLEN VEHICLE

INTER | NON INTER | X RD CLS | INTERSECTING STREET OR ROAD OR REFERENCE CROSS STREET OR ROAD

OBJECT STRUCK: NAME OF OBJECT STRUCK AND OWNER'S NAME | EST. DAMAGE $

SPECIAL CODING USE

UNIT NO. 1 | UNIT NO. 2 ☐ VEHICLE ☐ PEDESTRIAN ☐ PEDALCYCLIST

DRIVER'S NAME — LAST, FIRST, MIDDLE

STREET ADDRESS

CITY | STATE | ZIP CODE | PHONE NO.

DRIVER'S LICENSE NO. | STATE | SEX | DATE OF BIRTH (MO DAY YR)

OCCUPATION | FIRM NAME & PHONE NO. | EYES | WEIGHT | HEIGHT

☐ CHECK IF OPERATOR WAS DRIVING A COMMERCIAL VEHICLE AS AN EMPLOYEE OF ANOTHER

CODES ▶ 3 | 4 RESTRAINT SYSTEM | 5 EJECTION | 6 MOTORCYCLE SAFETY

NATURE OF INJURIES

REMOVED FROM SCENE BY ☐ AMBULANCE ☐ POLICE CAR ☐ HELICOPTER ☐ PRIVATE VEHICLE ☐ NOT TRANSP.

VEH. YEAR | MAKE (DODGE, CHEV) | MODEL (DART, NOVA) | STYLE (2 DR, CONV)

VEH. COLOR | LICENSE PLATE NO. | STATE | TRAILER PLATE NO. | STATE

VEHICLE IDENTIFICATION NO.

REGISTERED OWNER — LAST, FIRST, MIDDLE | PHONE NO.

ADDRESS OF OWNER

NAME & ADDRESS OF INSURANCE CO. OR AGENT

SHADE IN DAMAGED AREA (TOP / TO BOTTOM) | VEH. DAMAGE ☐ DISABLING ☐ FUNCTIONAL ☐ OTHER DMGE | CITATION NO. / CHARGE (ENFORCEMENT ACTION) | EST. DAMAGE $

VEHICLE REMOVAL: ☐ DRIVEN AWAY ☐ REMAINED ☐ TOWED AWAY BY

DRIVER / VEHICLE OWNER

DIAGRAM OF COLLISION (USE SUPPLEMENTAL SHEET IF NECESSARY) | INDICATE NORTH BY ARROW

DESCRIPTION OF COLLISION (USE SUPPLEMENTAL SHEET IF NECESSARY)

NAME, ADDRESS & INJURIES OF PERSONS INVOLVED
OCCUPANTS / WITNESSES (USE SUPPLEMENTAL SHEET FOR ADDITIONAL NAMES)

CODES: SEX | AGE | 1 STATUS | — IN VEH NO. | 2 SEAT POSIT. | 3 INJ. CLASS | 4 RESTR | 5 EJECT | 6 MCY. SAFETY

NAME / ADDRESS | PHONE NO. | NATURE OF INJURIES | REMOVED FROM SCENE BY ☐ AMB ☐ POLICE CAR ☐ HELICOPTER ☐ PRIV. VEH ☐ NOT TRANSP.

NAME / ADDRESS | PHONE NO. | NATURE OF INJURIES | REMOVED FROM SCENE BY ☐ AMB ☐ POLICE CAR ☐ HELICOPTER ☐ PRIV. VEH ☐ NOT TRANSP.

NAME / ADDRESS | PHONE NO. | NATURE OF INJURIES | REMOVED FROM SCENE BY ☐ AMB ☐ POLICE CAR ☐ HELICOPTER ☐ PRIV. VEH ☐ NOT TRANSP.

X INVESTIGATING OFFICER'S NAME & RANK | BADGE OR ID NO. | AGENCY | UNIT | POLICE DISPATCHED 2400 HRS | POLICE ARRIVED 2400 HRS | DATE OF REPORT | APPROVED BY | DATE mainframe computer. The accident information on the mainframe can be retrieved in two ways:

- the on-line data system, and
- the Master Accident Report System (MARS).

The On-line System

The on-line system is a recent improvement over an older data access system. The new on-line system is a user oriented batch procedure that allows all authorized WSDOT personnel access to the majority of the mainframe traffic accident data through remote terminals. The on-line system enables users to quickly retrieve data and to create user specified accident listings by roadway section, date, accident type and other categories. Exhibit 4 shows a screen from the on-line data system. The system uses the RECSELECT program to sort and extract information from the accident files, and a Mark IV routine to generate the accident listing.

MARS

MARS is a master data file created to store detailed accident, vehicle and occupant data and contains information from 1977 to the present. Due to its large size, it is stored on magnetic tape to reduce storage costs. It contains detailed "human" factors and can be accessed by SDB and WSDOT district traffic offices. Subfiles can be generated from MARS for specific accident analyses. Currently the SDB is using a microcomputer accident analysis subfile system called Problem Identification & Cause Analysis (PICA) to analyze MARS data. PICA was developed within a standard statistical package (SPSS) to perform in-depth analysis of accident data.

Data Users

The WSDOT accident database is the source of information for departmental engineers and analysts, as well as users from the private sector and other state and federal agencies. The table below is a summary of who requested traffic accident data during 1987.

Exhibit 4
Screen From On-Line Data System

```
DP55010      STATE OF WASHINGTON DEPARTMENT OF TRANSPORTATION
                   TRAFFIC ACCIDENT REPORT SELECTION

    SELECT DESIRED REPORTS BY PLACING AN "X" BY THE REPORT NAME:
           <== ACCIDENT HISTORY BY SR AND SRMP
           <== ACCIDENT HISTORY BY ACCIDENT DATE
           <== ACCIDENT HISTORY BY COLLISION TYPE
           <== SUMMARY ONLY
    ENTER SELECTION CRITERIA:
      DISTRICT NUMBER:           STATE ROUTE:          SR ADDL ID:
      BEGIN SEQ:      BEGIN SRMP:          END SEQ:      END SRMP:

    ACCIDENT DATE RANGE:  (AVAILABLE   01/01/77  THROUGH   08/31/87 )
      BEGIN DATE:                END DATE:             (MMDDYY)

    REPORT TITLE:
      PROJECT NUMBER:            CONTROL SECTION NUMBER:
      PROJECT DESC  :

    JOB CLASS:  X   ( M =DAY  X =NIGHT)  HOLD:   N
       COPIES:  1                       ACCOUNT:   TSFSAFTY   PRINTER:   0

ENTER KEY TO CONTINUE                                   END KEY TO STOP
```

1. WSDOT District Offices -- 28%,
2. Private sector (media, private attorneys and individuals) -- 22%,
3. WSDOT Headquarters -- 16%,
4. Attorney General's Office -- 15%,
5. State Patrol -- 9%,
6. Federal Agencies -- 3%,
7. Traffic Safety Commission -- 2%,
8. All others -- 5%.

A total of 436 requests for data were made in 1987. The most comprehensive user of the WSDOT accident database was internal departmental users. In addition, District and Headquarter's requests were often more complex and required more staff and computer resources than most private sector requests. Following the WSDOT, the private sector had the highest number of data requests, although most of these requests were simple and could be handled easily by SDB staff.

Existing Analysis Procedures

As mentioned previously, most highway accident analysis involves

- identifying hazardous locations,
- identifying hazardous roadway elements, and
- evaluating the effectiveness of safety countermeasures.

The following paragraphs discuss the WSDOT's existing procedures for performing these analyzes.

Identifying High Accident Locations

The Program Development Branch of the WSDOT is responsible for developing the priority array that determines construction and funding priorities. A part of this process involves

- the identification of hazardous locations,
- accident severity analysis, and
- the ranking of hazardous locations.

This process provides the WSDOT with information on priorities for budget allocation for construction projects.

The hazardous location identification process is divided into the identification of "hazardous accident locations" and "fatal accident locations." The difference between the two categories is that all accidents are considered in the hazardous location analysis, while only fatal accidents are used when fatal accident locations are identified. Each of these two location analyses involves five major steps, which are

- correlation of accident data,
- assignment of roadway categories,
- assignment of accident severity factors,
- identification of hazardous accident locations, and
- priority ranking.

The hazardous location identification process is based on an accident data file commonly known as the "69" record. The "69" record is produced by the SDB and is a condensed version of the WSDOT's last two year-end primary tapes, each of which contains one year's actual accident experience on the state highway system. The analysis is described in detail below.

Correlation of data involves two steps.

- The first step eliminates accidents that occurred on highway sections that have since had major improvements.
- The second step reassigns current milepost locations to accidents that occurred on highway sections that have incurred route length or other milepost changes.

Assignment of roadway categories. After the accident data have been correlated, each highway accident is assigned to one of 18 roadway categories (Exhibit 5). These categories classify a highway either by rural or urban, divided or undivided, the number of lanes, and by the level of access control provided. These

Exhibit 5. Roadway Categories Conversion Table

Base Roadway Category	Rural or Urban	2-Lane or Multilane	Divided or Undivided	None, Partial or Full Access Control
01	Rural	2-Lane		None
02	Rural	2-Lane		Partial
03	Rural	2-Lane		Full
04	Rural	Multilane	Undivided	None
05	Rural	Multilane	Undivided	Partial
06	Rural	Multilane	Undivided	Full
07	Rural	Multilane	Divided	None
08	Rural	Multilane	Divided	Partial
09	Rural	Multilane	Divided	Full
10	Urban	2-Lane		None
11	Urban	Multilane		Partial
12	Urban	2-Lane		Full
13	Urban	Multilane	Undivided	None
14	Urban	Multilane	Undivided	Partial
15	Urban	Multilane	Undivided	Full
16	Urban	Multilane	Divided	None
17	Urban	Multilane	Divided	Partial
18	Urban	Multilane	Divided	Full

Exhibit 6
Accident Analysis Roadway Categories

Accident Analysis Roadway Category	Rural or Urban	2-lane or Multilane	Access Control
1	R		full access control
2	R	2-lane	not full (i.e., partial or none)
3	R	4-lane	not full
4	U		full access control
5	U	2-lane	not full
6	U	4-lane	not full

categories are simplified to six accident analysis categories for some calculations (Exhibit 6).

Assignment of accident severity factors. Each accident is assigned a weight that reflects the severity of the accident. The weighting factors used are shown in Exhibit 7.

Identification of hazardous locations is performed by a computer program that assigns severity indices to all sections of the highway and then selects the highest ranking of those sections. The computer program examines a 0.1 mile segment of highway starting every 0.01 mile (e.g., mileposts 0.00 to 0.1 and mileposts 0.01 to 0.11 are two separate sections). The search starts from the beginning milepost for each state route and ends with the last milepost on the highway. A severity spot is defined as any 0.1 mile segment of roadway having a total weighted severity factor (the sum of the severity factors for all accidents in a section) of 10 or more.

Severity spots identified in the above analysis are then compared with construction records maintained by WSDOT. This analysis uses the Effective Date Delete Records or "49 file", to identify the date a highway section was opened to traffic or reopened after a safety improvement. With the help of this file, severity

Exhibit 7
Accident Severity Table

Severity Type	Accident Description	Weighting Factors (Weighted Severity)
1	Property Damage Only	1
2	Possible Injury Accident	2
3	Nondisabling Injury Accident	3
4	Disabling Injury Accident	9
5	Fatal Accident	10

locations at which there has been a recently completed major construction effort are deleted from further analysis. The service time (how long the section of road has been in service) of each severity location is then calculated for all remaining severity locations.

Once the history/service time for a section of highway is established, the average number of accidents per year is computed for the identified severity spot. The average number of accidents is equal to the number of accidents in the rated spot divided by the number of computed years of service for the rated spot. To qualify for further analysis, a severity spot must have an average of three or more accidents per year.

For the remaining severity spots, the average daily traffic (ADT) is determined and then the severity per million vehicles is calculated. The severity per million vehicles is defined as the severity totals (sum of the weighted severity factors) times one million, divided by the ADT times the days of service history for that particular section, as shown in the following equation:

$$\frac{\text{Severity}}{\text{million vehicles}} = \frac{\text{Severity}}{\text{Total}} \times \frac{1{,}000{,}000}{\text{Years of history} \times 365 \times \text{ADT}}$$

where severity total = sum of the weighted severities of all accidents in the rated section of the location being analyzed.

Next, the critical severity rate and the severity indices are calculated with the following equations:

$$Rc = Ra + K\sqrt{\frac{Ra}{M}} - \frac{1}{2M}$$

where Rc = critical severity rate

Ra = statewide average severity per million vehicles for analysis roadway category

K = probability factor to establish a desired level of confidence. A probability factor of two (2) is generally used giving us a confidence level of approximately 98 percent

M = vehicle exposure for the study period expressed in million vehicles (average daily traffic(365)(Years of History for the Spot)/(1,000,000)

All the severity spots that have severity rates higher than the critical rates are retained as hazardous locations.

Priority ranking. Two rankings are assigned to the remaining severity spots. The first is based on the severity index, the second on the severity total. A combined index, based on a 50/50 weighting of these two indices, is then computed and used as the final rank for the spot. No ties are allowed in the final rankings. To break ties, the following information is used (in this order): average rank, severity per million vehicles, total severity and average daily traffic.

These ranked locations are often referred to as the "severity accident locations." A printout of these locations represents a list of the most hazardous highway locations on the state highway system during the two year analysis period. Fatal accident locations are analyzed using the same procedures as above, with the exception that only fatal accidents are used in the process. A report used by the Program Development Branch combines severity accident locations with fatal accident locations.

Identifying Hazardous Roadway Elements

Until a few years ago the WSDOT did not have a statistical method for analyzing accidents on state highways to help determine their causes. In response to this lack, the SDB developed the Problem Identification and Cause Analysis system (PICA) using the Statistical Package for the Social Sciences (SPSS™). PICA is a microcomputer based system which uses information extracted from the MARS file. The program's analysis procedures can calculate frequencies, crosstabs, and the

Traffic Accident Profile (TAP). PICA can also produce reports and simple graphics to assist in the analysis of the accident data. PICA provides primarily descriptive statistics although its framework allows for more analytical procedures given proper experimental design. The commonly used PICA analysis procedures are discussed below.

Frequencies. PICA has the capability to summarize the traffic accident data into tabular reports. These forms can include a breakdown of any of the many variables available in the MARS accident database. (Exhibit 8)

Variable Analysis. Since SPSS™ allows univariate and multivariate analyses, PICA can examine the relationships of two or more accident variables. The variables can be output in the form of a matrix (Exhibit 9), which displays the joint distribution of different variables. With this variable analysis, the quantitative relationship between variables that are suspected of being related to traffic accidents can be analyzed.

There are many variables available through the MARS file. The variables most often used within PICA are

- collision type,
- object struck,
- impact location,
- road surface conditions,
- light conditions,
- driver age,
- driver sobriety,
- vehicle type,
- milepost,
- time of day, and
- day of week and month.

Exhibit 8
Typical PICA Frequency Table

Page 35 SR 90 MP 34.44 to 80.54 DOUBLE TRAILER ACCIDENTS
ACCIDENTS WHERE VEHICLE 1 IS A DOUBLE TRAILER TRUCK

OR1CC1 DRIVER 1 CONTRIBUTING CIRCUMSTANCES

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
UND INF OF ALCH	1	2	3.5	3.5	3.5
EX SPEED LIMIT	3	1	1.8	1.8	5.3
EX SAFE SPEED	4	31	54.4	54.4	59.6
APP ASLEEP	14	3	5.3	5.3	64.9
OPER DEF EQUIP	16	4	7.0	7.0	71.9
OTHER	17	1	1.8	1.8	73.7
NO VIOL	18	14	24.6	24.6	98.2
INATTENTION	23	1	1.8	1.8	100.0
	TOTAL	57	100.0	100.0	

Valid Cases 57 Missing Cases 0

DRIVAC DRIVER 1 VEHICLE ACTION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
MOVING STRAIGHT	1	48	84.2	84.2	84.2
SLOWING	6	2	3.5	3.5	87.7
STOPPED FOR TRAFF	7	2	3.5	3.5	91.2
STOP IN RDWY	9	4	7.0	7.0	98.2
CHANGING LANES	20	1	1.8	1.8	100.0
	TOTAL	57	100.0	100.0	

Valid Cases 57 Missing Cases 0

Exhibit 9
Typical PICA Variable Analysis Matrix

Page 5 SPSS/PC+

Crosstabulation: MONTH By SURFACE

MONTH \ SURFACE-> Count	DRY 1	WET 2	SNOW 3	ICE 4	Row Total
1 JAN	9	4			13 8.3
2 FEB	3	2	1		6 3.8
3 MAR	10	7			17 10.9
4 APR	12	4			16 10.3
5 MAY	16	4			20 12.8
6 JUN	10	1			11 7.1
7 JUL	15				15 9.6
8 AUG	14	1			15 9.6
9 SEP	8	4			12 7.7
10 OCT	7	6			13 8.3
11 NOV	1	4	3	1	9 5.8
12 DEC	5	4			9 5.8
Column Total	110 70.5	41 26.3	4 2.6	1 .6	156 100.0

Number of Missing Observations = 0

Because PICA is designed to run within SPSS, it can be executed on either the WSDOT mainframe or on microcomputers.

Traffic Accident Profile (TAP). TAP, produced every two years, uses the most current three years of traffic accident data, combined with frequencies and crosstabs for state highway accidents, in order to develop the "norm" or expected accident experience for sections of road within study groups. Comparison of the norm with the accident experience for a specific area allows abnormalities to be identified at those locations.

Evaluate the Effectiveness of Safety Countermeasures

Each year the Safety Data Branch evaluates the effectiveness of roadway projects by measuring the accident rate before and after a highway improvement has been implemented. The improvements can include guardrails, bridge rails, traffic signals and other roadway improvements. The Safety Data Branch then submits the results of the effectiveness evaluation to the WSDOT's location design section. This section creates a summary which is sent to the FHWA (as required by law).

Under the current process and depending on the number of accidents, the SDB performs either a limited or a full effectiveness evaluation of a highway safety project. A full effectiveness evaluation is similar to a limited evaluation except that it includes a benefit cost analysis and some related additional analyses. In order to justify a full evaluation, certain statistical requirements must be met. For example, if 25 accidents occur during the study period, at least a 32 percent change in the accident rate must be present to warrant the effectiveness evaluation at the 95 percent confidence level. The SDB attempts to use an evaluation time span of two years before and two years after the safety project is implemented when performing these evaluations.

The current full effectiveness evaluation is performed using a Lotus 1-2-3 spreadsheet and follows the Highway Safety Evaluation Procedural Guide (1981) produced by the Federal Highway Administration. Because the full effectiveness evaluation procedure includes the limited evaluation procedure process, only the full evaluation process is described below. Samples of each worksheet used for the evaluation are contained in Appendix B.

Step 1 -- Exposure worksheet. For each project evaluation, the following information is collected:

- location, including state route and milepost,
- the length of the before and after period (typically each period is two years),
- project length in miles, and
- average daily traffic (ADT)

Using this information, the spread sheet program calculates the vehicle exposure per mile of the highway project being evaluated.

Step 2 -- MOE data comparison worksheet. The next calculation is the MOE (Measure of Effectiveness) worksheet, which evaluates whether the number of accidents that were reported in the after period is greater or less than the number that were expected to occur, accounting for the changes in annual traffic volumes before and after the implementation of the countermeasures. The percent of the reduction in the number of accidents is calculated. If the percent is negative, then the number of accidents increased after the countermeasures were implemented.

Step 3 -- Statistical test worksheet. This worksheet is used to compare the before and after accident levels to determine if they are statistically different using a Poisson distribution. The Poisson test was developed from the FHWA Highway Safety Evaluation Procedural Guide. The observed percent of accident reduction (or increase) calculated in the MOE worksheet is compared with the expected percent of change under a confidence level (typically 95 or 99 percent) extracted from a Poisson curve. If the observed reduction is greater than the value taken from the Poisson curve, the reduction is said to be significant. If the observed reduction is less than the Poisson curve, the conclusion is that the number of accidents has not been significantly reduced.

If more than one state route is included for a safety countermeasure project (i.e., guardrails were added to five locations), the above steps are repeated for each state route. The information is then combined in an accumulative worksheet. With an accumulative worksheet, the number of accidents for each accident type, for both the before and after periods, is divided by the exposure for the corresponding period. The composite exposure is then computed as the sum of the individual exposures. Then the accidents per million vehicle miles for each accident type are calculated as the number of accidents in the accident type divided by the sum of the exposures.

Step 4 -- Benefit/cost analysis worksheet. The benefit/costs worksheet is used to summarize the effectiveness of the project countermeasures in a monetary framework. The initial implementation cost, annual operation and maintenance costs (before and after) and the net annual operation and maintenance costs are needed to complete the calculation for the total cost. For total benefit, the annual benefit is computed by calculating the difference between the number of accidents in the before and after periods for each of the three accident severity levels. The accident cost value for each severity level, developed by the National Safety Council, is used to calculate the annual safety benefit of a safety project by adding the product of the accident cost values and the reduction in the number of accidents within each category. The benefit/cost ratio is then calculated as the annual benefit divided by the annual cost.

Step 5 -- Effectiveness evaluation worksheet. Once these worksheets are completed, the results are summarized using the effectiveness evaluation summary worksheet. This worksheet provides information about the project, a summary of the number of accidents in the before and after periods and the percentage of accident reduction. The effectiveness of the project is evaluated based on the benefit/cost ratio. This information is summarized for groups of projects in a yearly summary.

The Safety Data Branch is considering alternative software to the existing Lotus 1-2-3 spreadsheet. It is currently reviewing the FHWA's "Highway Safety Evaluation Program" (HISAFE) software that performs many of the same procedures as the existing software.

INITIAL TRIPS ANALYSIS REPORT

This section of the report describes the TRIPS Functional Specifications and Data Specifications Reports submitted by Arthur Andersen (AA). This analysis on the accident portions of TRIPS is contained in a notebook titled "TRIPS Safety," and includes the following sections:

- Data Flow Diagrams and Process Descriptions,
- Dataflow Definitions,
- Stored Data Elements,
- Calculated Data Elements,
- Referenced Data Elements, and
- Inventory of Files.

The majority of sections within the AA report describe individual data elements that are either stored on the accident records or calculated as part of one of the programs that will use the accident records. One section, Dataflow Diagrams and Process Descriptions, provides the initial guidelines for the processing requirements for this portion of TRIPS. The dataflow diagrams from the AA report have been included as Appendix C. The original TRIPS report is required to examine the definitions and computation of data elements included in the AA report.

The current work on TRIPS is being led by the WSDOT MIS department. As part of this work, the AA report is being reviewed and revised as necessary by

WSDOT MIS. The WSDOT review of the Safety portions of the AA report should take place during early 1989. This review effort may change the functions and structure of TRIPS from that described and implied in the AA report. The brief description of the AA results presented below does not attempt to describe likely changes to TRIPS. However, some recommended changes to the A.A analysis are presented in the evaluation section of the following chapter and are intended as input to the WSDOT review process.

Decisions about the actual functions to be performed, the data structure to be used and the programs to be written for the TRIPS Safety system have not been made at this time. Such decisions will not be made until after a thorough review of the structure and functional requirements of the accident process have been made.

The project team's review of the AA design is broken into three parts

- Data Flows,
- Data Storage Formats, and
- Data Elements to Be Stored.

Each of these subjects is addressed separately.

Data Flows

The AA design envisions four primary types of Safety data usage:

- maintenance of the database (Dataflow 3.1),
- inquiries to the database (Dataflow 3.2),
- reporting from the database (Database 3.3), and
- analysis using the database (Dataflow 3.4).

Each of these basic processes contains a series of lower level functions. For example, Dataflow 3.3 contains five subfunctions:

- Prepare Annual Accident Report (Dataflow 3.3.1),
- Prepare Requested Accident Listing (Dataflow 3.3.2),
- Prepare High Accident Location Listing (Dataflow 3.3.3),

- Prepare Proposal Accident Listing (Dataflow 3.3.4), and
- Prepare Highway Safety Report (Dataflow 3.3.5).

Each of these steps includes a number of processing tasks required to produce a response (usually a report or data file for further analysis) to a request for information supplied by a user.

__Maintenance of the database__ shows the paths used to enter accident data into TRIPS. This flow also includes methods for editing accident data after those data have entered the TRIPS file structure.

__Inquiries to the database__ describes the production of screen oriented reports using accident data. All WSDOT users of TRIPS information are expected to be able to request specific accident data using these protocols and processes.

__Reporting from the database__ is the flow that provides larger printed reports using accident data and other information kept within TRIPS.

__Analysis using the database__ shows the need for retrieving accident data from TRIPS and exporting that information to other analytical programs (i.e., spreadsheets, microcomputers, etc).

Data Storage Formats

The AA report indicates that two major accident files will be stored by the TRIPS system. These files are for information on accidents that occur on the state highway system and off the state highway system. The AA report indicates that these files will be stored as ADABAS files. ADABAS is a database programing language particularly adept at accessing small numbers of records at any given time from a large database. For example, it is well suited to quickly look up one record for a particular driver from a database containing records for all drivers in the state.

Data Elements To Be Stored

The data elements to be stored in the AA report are those accident fields currently collected by the Washington State Patrol and transmitted via tape, as described in the previous section. These are the data being maintained in the existing accident data files. In addition, the AA report includes the necessary "Key" variables (dates, location codes, etc.) that will allow TRIPS to match the accident records to roadway and traffic information. Exhibit 10 provides a list of these variables.

Exhibit 10

Key Variables to Match Accident Records to Roadway and Traffic Information

SUPERDESCRIPTOR/KEY

Accident-Key
- State-Route-Number
- Related-Rdwy-Type
- Related-Rdwy-Qual
- Srmp
- Srmp-Ab-Ind
- Accid-Date
- Accid-Report-Num
- Record-Type

Vehicle-Key
- State-Route-Number
- Related-Rdwy-Type
- Related-Rdwy-Qual
- Srmp
- Srmp-Ab-Ind
- Accid-Date
- Accid-Report-Num
- Record-Type
- Accid-Vehcl-Num

Occupant-Key
- State-Route-Number
- Related-Rdwy-Type
- Related-Rdwy-Qual
- Srmp
- Srmp-Ab-Ind
- Accid-Date
- Accid-Report-Num
- Record-Type
- Accid-Vehcl-Num
- Ocpant-Num

CHAPTER 3
EVALUATION OF THE EXISTING WSDOT PROCESS

This chapter presents the project team's evaluation of WSDOT's accident data collection, storage and analysis processes and the initial TRIPS accident analysis performed by Arthur Andersen. The chapter is broken into four parts:

- data collection,
- data storage,
- analysis techniques and capabilities, and
- initial TRIPS analysis report.

DATA COLLECTION

WSDOT's collection of accident information is for the most part quite good. Cooperation between the Department and the WSP is good, and the two agencies continue to work together on improving the flow of accident data. It would not be beneficial or cost-effective for WSDOT to change the basic process by which WSP collects accident data.

The evaluation of the data collection process shows only a few weaknesses. Most of these weaknesses exist because of a lack of funding to provide more acceptable systems. For the most part, the benefits from fixing these shortcomings do not outweigh the costs of creating new automated procedures.

The shortcomings in the data collection process that the project team believes impact WSDOT's accident analysis process the most are the following:

- the WSP Collision Report Form does not collect all of the data that could be used by the WSDOT,
- the time lag between when an accident happens and when that accident appears in the WSDOT database is too long,
- accident location information is often not accurate,

- some information about the physical aspects of the highway system at accident locations currently maintained by WSDOT is not available for analysis.

Each of these subjects is described below.

The WSP accident form could be improved. The most significant limitations with the WSP form are that it does not ask for descriptive information on trucks involved in accidents and that it limits the number of objects struck by vehicles that can be reported. The most important of these limitations is the lack of descriptive truck data. Recent legislative increases in allowable sizes and weights of trucks and the growing percentage of travel by large vehicles have resulted in many unanswered questions concerning the safety of various truck styles. Currently, the WSP accident form does not provide sufficient room for, or any assistance to, the officer filling out the form to describe the trucks involved in an accident. This means that it is difficult to later analyze the frequency with which specific types of trucks are involved in accidents. The current form also limits the description of an accident to the "first object struck." This restricts the clarity with which an accident can be described and limits the later analysis of an accident in which multiple objects were hit (e.g., an automobile may have been sideswiped, then have hit a median barrier and have rebounded into another vehicle.) The addition of a second field for objects struck would allow a more complete electronic description of an accident, and thus a more complete analysis of factors affecting that accident.

The time lag between when an accident occurs and when information on that accident becomes available is often three to four months. The primary cause for this delay is WSP's difficulty in coding accident location information for accidents that occur off of the state highway system. (WSDOT codes accident locations on the state system. This process is performed within an acceptable time frame.)

WSP will not transmit the monthly accident data tape until it has received location information for all accidents occurring in that month. Information from accidents on the state system is thus held up by the delays in obtaining location information for accidents that occurred off of the state system. These delays inhibit WSDOT's analysis of current safety information.

The existing delay does have one good point. Current state regulations mandate that if persons injured in an accident die of those injuries within 90 days, the accident is classified as a fatal accident. Because of the above delays, all such revisions to the accident record are made to the accident file prior to its transmittal to WSDOT. If the transmittal took place prior to the 90-day limit, WSDOT would need to make the revisions.

The accuracy of location information is an issue for accidents that occur on the state system, as well as off of the state system. However, this report will discuss only the inaccuracies that impact the Department, as the inaccuracy of location information off of the state system is not a significant problem for WSDOT.

There are three basic causes of inaccuracy in the location information included on the WSP accident tape. The first is that persons filling out accident report forms (either law enforcement officers or private citizens) often do a poor job of indicating the location of an accident on the form. On rural state highways this is partly due to the distance between milepost markers or other distinguishing features on the roadway.

The second cause of inaccuracy is that the physical mileposting system in the field is not reflected by the electronic milepost locations in the database (or vice versa). For example, highways are occasionally re-mileposted to account for changes in alignment or the addition of new sections of road, but the signs on the road are not always moved in a timely fashion to reflect these changes. In addition, historically, old accident records have not been updated to reflect changes in state route mileposts. This means that WSDOT personnel who are unaware of these changes may erroneously reference some accident records, and those staff that are aware of the changes must manually perform the update.

The third cause of inaccuracy is that the maps available to the SDB are not always up to date. The SDB is responsible for the location coding of accidents on the state highway system, including all accidents that occur on city or county roads within 100 feet of an interchange ramp terminal. Changes in road systems and jurisdictional boundaries, both within and outside of city limits, are often not accurately depicted on available maps. It is sometimes difficult to determine from the location information on the accident report form whether a particular accident happened inside or outside the boundaries of the state highway system, and/or if the accident happened inside city limits.

Highway appurtenance data are not collected within the structure of the existing accident analysis process. The data are maintained within the maintenance section of the WSDOT, but they are not available for accident analysis. Without access to this type of information, it is nearly impossible for the Safety Data Branch to analyze the impact of different appurtenance designs on the severity of accidents. To perform this kind of analysis, the Safety Data Branch would have to manually correlate historical information obtained from the maintenance section and/or the video tape log with accident records. Correlation of the accident and appurtenance files would allow the Safety Data Branch to perform an additional series of important analyses. The storage and use of the data are discussed in more detail later in this chapter.

DATA STORAGE

The data storage procedures WSDOT currently uses (with or without proposed changes based on the Arthur Andersen TRIPS analysis report) are adequate but not optimal. The existing file system stores all accident information related to an incident in one large record. This information would be better separated into three files or record types (as noted in the AA TRIPS analysis report). These three files are

- accident characteristics,
- vehicle characteristics, and
- occupant characteristics.

In addition, not all of the vehicle and occupant data need to be available to WSDOT personnel outside of the SDB. The implementation of this file structure is discussed in detail in the recommendations section of this chapter.

The single record format currently used creates some significant restrictions on how data can be transferred into conventional, computerized statistical analysis packages. The most common limitations impact the examination of vehicle and occupant data in which a single record contains information on multiple vehicles and/or occupants involved in a single accident. Standard statistical packages usually require these data to be placed in separate records for analysis. Thus, to use these statistical packages, the Safety Data Branch must perform an unreasonable amount of data manipulation to separate the vehicle and occupant information into an acceptable format. With the separating of the current accident record into three files, the transfer of this information to other analysis systems would be greatly improved, reducing required staff and computer time and resources.

However, the project team does not agree with the AA report that the accident information should be kept in an ADABAS file structure. The project team believes that such a structure would reduce the efficiency of the most common types of accident analyses and result in higher than necessary computer charges.

A final area of concern to the project team is that the SDB does not currently have access to data maintained by WSDOT that could be readily used in a variety of Safety analyses.

The first of these data relates to historical roadway information. The TRIPS system is designed to maintain <u>current</u> roadway data, such as the width of lanes and shoulders and the type of pavement. This type of information will be available for accident analyses after the completion of the TRIPS system. However, the data of importance in accident analysis is not the current roadway configuration and condition, but the condition of the road at the time of the accident. Historical roadway information is not stored as part of the Roadway database file. It can be determined by examining a separate file containing historical changes to the Roadway file, but this will most likely be a long, cumbersome task if such information were required for large sections of highway (e.g., all interstate highways) for multiple time periods (e.g., 1977 to present), which is how such data would be most often utilized.

Historical roadway data could be used by the Safety Data Branch in a variety of analyses. In particular it would allow the SDB to analyze the correlation between accidents and roadway configuration. This would result in more effective design information and would most likely save WSDOT funds by decreasing highway expenditures.

Another example of data maintained by WSDOT but not usable within the accident analysis framework is roadway appurtenance information. The Safety Data Branch could make good use of data on the specific location and design of signs, guardrails, light standards and other appurtenances. For example, it could investigate the effects of different light standard designs on the severity of accidents involving light standards. While a considerable amount of laboratory research has been performed in this area, little is known about the actual impacts of changing vehicle and highway designs and design standards on accident rates and accident severity. An improvement in the State's reporting capability would be to analyze whether older designs actually pose a hazard to motorists, and should receive more immediate attention, or whether they present no special threat to safety, and should receive no additional attention.

Appurtenance data are currently maintained by the maintenance section. The accuracy of the location information on this file is sometimes suspect due to the ease with which these devices are knocked down, moved and removed. Correcting the location information on this file and making it available to the Safety Data Branch would significantly increase the ability of the SDB to analyze the effectiveness of different appurtenance designs.

In addition, an effort would need to be made to keep this file up to date. Resources would need to be committed (either within the Data Office or Maintenance) to ensure that the file represented the actual devices that exist in the field. The advantages of maintaining an accurate file are obvious, but often the resources required to perform this maintenance are diverted to other more visible projects.

WSDOT MIS is aware of the Safety Data Branch's desire for access to this information and indicated to the project team that they are working toward a solution to the problem.

ANALYSIS TECHNIQUES AND CAPABILITIES

The existing WSDOT analysis system is on a par with, or better than, systems used by most other state highway departments. However, the WSDOT process does have limitations. These limitations relate to the "statistical validity" of many of the analyses performed as part of the routine analysis of accident data.

The strengths of the existing analysis process are the relative ease and low cost with which the Safety Data Branch staff can produce tables and reports describing the number, locations and characteristics of accidents both on and off of the state highway system. The use of microcomputers and statistical programs (e.g., SPSS™) make the PICA system equal to many more expensive and elaborate systems in the country.

The shortcomings of the analyses do not result from the tools that the personnel use, but from the manner in which the Department as a whole treats accident analyses and the intent of the Department's accident analysis process.

The Department treats the evaluation of accident response measures as an afterthought to the safety program. It does not consider the need for statistical control of samples when it decides what locations will receive safety improvements but simply uses the priority array rankings and available funding to select safety response locations. While this may be the best political and/or legal approach to fixing high accident locations, it makes statistically valid examination of the effectiveness of the safety improvements almost impossible.

Statistically valid comparisons of accident rates before and after safety improvements are implemented are difficult to perform because accidents are relatively uncommon occurrences. For example, in most cases a location with more than three or four accidents per year has a high accident rating. A low frequency of accidents makes it very hard to measure with confidence whether a decrease (or increase) in the expected accident rate has occurred.

In addition to low accident rates, the presence of phenomena such as regression to the mean and safety improvements external to a specific location (e.g., new vehicle braking systems, better tires, seat belt laws, or speed limit changes) make it exceptionally difficult to distinguish the effects of a specific safety improvements at a location. Research compiled by the FHWA indicates that the only way to accurately measure the effects of specific changes in accident rates due to specific safety improvements is to design special studies to analyze those issues. A good design requires selecting both locations that will receive safety treatments and control groups of similar locations that will not receive improvements <u>before</u> the safety improvements are made. Only with such sample designs can statistically valid results be reasonably assured.

For WSDOT to use such a system would require that it alter the manner in which locations are chosen for safety improvements. Such a change would mean discontinuing strict adherence to the priority array process and instead use the priority array to designate locations that would then be split into control groups and study groups. This means that some high accident locations would remain untreated intentionally. These locations would be used to measure the impacts of safety changes not directly related to the specific safety measure being implemented.

The implementation of such a site selection strategy would leave open the possibility of law suits based on the legal argument that the Department had not fixed the highest ranked hazardous locations in the state. The counter to this argument is that a more rigorous statistical analysis of hazardous locations will indicate that the differences in rank among locations in the upper part of the priority list are not statistically different. (That is, the priority array is only one way of providing rankings, and among the identified locations each are roughly equivalent in priority.) The counter argument to the legal challenge might win the argument in a court of law, but it may be a position that the Department is unwilling to take.[1]

Such a change in the analysis procedure would also require that forethought be given to what improvements were to be evaluated. It is almost impossible to analyze (in a statistically correct manner) the impacts of most accident related roadway factors without initially setting up a proper experiment. Care must be taken to remove as many external factors as possible from such an analysis. By removing external influences, the researcher can confidently conclude that accident rate changes measured in the experiment occur because of the safety project (i.e., the changes in the roadway features being studied) and not some external factor.

Systems like PICA can be used to produce descriptive statistics, which are useful and can show large trends, but such systems can not be expected to function effectively for analyses that require more precise comparisons. Thus the project team's evaluation concludes that the existing system produces many useful reports

[1]Note that the project team does not include a legal expert, and the advice given above is the opinion of the authors, not that of an attorney.

and analyses but does not allow for the statistically correct evaluation of safety measure effectiveness.

In further evaluating the existing process, the project team also noticed one weakness in the FHWA Safety Project Evaluation Before-and-After Studies done annually by the Safety Data Branch. In these studies, the cost of implementing safety projects was often left blank because such data were not available to the SDB. Leaving out this information significantly reduces the value of cost/benefit analysis. The addition of even an estimated cost for such projects would improve the utility of these analyses.

INITIAL TRIPS ANALYSIS REPORT

As noted in the previous chapter, WSDOT MIS will review the AA analysis report for the Safety portion of TRIPS as part of the Safety development effort. The evaluation of the AA report presented below and the recommended changes presented in the last half of this chapter should be used as input to that process and not viewed as final recommendations for the structure and flow of data within TRIPS. Many of the approaches recommended for dealing with problems observed during this review may be impractical from a design and programing standpoint. Likewise, changes made by WSDOT MIS may make some of the comments presented in the evaluation irrelevant.

The scope of this project did not include a thorough examination of the programing effort involved in the TRIPS Safety development effort. The cost and difficulty of programing the various TRIPS Safety functions will significantly impact the selection of which functions are automated in TRIPS, and the selection of these functions will impact the applicability of the recommendations contained in this report.

The majority of the AA report's sections describe individual data elements, are accurate and require no changes. However, the TRAC project team believes that the initial data flow diagrams and process descriptions need some revision and significant amounts of additional review. TRAC's primary concerns (discussed in detail below) are the following:

- the AA report implies that the WSDOT will need to reprogram a group of accident analysis processes that already operate well;
- the Arthur Andersen report does not adequately consider the nature of the accident analysis process in its structure of the accident records; and
- the current flow of information and the group of functions described do not take advantage of the opportunity to make significant improvements to the existing accident analysis procedures by linking the accident information to types of WSDOT highway data not currently included in Safety analyses.

Processing Changes

The WSDOT Safety Data Branch already has a series of computer programs that perform most of its required functions. These systems are not perfect, suffering from several drawbacks, including the following:

- the existing systems are not integrated with the available traffic and roadway information;
- milepost locations on historical accident records are not updated to represent current milepostings;
- the programs used to perform the analyses are not all well documented and often use software products that are no longer actively supported by WSDOT MIS;
- the accident file structure is not as flexible as it should be, particularly with respect to analyzing vehicle and occupant data for accidents; and
- the operation of the available computer programs is not intuitively easy, requiring that a potential user be thoroughly trained and also

continually use the system to be able to reliably operate the computer programs.

The above list of difficulties is a strong argument for redoing of the Safety Data Branch's file management process. However, it is not clear to the project team that the information presented in the AA report is the most cost effective means of performing that revision.

As noted in the previous chapter, the AA report divides the TRIPS Safety effort into four major branches (dataflows), Updates to the Files, Inquiries, Reports and Analyses. While these are reasonable partitions from an analysis, business function standpoint, they do a poor job of describing the actual needs of the WSDOT Safety Data Branch.

The Updates partition is necessary. However, a special Inquiry section is probably not necessary. Conversations at the various meetings attended by the project team indicated that screen oriented inquiries of accident data appear to be unnecessary. (An Inquiry is essentially a query that the database responds to on the screen of the user, rather than to a printer.) Screen size often limits the amount of data that can be displayed at one time, and a hard copy of the results is usually desired by most users, even after they use preliminary output on a screen. The project team believes that while screen inquiries might be useful to a certain extent, their utility might not be worth their development cost.

The report dataflow is necessary, but it is not clear whether the programs that already exist need to be rewritten, or whether interfaces between new datafile structures and the existing programs are necessary. The reports that fall within this category are the High Accident Location report, the Annual Accident report and the Highway Safety report.

The project team's specific recommendations concerning the functions that TRIPS Safety should perform is included in the following chapter.

Structure of the Record System

The AA report separates accident data into two files:

- accidents on state routes, and
- accidents off of state routes.

Each of these files contains three record types, accident records, vehicle records, and occupant records.

The AA notebook indicates that accident information could be stored as ADABAS files. This would be appropriate if the records were to be primarily reference oriented, used for on-line query and retrieval of small numbers of records. While this on-line capability is needed, TRAC's discussions with SDB personnel indicate that far more common and costly uses of the data are

- to print lists of all accident records between selected mileposts within a state route or district, or
- to produce large batch files that are downloaded onto a microcomputer for later analysis.

Both of these processes require large numbers of records to be read. A search for a single record (e.g., the accident record for accident number 00125 on SR 5 at milepost 23.33) is a relatively uncommon procedure.

According to most published information on database design (e.g., *Database Design*, by Gio Wiederhold, McGraw-Hill, 1983) the ADABAS type of file structure requires excessive amounts of computer time to process large portions of extensive files. The project team believes that an indexed, sequential file structure would be a better approach to maintaining the accident records. The reasoning behind this conclusion is explained in the Recommendations section of this report.

New Information Links

The AA report references the existing accident analysis process performed by WSDOT. It does not attempt to identify any improvements or additional analyses that should be incorporated into the TRIPS design. In addition, several minor modifications to the information stored within TRIPS might also improve the capabilities of the system.

The AA report does not include references to the automated collision diagram process being developed by Ron Cihon of the Department's cartography division. It also does not include the output of files that contain accident location information, which can be combined with the existing mapping capabilities of the Department for graphical display of accident data. Both of these functions are important additions to the capabilities of the Safety Data Branch, and TRIPS should be designed to support them.

The second area in which the AA report is lacking is with the information stored in the accident records themselves. Some of this information should be changed. The file structure is not designed to easily retrieve historical roadway configuration data so that this data can be used in various safety analyses. (When analyzing an accident that occurred in 1979, the analyst is interested in what the roadway looked like in 1979, not 1987.) TRIPS could easily be programmed to look up the roadway configuration at an accident location for the date of that accident by accessing the roadway file when the accident data is initially entered into the system. It could then write that information onto the accident record to simplify its retrieval.

In addition, the WSP accident form may undergo changes in the near future. The form was last revised in 1980, and additional information may now be needed on accidents that should be recorded in the accident files. The Safety Data Branch and the project team have discussed suggested changes to the accident form with the WSP accident records supervisor. If these changes are made, the record structure will need to accommodate them.

Finally, no mention is made of WSDOT's desire to link the accident files to files external to TRIPS or the WSDOT. There is at least one other database (the appurtenance file) maintained by WSDOT that might be used in accident analyses, and both the Traffic Safety Commission and the WSP maintain (or will maintain) files that could be linked to TRIPS to provide more analytical capabilities to the Safety Data Branch.

The use of each of the above data sources is presented in more detail in the Recommended Changes chapter.

CHAPTER 4
RECOMMENDED CHANGES

This chapter describes the project team's recommended changes to the existing WSDOT accident analysis system. Presented is a series of recommendations for altering the existing procedures and TRIPS Analysis Report. These recommended actions are discussed in detail and include explanations of their importance to the WSDOT and their impact on the existing Safety Data Branch functions. The recommendations are intended to increase the analysis capabilities, accuracy, and efficiency of the existing WSDOT safety data collection, distribution and analysis process.

The recommendations presented in this chapter are based on a review of current Safety Data Branch analyses, a review of literature concerning safety analyses throughout the nation, an examination of the (AA) TRIPS Safety system analysis documentation, discussions among TRAC project team members and Safety Data Branch personnel, and brief discussions with WSDOT MIS staff.

The recommendations are divided into the same four sections as the previous chapter:

- data collection,
- data storage,
- analysis techniques and capabilities, and
- initial TRIPS analysis.

Specific actions for implementing the recommended changes are discussed at the end of the chapter.

DATA COLLECTION

Recommended changes to the accident data collection process are broken into the four categories described in the evaluation section above:

- improving the WSP accident form,
- reducing the delay in receiving accident data,
- improving the accuracy of location information, and
- collecting highway appurtenance data.

These subjects are discussed in the following paragraphs.

Improving the WSP Accident Form

Two modifications to the WSP accident form are recommended as a result of discussions with Safety Branch personnel, the project team and the WSP. These changes are

- better vehicle classification data, particularly truck type information, and
- the addition of a "second harmful event" variable.

The current accident form reveals little about the configuration of the trucks that were involved in an accident. In addition, a number of state agencies use a variety of vehicle classification schemes. The project team recommends that a single classification scheme based on the FHWA 13 category classification chart (see Exhibit 11) be added to the existing WSP accident form.

Exhibit 11

FHWA Vehicle Classification Categories

Motorcycles (Optional)
Passenger Cars with/without Trailers
2-axle, 4-tire pickups, vans and motorhomes
Buses
2-axle, 6-tire single units
3-axle single unit
4-or-more axle single unit
4-or-less-axle double unit
5-axle double unit
6-or-more-axle double unit
5-or-less-axle multi-unit
6-axle multi-unit
7-or-more-axle multi-unit

In addition, the form should contain picture examples of the 13 classifications to assist officers who must identify the types of vehicles that were involved in the accident. The picture examples could be placed on the back of the coding form's overleaf. These changes to the form will allow more consistent reporting of vehicle types, improve the accuracy of truck accidents analyses and provide police officers with assistance in classifying vehicles.

The second recommendation for improving the accident report form is the addition of a "second harmful event" question. This addition will provide increased information about the impacts that occur during severe accidents and provide a better database for examining the effects of various appurtenances in relation to accident severity. Currently, only the first harmful event is recorded on the accident record, and situations where a vehicle hits a second or third vehicle or object are not always completely recorded.

To implement these changes, the WSDOT will need to work with the WSP. The WSP is willing to consider changes to the report form but must balance requested changes to the form with the needs of many different agencies that use accident data and the abilities of the responding officers. Data to be supplied by the officer responding to an accident must be within his/her technical knowledge, and collecting that data must not hinder his/her ability to provide traffic control at the accident site and assistance emergency vehicles and personnel.

The project team believes that these two requested changes will actually make the responding officer's job easier, particularly with respect to the identification of vehicle types. The requested changes can be made on the existing form without deleting previously collected data, and without adding additional pages to the form. This should limit any negative impact of the requested changes on other agencies and researchers. An example of the modified, two-page accident report form, including the recommended changes, is shown in Exhibit 12.

Exhibit 12
Modified Washington State Patrol Traffic Collision Report

ROADWAY SURFACE CONDITION
[illegible]

WEATHER
1 CLEAR CLOUDY & OVERCAST
2 RAINING
3 SNOWING
4 FOG
5 OTHER *

LIGHT CONDITIONS
1 DAYLIGHT
2 DAWN
3 DUSK
4 DARK STREET LIGHTS ON
5 DARK STREET LIGHTS OFF
6 DARK NO STREET LIGHTS
7 OTHER *

TRAFFIC CONTROL
1 SIGNALS
2 STOP SIGN
3 YIELD SIGN
4 FLASHING RED
5 FLASHING AMBER
6 RR SIGNAL
7 OFFICER/ FLAGMAN
8 OTHER TRAFFIC CONTROL *
9 NO TRAFFIC CONTROL

TYPE OF ROADWAY
1 ONE WAY
2 TWO WAY
3 REVERSIBLE ROAD
4 INTERCHANGE LOOP ROAD
5 ALLEY
6 CENTER LANE TWO WAY LEFT TURN LANES
7 DRIVEWAY

ROADWAY STRUCTURE
1 OCCURRED ON ROADWAY STRUCTURE (ON BRIDGE, OVERPASS, DOCK, ETC.)
2 DID NOT OCCUR ON STRUCTURE

CONSTRUCTION AREA
1 OCCURRED IN CONSTRUCTION AREA (HIGHWAY, UTILITY, ETC.)
2 DID NOT OCCUR IN CONSTRUCTION AREA

ROADWAY CHARACTER
1 STRAIGHT & LEVEL
2 STRAIGHT & GRADE
3 STRAIGHT AT HILLCREST
4 STRAIGHT IN SAG
5 CURVE & LEVEL
6 CURVE & GRADE
7 CURVE AT HILLCREST
8 CURVE IN SAG

ROADWAY SEPARATION
2 DIVIDED
3 UNDIVIDED

ROADWAY SURFACE TYPE
1 CONCRETE
2 BLACKTOP
3 BRICK OR WOOD BLOCK
4 GRAVEL
5 DIRT
6 OTHER *
0 UNKNOWN

SPECIAL HAZARDOUS DRIVING CONDITIONS
(DUST, WIND GUSTS, SMOKE, ETC.) *
CHECK (✓) HERE AND EXPLAIN IN DESCRIPTION AREA

HAZARDOUS MATERIALS BEING TRANSPORTED
(IDENTIFY IN DESCRIPTION AREA)
1 FLAMMABLE LIQUID
2 CORROSIVE MATERIAL
3 EXPLOSIVES
4 RADIO ACTIVE MATERIALS
5 AMMONIA
6 CHLORINE
7 OTHER *

PEDESTRIAN/PEDALCYCLIST WAS USING
1 SIDEWALK
2 WALKWAY
3 SHOULDER
4 MARKED XWALK
5 UNMARKED XWALK
6 OTHER *
7 DESIGNATED BIKE ROUTE

PEDESTRIAN/PEDALCYCLIST CLOTHING COLOR
1 DARK
2 LIGHT
3 MIXED
4 RETRO-REFLECTIVE
5 OTHER REFLECTIVE APPAREL - SHOES PATCHES *

PEDESTRIAN/PEDALCYCLIST (CONTRIBUTING CIRCUMSTANCES)
1 INTOXICATED
2 DISREGARDED TRAFFIC CONTROLS
3 FAILURE TO YIELD RIGHT OF WAY TO VEHICLE
4 INATTENTION
5 ON WRONG SIDE OF ROAD
8 HITCHHIKING
9 PEDALCYCLE NOT LIGHTED
0 FAILURE TO USE XWALK

CONTRIBUTING CIRCUMSTANCES (NOT MORE THAN TWO)
[illegible]
5 DID NOT GRANT R/W TO VEHICLE
6 IMPROPER PASSING
7 FOLLOWING TOO CLOSELY
8 OVER CENTER LINE
14 APPARENTLY ASLEEP
15 IMPROPER PARKING LOCATION
16 OPERATING DEFECTIVE EQUIP.
22 DID NOT GRANT R/W TO PEDESTRIAN
23 DRIVER INATTENTION

DRIVER/VEHICLE ACTIONS (ONE OR MORE)
1 GOING STRAIGHT AHEAD
2 OVERTAKING AND PASSING
3 MAKING RIGHT TURN
4 MAKING LEFT TURN
5 MAKING U TURN
6 SLOWING
7 STOPPED FOR TRAFFIC
8 STOPPED AT SIGNAL OR STOP SIGN
9 STOPPED IN ROADWAY
10 STARTING IN TRAFFIC LANE
11 STARTING FROM PARKED POSITION
12 MERGING (ENTERING TRAFFIC)
13 LEGALLY PARKED OCCUPIED
14 LEGALLY PARKED UNOCCUPIED
15 BACKING
16 GOING WRONG WAY ON DIVIDED HIGHWAY
17 GOING WRONG WAY ON RAMP
18 GOING WRONG WAY ON ONE-WAY ST. OR RD.
19 OTHER *
20 CHANGING LANES
21 ILLEGALLY PARKED OCCUPIED
22 ILLEGALLY PARKED UNOCCUPIED

VEHICLE CONDITION (ONE OR MORE)
1 DEFECTIVE BRAKES
2 DEFECTIVE HEADLIGHTS
3 DEFECTIVE REAR LIGHTS
4 TIRES WORN OR SMOOTH
5 TIRES PUNCTURED OR BLOWN
6 LOST A WHEEL
7 DEFECTIVE STEER MECH.
8 POWER FAILURE
9 HEADLIGHTS GLARING
10 OTHER LIGHTS/REFLECTORS INSUFFICIENT
11 OTHER DEFECTS *
12 NO DEFECTS
13 MOTORCYCLE LIGHTS OFF
14 EQUIPPED WITH STUDDED TIRES
15 MOTORCYCLE WINDSHIELD INSTALLED
16 TRUCK/TRAILER SAFETY INSPECTION

DIRECTION OF MOVEMENT
NORTH / WEST / EAST / SOUTH

POSTED SPEED
MILES PER HOUR FOR EACH VEHICLE INVOLVED

SOBRIETY

CHEMICAL TEST

TEST RESULTS LIST ACTUAL TEST RESULTS IN 100ths

VEHICLE LEGALLY STANDING

STATE OF WASHINGTON
POLICE TRAFFIC COLLISION REPORT
WSP 159 (REV. 1-79)

① UNIT NO. 1
② UNIT NO. 2 (VEH., PED., BIKE)
* DESCRIBE IN THE COLLISION DESCRIPTION AREA
\+ CODES DESCRIBED BELOW
SEE REVERSE SIDE FOR INSTRUCTIONS

VEHICLE CLASSIFICATION
1. Motorcycles
2. Passenger Cars w/wo Trailers
3. 2-axle, 4-tire pickups, vans & motorhomes
4. Buses
5. 2 axle, 6 tire single units
6. 3 axle single unit
7. 4-or more-axle single unit
8. 4-or-less-axle double unit
9. 5-axle double unit
10. 6-or-more-axle double unit
11. 5-or-less-axle multi-unit
12. 6-axle multi-unit
13. 7-or-more-axle multi-unit

Unit 1
Unit 2

PEDESTRIAN ACTION
1 XING AT INT W SIG
2 XING AT INT AGST SIG
3 XING AT INT NO SIG
4 XING AT INT DIAG
5 FROM BEHIND PARKED VEH
6 XING NON INT NO XWALK
7 XING NON INT IN XWALK
8 WALK G IN RDWY W TRAF
9 WALK G IN RDWY OPP TRAF
10 WALK G ON RDWY SHLDR WITH TRAFFIC
11 WALK G ON RDWY SHLDR OPPOSITE TRAFFIC
12 STANDING OR WORKING IN ROADWAY
13 PUSH'G OR WORK G ON VEH
14 PLAY'G IN ROADWAY
15 LYING IN ROADWAY
16 NOT IN ROADWAY
17 ALL OTHER ACTIONS *
18 FELL OR PUSHED INTO PATH OF VEHICLE

PEDALCYCLIST ACTION
43 XING DIAGONALLY
44 RIDING WITH TRAFFIC
45 RIDING AGAINST TRAFFIC
46 FELL OR PUSHED INTO PATH OF VEHICLE
47 CYCLIST TURNED INTO PATH OF VEHICLE - SAME DIRECTION
48 CYCLIST TURNED INTO PATH OF VEHICLE - OPPOSITE DIRECTION
49 ALL OTHER ACTIONS *
50 XING OR ENTERING TRAFFICWAY

\+ THE FOLLOWING CODES ARE USED TO DESCRIBE THE DRIVER OCCUPANT INJURY CLASS RESTRAINT SYSTEM EJECTION AND MOTORCYCLE SAFETY DATA

(1) STATUS: 2 PASSENGER, 3 PEDESTRIAN, 4 BICYCLIST, 5 OTHER, 6 WITNESS
(2) SEAT POSITION: 7 OTHER POSITION, 8 POSITION UNKNOWN, 9 MOTORCYCLIST
(3) INJURY CLASS: 1 NO INJURY, 2 DEAD AT SCENE, 3 DEAD ON ARRIVAL, 4 DIED IN HOSPITAL, 5 DISABLING INJURY, 6 NON DISABLING (EVIDENT) INJURY, 7 POSSIBLE INJURY
(4) RESTRAINT SYSTEMS: [illegible]
(5) EJECTION: 1 NOT EJECTED, 2 TOTALLY EJECTED, 3 PARTIALLY EJECTED, 4 UNKNOWN IF EJECTED
(6) MOTORCYCLE SAFETY: [illegible]

Exhibit 12
Modified Washington State Patrol Traffic Collision Report (cont.)

WSP 159 (REV 1-80)

STATE OF WASHINGTON PAGE OF

POLICE TRAFFIC COLLISION REPORT

☐ TRAFFICWAY ☐ PRIVATEWAY

No.

POLICE COMPLAINT NUMBER

DATE OF COLLISION: MO DAY YEAR | DAY OF COLLISION: SUN MON TUES WED THURS FRI SAT | TIME (USE 24 HOUR HOURS) | COUNTY

COUNTY NO | CITY NO | FHWA ☐ URBAN ☐ RURAL

MILES ☐ N ☐ E ☐ S ☐ W ☐ OF | CITY OR TOWN | ON | NAME & NO. OF STREET OR HIGHWAY

FCT CLS | ADM CLS | PREFIX | ROUTE OR STREET CODE | SECTION

INTERSECTION WITH STREET OR ROAD | NON INTERSECTION BETWEEN STREET & STREET

PREFIX | EQ | MILE POST

DISTANCE & DIRECTION FROM REFERENCE, CROSS STREET OR NEAREST MILE POST ☐ MILES ☐ FEET N S E W ☐ ☐ ☐ ☐ OF | ACCIDENT MILEAGE CODE MILES IN HUNDREDTHS

RAMP | DIAGRAM DATA

COLLISION INVOLVED: TOTAL NO. OF VEHICLES ☐ SEVERITY: NO. KILLED ____ NO. INJURED ____ ☐ PROPERTY DAMAGE | ☐ FUEL SPILLAGE ☐ HIT & RUN ☐ FIRE RESULTED ☐ STOLEN VEH

INTER | NON INTER | X-RD CLS | INTERSECTING STREET OR ROAD OR REFERENCE CROSS STREET OR ROAD

FIRST OBJECT STRUCK (NAME OF OBJECT STRUCK AND OWNER'S NAME) | EST. DAMAGE $

SECOND OBJECT STRUCK (NAME OF OBJECT STRUCK AND OWNER'S NAME)

SPECIAL CODING USE

UNIT NO. 1		UNIT NO. 2 ☐ VEHICLE ☐ PEDESTRIAN ☐ PEDALCYCLIST
DRIVER'S NAME LAST FIRST MIDDLE	DRIVER	DRIVER'S NAME LAST FIRST MIDDLE
STREET ADDRESS		STREET ADDRESS
CITY STATE ZIP CODE PHONE NO		CITY STATE ZIP CODE PHONE NO
DRIVER'S LICENSE NO STATE SEX DATE OF BIRTH MO DAY YR		DRIVER'S LICENSE NO STATE SEX DATE OF BIRTH MO DAY YR
OCCUPATION FIRM NAME & PHONE NO EYES WEIGHT HEIGHT		OCCUPATION FIRM NAME & PHONE NO EYES WEIGHT HEIGHT
☐ CHECK (✓) IF OPERATOR WAS DRIVING A COMMERCIAL VEHICLE AS AN EMPLOYEE OF ANOTHER		☐ CHECK (✓) IF OPERATOR WAS DRIVING A COMMERCIAL VEHICLE AS AN EMPLOYEE OF ANOTHER
CODES ▶ 3 4 5 6		CODES ▶ 3 4 RESTRAINT SYSTEM 5 6 MOTORCYCLE SAFETY
NATURE OF INJURIES		NATURE OF INJURIES
REMOVED FROM SCENE BY ☐ AMBULANCE ☐ POLICE CAR ☐ HELICOPTER ☐ PRIVATE VEHICLE ☐ NOT TRANSPORTED		REMOVED FROM SCENE BY ☐ AMBULANCE ☐ POLICE CAR ☐ HELICOPTER ☐ PRIVATE VEHICLE ☐ NOT TRANSPORTED
VEH YEAR MAKE DODGE CHEV MODEL DART NOVA STYLE 2 DR CONV	VEHICLE	VEH YEAR MAKE DODGE CHEV MODEL DART NOVA STYLE 2 DR CONV
VEH COLOR LICENSE PLATE NO STATE TRAILER PLATE NO STATE		VEH COLOR LICENSE PLATE NO STATE TRAILER PLATE NO STATE
VEHICLE IDENTIFICATION NO		VEHICLE IDENTIFICATION NO
REGISTERED OWNER LAST FIRST MIDDLE PHONE NO	OWNER	REGISTERED OWNER LAST FIRST MIDDLE PHONE NO
ADDRESS OF OWNER		ADDRESS OF OWNER
NAME & ADDRESS OF INSURANCE CO. OR AGENT		NAME & ADDRESS OF INSURANCE CO. OR AGENT
SHADE IN DAMAGED AREA (9 TOP, 10 BOTTOM) ☐ DISABLING ☐ FUNCTIONAL ☐ OTHER DAMAGE EST. DAMAGE $	ENFORCEMENT ACTION: CITATION NO. CHARGE	CITATION NO. CHARGE ☐ DISABLING ☐ FUNCTIONAL ☐ OTHER DAMAGE EST. DAMAGE $ SHADE IN DAMAGED AREA (9 TOP, 10 BOTTOM)
☐ DRIVEN AWAY ☐ REMAINED ☐ TOWED AWAY BY	VEHICLE REMOVAL	☐ DRIVEN AWAY ☐ REMAINED ☐ TOWED AWAY BY

DIAGRAM OF COLLISION (USE SUPPLEMENTAL SHEET IF NECESSARY) INDICATE NORTH BY ARROW (N)

DESCRIPTION OF COLLISION (USE SUPPLEMENTAL SHEET IF NECESSARY)

NAME, ADDRESS & INJURIES OF PERSONS INVOLVED OCCUPANTS / WITNESSES (USE SUPPLEMENTAL SHEET FOR ADDITIONAL NAMES)

CODES: SEX | AGE | 1 STATUS | — IN VEH NO | 2 SEAT POS | 3 CLASS | 4 RESTR | 5 EJECT | 6 M/CY SAFETY

NAME / ADDRESS	PHONE NO / NATURE OF INJURIES	REMOVED FROM SCENE BY
NAME / ADDRESS	PHONE NO / NATURE OF INJURIES	☐ AMB ☐ POLICE CAR ☐ HELICOPTER ☐ PRIV VEH ☐ NOT TRANSP
NAME / ADDRESS	PHONE NO / NATURE OF INJURIES	☐ AMB ☐ POLICE CAR ☐ HELICOPTER ☐ PRIV VEH ☐ NOT TRANSP
NAME / ADDRESS	PHONE NO / NATURE OF INJURIES	☐ AMB ☐ POLICE CAR ☐ HELICOPTER ☐ PRIV VEH ☐ NOT TRANSP

X INVESTIGATING OFFICER'S NAME & RANK | BADGE OR ID NO | AGENCY | UNIT | POLICE DISPATCHED 2400 HRS | POLICE ARRIVED 2400 HRS | DATE OF REPORT | APPROVED BY | DATE

These requested changes have already been sent to the WSP with the approval of the Safety Data Branch. The WSDOT needs to continue to monitor the progress of the WSP in modifying the accident form to ensure that its needs are met by the newly emerging form. WSDOT may also need to follow up these requests to ensure that WSP understands their merits.

Reducing the Delay in Receiving Accident Data

The three-month delay between the time an accident occurs and the time that information on that accident arrives at WSDOT on tape from WSP needs to be reduced. Unfortunately, WSDOT can not affect the primary cause for this delay, which is that WSP must wait until county and city accident collision report forms are received from each agency. WSDOT may want to work with the WSP to investigate the development of a separate monthly tape of state route accidents for WSDOT's use. The WSP would have to provide the computer support and programing to provide a separate state route data tape. It is not clear whether this would be feasible within WSP budget constraints. However, the project might be undertaken as part of the on-going update of WSP's computer system. To implement this recommendation, WSDOT needs to continue to express this need to WSP personnel, both formally and informally, and determine if and when such a processing step might be accomplished.

Improving the Accuracy of Location Information

There are two recommendations in this area. As a short term measure, it is recommended that the SDB request additional resources to maintain the locator log used both by SDB and the WSP. An estimate for completely updating the log is roughly 2 FTE and $100,000. The project team feels that while this is a reasonable expenditure it is not necessary that the entire locator log be updated every biennium. Instead, given current WSDOT budgetary constraints, the project team recommends that roughly 0.5 FTE and $25,000 be expended per biennium to update just those sections of the locator log that are experiencing the greatest amount of change. We believe this will provide significant benefits at a cost acceptable to the department.

While the locator log improvements will help, truly accurate location information will only come about through technological advancements in automatic location devices. At some point in the future, state patrol (and other jurisdictions') cars may be equipped with transponders that will indicate the X/Y position of a vehicle, but this is not a practical option at this time. Until such a device is available, officers will continue to rely on available visual information and the locator log provided by SDB for location referencing. This will result in some inaccuracy in the location data.

Because of reductions in staffing levels in the cartography section, it is also not practical to expect significant increases in map quality for most areas within the state. In the long term, research into the automated conversion of photogrammetry data into digital map information may allow the low cost expansion of available digital map information. Such systems are only in preliminary research phases, and should not be expected to provide assistance in this area in the foreseeable future. The WSDOT research office should become aware of the potential for these improvements and should consider funding investigations of these systems in the coming biennium.

The use of TRIPS should eliminate the current problem of having incorrect milepost references on old accident records because the DOT has re-mileposted a route. TRIPS will maintain all records with current mileposts and will make the appropriate adjustments to all records when a change in mileposts occurs. However, because permanent changes have not been made to milepost information on historical accident records, either a data conversion process must take place during the TRIPS implementation so that all accident records can be converted to the current mileposting, or manual analysis procedures must be maintained for several years after TRIPS Safety is implemented. The project team recommends that the milepost information be converted.

Finally, in addition to TRIPS, a procedure must be installed within the Department (including the districts) that ensures that the milepostings in TRIPS are accurately represented by milepost signs placed beside the highway. That is, if a district moves mileposts for any reason, those new locations must be indicated within TRIPS so that differences between the TRIPS file and milepost signs do not occur. Similarly, if mileposts are changed within TRIPS, the physical location of signs on the highway must be moved to account for the revised mileage.

Collecting Highway Appurtenance Data

The WSDOT should make appurtenance data available to the Safety Data Branch if at all possible. In particular, the Safety Data Branch should have access to the location and design characteristics of light standards, guardrails, median barriers and major sign posts. This could be done by adding appurtenance data to TRIPS, or by manually collecting appurtenance data and adding it to the accident record. The project team does not have the resources to estimate the cost of adding appurtenance data to TRIPS, but the manual effort would likely require 0.5 FTE per year, in addition to the existing SDB staff.

The funds for making this information available may not exist at the present time. While this information may not result in immediate and significant monetary savings to the Department, it could be used to effectively examine the Department's use of various median barriers and light standards. Such information would be very useful in reviewing design standards and for prioritizing the replacement of ineffective designs. Thus the use of such information could result in significant savings in tort liability cases.

DATA STORAGE

The project team makes three related recommendations for changes in the manner in which the Safety Data Branch stores information. These recommendations are

- to provide for historical roadway configuration data directly in the accident records,
- to provide storage for additional new variables including the variables collected by the WSP as a result of the recommendations made in the above section, and
- to provide recommendations for consideration in the TRIPS design.

Historical information from the roadway portion of TRIPS should be written to the accident files. The provision of specific variables to contain roadway configuration data within the accident records will allow the easy and inexpensive retrieval of historical roadway data for use in accident analyses. This should be a less expensive means of accomplishing this task than searching the file which contains roadway history for every accident record each time history is needed for an analysis.

To contain this roadway information, the following variables should be added to the state route accident record:

- number of lanes in the direction of travel and the total roadway,
- roadway width total and in the direction of travel,
- shoulder width in the direction of travel (center and right),
- shoulder type (left, center and right),
- median type,
- pavement type,
- parking zone type,
- horizontal and vertical curvature,

- acceleration lane presence, width and length, and
- turn lane presence, width and length.

This information can be obtained directly from the TRIPS roadway database at the time new accident records are added. Additional variables may also be necessary in order to contain appurtenance data that may be collected as part of previous recommendations in this report. As with roadway data, historical, not current appurtenance information, are important in accident analyses.

TRIPS should be able to add new variables such as those included on the revised WSP accident form. Based on earlier recommendations these variables include another vehicle type descriptor and variables for describing secondary impacts during the accident. The need to add variables to TRIPS may result from changes made to the accident form at the request of the WSP, the Traffic Safety Commission or the needs of the WSDOT.

ANALYSIS TECHNIQUES AND CAPABILITIES

Recommendations in this subject area are stratified into two separate groups:

- short-term fixes, and
- long-term changes.

In the short term, the project team recommends that the Safety Data Branch and the WSDOT Research office undertake the development of "default" cost estimates for common safety improvement projects. These estimates could be expressed as unit costs (e.g., the cost per foot of guardrail, the monthly cost of electricity for signal operation), as complete costs (e.g., the average cost of installing a signal or of operating that signal for a year), or as a combination of the two, depending on the specific safety improvement. These costs could then be used in benefit/cost analyses done as part of the FHWA Highway Safety Project Evaluations when actual costs were not available. Use of these defaults is not the desired option, but they are better than having no estimate of project costs to compare against measured benefits.

A second short-term recommendation for the existing process is to change the method for calculating expected accident rates for use in the before-and-after analysis. Currently, the WSDOT uses two-year accident histories before the safety improvement and compares them directly with a two-year period after the improvement. The project team recommends that two changes be made to this process:

- more than two years should be used to calculate "before" accident rates whenever possible; and
- a linear regression technique should be used in place of the simple average to provide a better prediction of expected rates.

The period studied before the improvement should be as long as possible without incorporating significant changes to the roadway structure. This, in combination with the regression technique, should provide a better predictor of "expected" accident rates and limit the effects of "regression to the mean," which essentially means that the recommended process will discount the impact of unusually high accident rates in the year or two directly preceding the safety improvement. With these two changes, the expected accident rate used in the before/after study should more accurately estimate the conditions without the safety improvement.

The project team recommends that, in the longer term, the WSDOT examine its true needs for evaluating the impacts of safety projects. The project team believes that the current method of evaluating safety projects is a reasonable and acceptable method for reviewing the impacts of various safety improvements, despite the known limitations in the procedure's statistical validity. The vast majority of safety improvements used by WSDOT have been heavily studied under controlled conditions by researchers throughout the nation. Those researchers have concluded that the safety improvements provide specific kinds of relief to hazardous locations. The WSDOT is not interested in continually reviewing this work, only in examining whether the Department is applying these proven safety measures in an effective manner. Given the knowledge that the safety measures have already been proven effective, the Department only needs to know whether the accident rates at the affected locations are improving. The Department does not need to know to a high degree of precision the extent to which specific safety improvements have impacted that location.

Therefore, unless the FHWA requires a more statistically stringent analysis process, the project team does not recommend changes in the present safety review process. The benefits to be gained by changing to a more statistically valid evaluation process do not outweigh the legal battles that might result from such a change, the difficulty in "selling" the necessary changes to the priority array process outlined in the evaluation section, and the significantly greater lead time required to set up and perform evaluations based on high quality sample designs.

Note that factors that have not been studied heavily on a national basis <u>will</u> need to be analyzed with more statistical care than the conventional before-and-after studies done by WSDOT. For example, if the Department wants to study the impacts on accidents and accident severity of replacing one kind of pavement surface with another surface, the Safety Data Branch would need to design a study to perform this specific analysis. This means that a minimum of three years (one year to select the appropriate samples and control locations and to place the new pavement, and a minimum of two years of accident history after placement of the pavement) would be needed before preliminary results of the study could be available.

INITIAL TRIPS ANALYSIS

The TRIPS recommendations presented below should serve as a starting point for further discussions between the WSDOT MIS staff, the Safety Data Branch staff and others involved in the development of TRIPS. The suggestions presented in this document are preliminary and must be further refined as part of the TRIPS design process.

The TRIPS recommendations are presented in three sections:

- Processing Changes
- Structure of the Record system, and
- New Information Links.

Each of these topics contains one or more specific recommendations, which are addressed below.

Processing Changes

The project team believes that dataflow D3.2, Prepare Accident Inquiries, in the AA analysis report is unnecessary. The functions described in this dataflow are duplicated by the reporting functions in dataflow D3.3 Prepare Accident Reports. The project team believes that while screen inquiries might be useful to a certain extent, their utility might not be worth their development cost. The project team recommends that the reporting program be written so that output produced by the computer is routed to a print queue, from which it can be retrieved and viewed on screen. After the output on screen has been viewed, the report could then be released to the printer for a paper report.

The project team recommends that WSDOT use the existing analytical software as much as possible. To an Engineer reviewing the report, the AA analysis implies that existing software such as the priority array process and the accident evaluation process should be rewritten as part of TRIPS. After a cursory examination of this subject, the project team believes that it would be more cost-effective to write a front end program to reformat TRIPS accident data so that it can be loaded into the existing software. (For example, if the accident file is no longer sequential, a preprocessor should produce a sequential dataset, ordered by state route and milepost.)

Maintaining the existing analysis software will also reduce the need to create new reporting programs as many of the reports that are described in the Arthur Andersen report are produced by existing analytical software. Included in this are the High Accident Location report, the Annual Accident report and the Highway Safety report. The High Accident Location report is done as part of the priority array process. The Annual accident report can be done using PICA. The analysis for the Highway Safety report is performed on a microcomputer using Lotus 1-2-3.

The Accident Listing report and the Proposal Accident Listing report described in the Arthur Andersen document are essentially identical and both are equal to the basic "inquiry." That is, they entail inputting locations of interest and receiving a list of accidents and accident characteristics at those locations or on those highway sections. One general program (similar to the existing program Menu55) could be used to fulfill all of these needs if it were enhanced with a "user friendly" screen system to help the novice user request information. For example, the user should be able to

- select identifying information such as SR, MP, jurisdiction, accident type, and severity level,
- select the variables to be output,
- instruct the program to write the appropriate search procedure, and
- send the results to a print queue from which the user can fetch it for viewing on the terminal and/or release it for paper output.

If this program also had an option for creating an output file instead of a paper report, this single program would be sufficient to meet most of the required accident analyses not served by special programs that already exist. Such a program should offer a number of options to the user. These options should include the following questions.

- Are the results to be a printed report, or should they be a file to be used by an analysis package?
- Should summaries of the data be included (e.g., the total number of accidents within the section, and/or the total severity of those accidents)?
- What variables should be included in the output?
- What variables will control the selection of accidents in the query (SR/MP, accident type, fatalities, etc.)?
- What years of accident data should be included in the response?
- What is the priority of the request (immediate response requested, overnight response is acceptable)?

Safety Data Branch personnel may wish to make other additions to this basic query process. The computer should then take the responses and write the necessary query program. By making this type of query simple, menu driven, and descriptive, such a program would handle the vast majority of accident data requests of the TRIPS system. It would also make the system less intimidating to new users and encourage the use of accident data throughout the Department.

Structure of the Record System

The project team agrees with the AA report that the accident records for state route and non-state route accidents should be maintained separately. In addition, the existing accident record should be broken into three related pieces:

- accident records,
- vehicle records, and
- occupant records.

Of these three record types, only accident records and parts of the vehicle records (citations, DWI, hazardous cargo, and various roadway variables) are routinely used by WSDOT staff. The remainder of the vehicle record information (vehicle and damage descriptions, contributing descriptive information, etc.) and the occupant records are used only occasionally. Most analyses that use these later variables are not within the jurisdiction of the WSDOT. It is difficult to determine if the occupant data and under-used parts of the vehicle record should be stored within the TRIPS data structure. Including them within the data structure would make correlation between the various pieces of information simple, as well as maintain accurate milepost referencing on all records, but it is difficult to determine at this point in time whether it is cost effective to develop the necessary programs to perform this function for data that is infrequently used.

The project team believes that the records stored within TRIPS will be more effectively used as indexed sequential files rather than ADABAS files, as indicated in the AA report. The reasons behind this recommendation are explained below, along with a detailed review of the recommended file structure. (State route accident information is discussed first, followed by non-state route accidents.)

Accident Records -- State Routes

Much of WSDOT's data processing of accident information consists of analyzing long, consecutive stretches of highway for accident information. If the sequential nature of the accident file is maintained, ordered by state route and milepost (SR/MP), only a limited number of searches and disk reads will be necessary to acquire data on the sections of roadway of interest to WSDOT staff. If the file is broken up into a less sequential order to permit easier updating, or faster individual accident referencing, the number of disk searches and reads will increase dramatically, significantly increasing the cost of running the analysis software.

If a pointer were created in the TRIPS files to reference the accident records, records could be quickly pinpointed within milepost ranges specified by queries. As envisioned by the TRAC project team, the pointer would locate the initial accident record that matched the SR/MP search criteria. The accident records could then be read sequentially to determine where that search criterion ended (i.e., where the milepost range was exceeded). Within that sequentially ordered read, records that met the remainder of the search criteria (year, accident type, etc.) would be selected for analysis. This combination of the indexed and sequential file search and processing would maintain the speed of the on-line access, as well as the speed of sequential processing for larger jobs.

The accident record would be sorted initially by state route, then by milepost and finally by date. Thus, all accident records for a section of highway would exist sequentially on disk. This structure would require that accidents from initial years be mileposted using the same milepost reference system. That is, a manual effort would be needed to correlate historical accidents to the present mileposting of roads.

Once the initial correlation process took place, changes to the mileposting system (i.e., re-mileposting of a state highway) could be easily accomplished with this file structure. The index pointer would not need to be altered during periodic updates to the state's mileposting system, although the milepost associated with that pointer and accident record might be altered. Changes to the milepost fields of the sequential accident files could be made by simply altering the field in place on the disk. Changes to mileposts would not affect the sequential ordering of the accident records, as the relative position of physical mileposts does not change.

The one data processing area which would suffer from the indexed sequential file structure is the cost of adding new records to the file. The sequential file will need to be sorted and rewritten each time additional accident data were added. Luckily, new accident information is entered only once per month. Thus, updates would have to be done only periodically and could be scheduled at low cost processing periods. Still, updating the indexed sequential file would be comparably expensive, since the pointers used within the TRIPS files would also need to be adjusted to reflect the new disk position of the sequential file.

Vehicle Records -- State Routes

Vehicle records can either be attached to the accident record itself, as is currently done, or positioned sequentially in a separate file like the accident record. (Multiple vehicle records per accident record would be stored together in order.) The project team recommends the storage of this information as a separate record, although some of the data on the Arthur Andersen vehicle record (roadway information, presence of DWI, etc.) needs to be moved to the accident record.

Under this system, the accident record could store a pointer to the beginning vehicle record for that accident. A pointer to the vehicle record could also be stored within the TRIPS structure. The sequential order of the file would be similar to that of the accident record (i.e., SR/MP with secondary sorting by date or other key). The ability to work directly from the accident file to the vehicle file would be advantageous because vehicle accident information could be easily and inexpensively written to a file for downloading to a microcomputer for further analysis.

The vehicle file would need to be updated in a manner similar to that followed by the accident record. Each month, the file would need to be revised by the merging of new records into the existing file. The file would then need to be updated (rewritten) and pointers within the accident and main TRIPS files modified to indicate the new positions. Updates to the accident, vehicle and occupant files could be done simultaneously, so that each file would have to be rewritten only once. (As with the accident file, a two tier file structure could be implemented, with one file for the latest year's records and the other for historical records.)

Occupant Records -- State Routes

If TRIPS development resources are tight, it is recommended that the occupant records not be stored within TRIPS as a cost saving measure. Occupant records should still be maintained in sequential form for use as required. If resources for TRIPS are available, the project team recommends storing occupant data in a manner similar to the vehicle records, that is, as a separate file. The accident record should store a pointer to the beginning of the occupant record. A pointer to the first occupant record for an accident should also be stored within the TRIPS ADABAS structure. The sequential order of the file would be similar to that of the accident record (i.e., SR/MP with secondary sorting by date or other key). The ability to work directly from the ADABAS file to the occupant file would be advantageous because the occupant accident information could be easily and inexpensively analyzed or written to microcomputer.

If occupant data were stored within TRIPS, the occupant file would need to be updated in a manner similar to that for the accident record. Each month, the file would need to be revised by the merging of new records into the existing file. The file would then need to be updated (rewritten) and pointers within the accident and ADABAS files modified to indicate the new positions. Updates to the accident, vehicle and occupant files could be done simultaneously, so that each file would have to be rewritten only once.

Non-State Route Accidents

Non-state route accidents should be stored in a sequential file. Since these accidents are not tied to the state route system, they have no need to be attached to the TRIPS SR/MP reference system. Furthermore, since WSDOT is not responsible for analyzing these accident locations, there is no compelling need for the accident records to be stored in ADABAS format. PICA can evaluate non-state accidents for any statewide accident summaries needed. Sequential storage will allow the most efficient processing of this information for the summary reports in which they are included.

As with state route accident data, the non-state route accidents will need corollary files for vehicle accident information and occupant information. Since non-state route accidents can not be tied to the SR/MP structure, these files will need another method for linking accident, vehicle and occupant records for a specific accident or location. Either the accident records should simply contain the vehicle and occupant records, or the accident record should contain pointers to the beginning vehicle and occupant records for each accident. The choice of storage for non-state accident records should be similar to the storage for state system accidents. Given the jurisdiction of the WSDOT (only state routes), the amount of effort that should be spent on the non-state route accident information is unclear to the TRAC project team.

It is important to reiterate that the above recommendations must be viewed in light of other system needs. The record formats suggested for maintaining the accident files, described in the paragraphs above, were determined with general knowledge of the operating characteristics of different storage methodologies and an understanding of the types of analyses that the accident analysis section performs. Note that many additional factors contribute to the efficiency of different storage techniques when record search and retrieval are performed. Such factors include

- different operating environments in different computer installations,
- software packages, and
- query languages.

As a result, the recommendations above should be reviewed as part of the overall system's design process, and such a review may result in different conclusions than those in this document.

New Information Links

The project team has four recommendations for increasing the linkage between accident records and other data. Two of these recommendations have been discussed earlier. The project team recommends that accident data be linked to the following other pieces of information:

- WSDOT appurtenance data,
- historical roadway data,

- WSDOT cartographic data, and
- the WSP CARS file.

Of these four recommendations, the first three are the most important. They are also within the direct control of WSDOT. The use of appurtenance and historical roadway data have been discussed above. The remaining two recommendations are discussed below.

Two uses of cartographic data need to be facilitated:

- automated collision diagrams, and
- automated presentation graphics.

Mr. Ron Cihon of the Cartography section is currently investigating the most effective means for producing automated collision diagrams. The automated system will probably function on some kind of microcomputer CAD package. Any automated microcomputer system will require accident and geometric information to be downloaded from other WSDOT computers. This function needs to be incorporated into the TRIPS design. While it is not clear what specific types of information will be required by this system, or even where these data might be stored (e.g., the cartography Intergraph system may contain the geometric data), some allowance must be made to accommodate these functions in the initial design of TRIPS.

The second use of cartographic data is in the presentation of accident information. The WSDOT cartographic section already maintains a complete high-level mapping system for the state highway system. While this system is not currently complex enough for analytical work within the Safety Data Branch, the ability to produce presentation style maps of accident data would be a significant improvement to the existing reporting process. Such reports are useful within the legislative information function performed by the DOT. This presentation function should be accounted for within TRIPS .

To accomplish this function, TRIPS should include a simple process for transferring the appropriate accident and location information (to be chosen by the user) to a file that can be read by the Intergraph computer. This file creation and transfer should be a specific routine within the TRIPS reporting process.

The final recommended addition to links to the accident data is the inclusion of the WSP CARS database into the accident analysis process. The CARS file is an activity report of WSP officer duties. Using this data, Safety Data Branch personnel could examine the impacts of WSP enforcement on the number and severity of certain types of accidents (i.e., Does increased WSP presence affect the number of alcohol related accidents? Does it reduce the number of accidents where excessive vehicle speed is a contributing factor?).

In order to use the CARS information, the WSDOT would need to obtain the data from the WSP and perform a number of data reduction tasks. This would entail an agreement between the WSDOT and WSP on sharing data resources. Such programs could be written as part of TRIPS or written by WSDOT personnel after the completion of Phase 1 of TRIPS.

As with the addition of roadside features to a file correlated with existing accident information, the use of WSP CARS information will require additional analysis. At this time neither the required size of this file nor its correlation to the WSDOT SR/MP reference system are clear. A number of jurisdictional, political and economic issues will also have to be addressed before this type of data would be available through the WSP. Consequently, this recommendation is not considered as important as the three other recommended information links.

IMPLEMENTATION

The above recommendations can be split into three primary categories:

- short-term actions,
- important liaison activities, and
- long-term activities and reviews.

For the most part, the minor changes recommended for the existing analysis process can be started immediately. Work with the TRIPS design and the state patrol databases, and major changes to the data stored and used will require liaisons to be established presently to ensure successful long-term implementation. Finally, some recommendations do not need to be acted on immediately and can be left for implementation at a later time. The specific actions that WSDOT should take are described below.

Short-Term Implementation

The Safety Data Branch should develop simplified costs for common "safety improvements." This effort should entail

- determining the standard types of "safety projects,"
- collecting capital, operating and maintenance costs for these types of improvements from other WSDOT divisions,
- analyzing that cost data, and
- developing single cost/unit or average cost estimates that can be used in the existing evaluation process.

A simple manual (or spreadsheet) should then be developed to assist SDB staff in including these cost estimates in future safety evaluations when real data are not available.

The SDB should also revise its existing safety evaluation spreadsheets or consider acquiring an evaluations package so that it can include additional years of accident rate information in the predictive section of the evaluation spreadsheet.

Both of these improvements should result in better benefit/cost analyses being included in the FHWA Safety Project Evaluation Reports. While these changes may not directly impact which improvements are applied to hazardous locations, they should both result in more representative evaluations of the impacts of the WSDOT safety improvements. Given the statistical limitations of the before and after study, these modest improvements should result in WSDOT providing the best analyses possible for the FHWA Evaluations, short of restructuring the entire safety improvement process.

Liaison Work

The recommended actions of the report will require a significant amount of liaison work between the Safety Data Branch and a variety of other groups both within and outside of the WSDOT. This work will be required to refine the design of the systems currently planned so that the accident analysis function will improve in the manner expected. These liaison activities will include the following:

- working with WSDOT MIS on the TRIPS design,
- working with WSP on revisions to the accident report form and other WSP activities,
- working with the WSDOT cartography section on the display of accident location data and automated collision diagrams, and
- working with WSDOT maintenance sections and Districts to gain access to appurtenance data.

Without continuous liaison activity, the likelihood that the recommendations in these areas will be realized is remote.

Work with WSDOT MIS will be particularly important because some significant changes and additions to the work done by AA are recommended in this report. Liaison with MIS will be necessary to determine which of the requested changes are feasible, how those changes will interact with each other, and how the necessary programming efforts can be prioritized.

Unlike the TRIPS effort, in which MIS will not proceed without SDB liaison, WSP will most likely revise the accident report form with or without further input from WSDOT. While the recommended changes to the accident form have already been submitted to WSP, without continued action by WSDOT WSP may underestimate the value of these requested changes and additions. Wholehearted WSDOT liaison efforts will ensure the proper consideration of Departmental recommendations and may also allow WSDOT to comment on WSP's review of other changes suggested by various researchers and agencies.

Active liaison with WSP may also help improve the speed of data transmittal from WSP to WSDOT. Without effort on the part of WSDOT, this improvement will not come about.

Work with the cartography section should be pursued to improve the presentation of accident data. While such improvements may not result in improvements to the quality of the accident analysis, they will help improve the perceived quality of those analyses and strengthen the impact of presentations of those results.

Finally in the area of cartography, a specific effort should be made to understand the needs and workings of the automated collision diagram process Ron Cihon is currently developing while he is on fellowship at the University of Washington. The automated collision diagram process should provide substantial improvements and savings to the SDB, but it will need to interface with TRIPS and potentially other WSDOT databases.

Access to appurtenance data can be considered part of the TRIPS development process, but it will also entail a significant degree of liaison work between the SDB and those persons who acquire and maintain the appurtenance data. These persons do have something to gain from these potential analyses, and an effort must be made to inform them of the possibilities in this area.

Long-Term Projects

The above liaison work is necessary in the immediate future because of its impact on the functioning of the TRIPS accident process and the importance of the analyses which it impacts. The work to be done in this section is of lesser important to the WSDOT or will require a longer time frame to complete.

The most important of the long-term implementation efforts is the need for upper WSDOT management to review the Department's accident analysis goals. The project team believes that descriptive analyses are sufficient to meet WSDOT's needs. If the management's opinion is otherwise, steps need to be taken to restructure the Department's entire accident analysis and safety improvement processes. (The main body of this chapter describes the required changes.)

A second long-term implementation project is the gradual improvement of the location information used in identifying accident sites. Because simple remedies are not currently available for solving location problems, the SDB should remain observant of the developments in the area of automatic vehicle identification (AVI) and automatic vehicle location (AVL), but not immediately proceed towards pressing for application of these new technologies. (For example, the Seattle police department is currently investigating the implementation of computers in its patrol cars. Several police jurisdictions already have satellite based vehicle locators on their vehicles.) Should WSP decide to utilize such technologies for better fleet management and/or faster trooper assistance, the SDB could then support those systems to improve the accuracy of location information.

The final long-term implementation effort is to provide the WSDOT with access to WSP information stored on the CARS file. While the CARS file could be accessed now, its inclusion in SDB's analysis activities should have a much lower priority than the previously mentioned efforts. Further investigation of the use of these data should thus be postponed until after the currently planned TRIPS effort has neared completion.

APPENDIX A
ACCIDENT ANALYSIS LITERATURE

APPENDIX A
ACCIDENT ANALYSIS LITERATURE

Brogan, James D., and Jerome W. Hall. Using Accident Records to Prioritize Roadside Obstacle Improvements in New Mexico. Transportation Research Record 1047. Traffic Accident Data, Drive Performance, and Motor Vehicle Update. Washington, D.C.: Transportation Research Board. 1985.

Brown, David B. RAPID: Records Analysis for Problem Identification and Definition System Overview. Auburn Alabama: Alabama Office of Highway and Traffic Safety. Report No. 300-77-002-401-052. August 1977.

Council, F.M., et al. Accident Research Manual. Chapel Hill, North Carolina: Highway Safety Research Center. FHWA Report No. FHWA/RD-80/016. 1980.

Engle, Robert M.; Brian T. Limotti, and H.K. Gupta. Development of Washington State's Problem Identification and Cause Analysis: PICA System. Unpublished paper presented at the International Seminar on Road Safety, Srinagar, Kashmir, India. September 1986.

Hauer, Ezra, and Bhagwant N. Persaud. "Problem of Identifying Hazardous Locations Using Accident Data. Transportation Research Record 975. Analysis and Management of Traffic Accident Records. 1984.

Mercer, Donald J. MIDAS (Michigan Dimensional Accident Surveillance System). Michigan Department of Transportation, Traffic and Safety Division. 1985.

Transportation Research Board. Introduction to Comprehensive Computerized Safety Record keeping Systems. Transportation Research Circular 293. Washington, D.C. July 1985.

Wandsnider, LuAnn; Laurence M. Spear, Steven Flint, and Robert U. Anderson. "Transportation Applications of Computer Mapping in New Mexico," Transportation Research Record 1050. Data Collection Methods and Information Systems for State and Local Government. 1985.

Zegeer, Charles V. Highway Accident Analysis Systems. National Cooperative Highway Research Program Synthesis of Highway Practice 91. Washington, D.C.: Transportation Research Board. July 1982.

APPENDIX B
WSDOT EFFECTIVENESS EVALUATION WORKSHEETS

Exhibit B-1
Exposure Worksheet

EXPOSURE WORKSHEET

EVALUATION NO.: 1987:E-6
DATE/EVALUATOR: 9/9/87/ST
DATA SOURCE: STATE TRAFFIC FILES

LOCATION: SR 516 - 152ND AVENUE NE

TIME PERIOD: BEFORE 05/01/82 TO 04/30/84
AFTER 11/01/84 TO 10/31/86

SITE	PROJECT LENGTH*	TIME PERIOD	AADT	EXPOSURE VEHICLES	EXPOSURE VEHICLE MILES
YR: 1982	0.33	245	13600	3332000	3332000
YR: 1983	0.33	365	14700	5365500	5365500
YR: 1984	0.33	120	15150	1818000	1818000
TOTAL BEFORE	0.33 0	730	14400	10512000	10512000
YR: 1984	0.33	61	15150	924150	924150
YR: 1985	0.33	365	15800	5767000	5767000
YR: 1986	0.33	304	17250	5244000	5244000
TOTAL AFTER	0.33 0	730	16350	11935500	11935500

* IF THE PROJECT LENGTH IS LESS THAN ONE, EXPOSURE IN NUMBER OF VEHICLES WILL EQUAL EXPOSURE IN VEHICLE MILES.

Exhibit B-2
MOE Data Comparison Worksheet

MOE DATA COMPARISON WORKSHEET

EVALUATION NO: 1987:E-6 SR 516
DATE/EVALUATOR: 9/9/87/ST
EXPERIMENTAL PLAN: BEFORE AND AFTER STUDY OF PROJECT SITE; MOE RATES

MOE DATA SUMMARY	PROJECT BEFORE B PF	PROJECT AFTER A PF
ACCIDENTS:		
TOTAL ACCIDENTS	35	22
FATAL ACCIDENTS	0	0
INJURY ACCIDENTS	21	8
PDO ACCIDENTS	14	14
REARENDS	20	12
ENTERING AT ANGLE	9	7

AADT BEF: 14400
AADT AFT: 16350
TIME: 730
LENGTH: 0.33
EXPOSURE: (MVM) 10.51 11.94

MOE COMPARISON RATE	B PR	A PR	EXPECTED RATE E R	PERCENT REDUCTION %
ACCIDENTS:				
TOTAL/MVM	3.33	1.84	3.33	44.74
FATAL/MVM	0	0	0	0
INJURY/MVM	2	0.67	2	66.5
PDO/MVM	1.33	1.17	1.33	12.03
REARENDS/MVM	1.9	1.01	1.9	46.84
ENTERING AT ANGLE/MVM	0.86	0.59	0.86	31.4

Exhibit B-3
Statistical Test Worksheet

STATISTICAL TEST WORKSHEET

EVALUATION NO: 1987:E-6SR 516
DATE/EVALUATOR: 9/9/87/ST
CONFIDENCE LEVEL: 90%
STATISTICAL TEST TECHNIQUE: POISSON
AFTER PROJECT EXPOSURE: 11.94 MILLION VEHICLE MILES

EVALUATION OBJECTIVE	TOTAL ACC'S	FATAL ACC'S	INJURY ACC'S	PDO ACC'S	OTHER REARENDS	OTHER AT ANGLE
EXPECTED AFTER RATE (E_R)	3.33	0	2	1.33	1.9	0.86
AFTER FREQUENCY 2 YEARS						
OBSERVED: (A_{PF})	22	0	8	14	12	7
EXPECTED: (E_F)	39.76	0	23.88	15.88	22.69	10.27
PERCENT REDUCTION						
OBSERVED:	44.74	0	66.5	12.03	46.84	31.4
REQUIRED:	20	0	26	32	26	40
SIGNIFICANT FOR 2 YEARS (YES OR NO)*	24.74 YES	* ERR	40.5 YES	-19.97 NO	20.84 YES	-8.6 NO

* TOO SMALL TO TEST

IT CAN BE CONCLUDED, WITH 90% CONFIDENCE, THAT THE NUMBER OF TOTAL ACCIDENTS, INJURY ACCIDENTS AND REAREND ACCIDENTS WERE SIGNIFICANTLY REDUCED. IN ADDITITION, IT CAN BE CONCLUDED THAT THE NUMBER OF PROPERTY DAMAGE ACCIDENTS AND ENTERING AT ANGLE ACCIDENTS WERE NOT SIGNIFICANTLY REDUCED.

Exhibit B-4
Poisson Curves

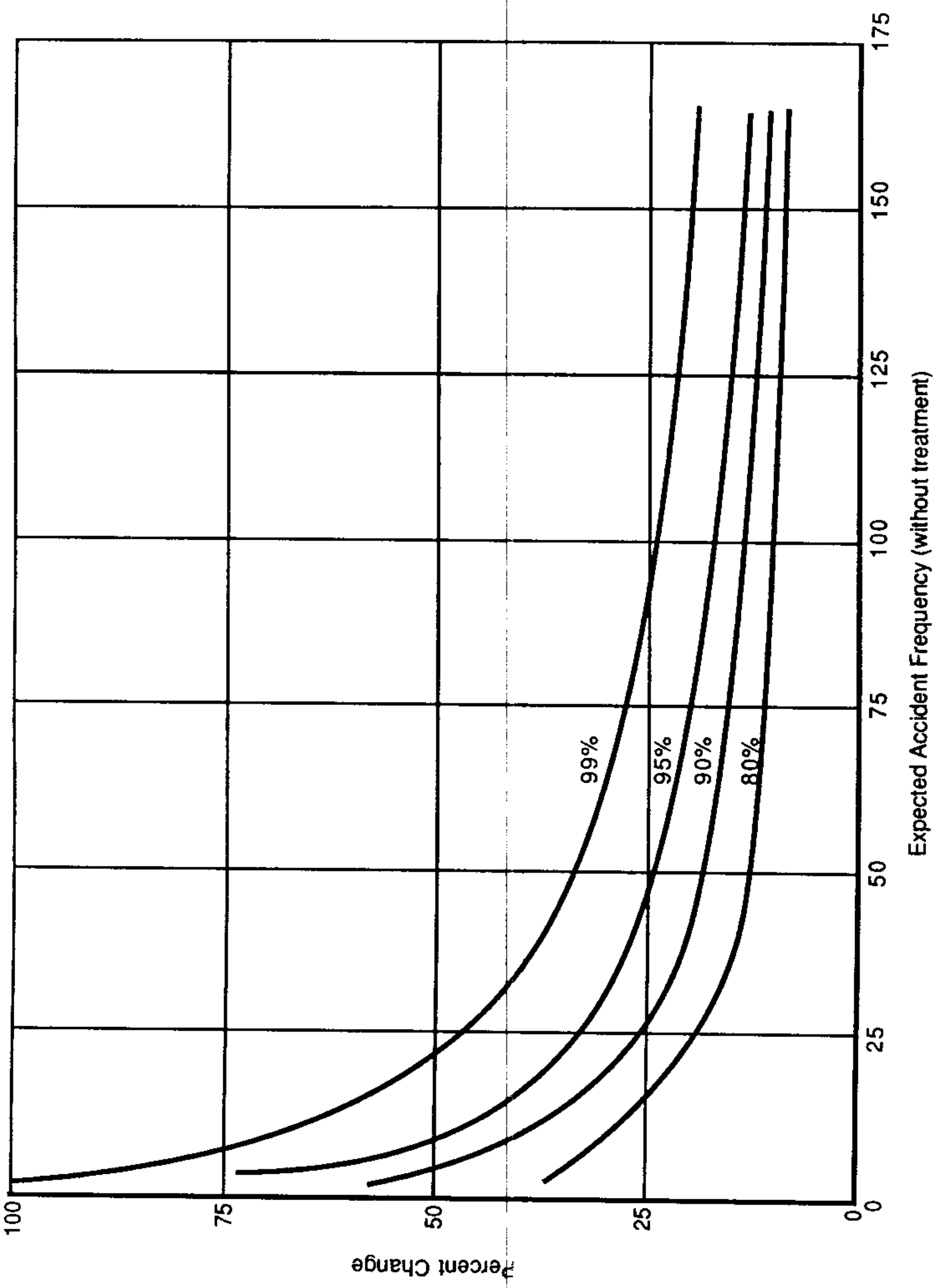


Exhibit B-5
B/C Analysis Worksheet

B/C ANALYSIS WORKSHEET

EVALUATION NO: 1987:E-6
PROJECT NO: 2613
DATE/EVALUATOR: 9/9/87/ST

INITIAL IMPLEMENTATION COST, I:	$	283736
ANNUAL OPERATING AND MAINTENANCE COSTS BEFORE PROJECT IMPLEMENTATION:	$	0 *
ANNUAL OPERATING AND MAINTENANCE COSTS AFTER PROJECT IMPLEMENTATION:	$	0 **
NET ANNUAL OPERATING AND MAINTENANCE COSTS, K:	$	0

* ANNUAL BEFORE COSTS UNAVAILABLE
** ANNUAL AFTER COSTS UNAVAILABLE

ANNUAL SAFETY BENEFITS IN NUMBER OF ACCIDENTS PREVENTED:

SEVERITY	BEFORE	- AFTER	=ANNUAL BENEFIT
FATAL ACCIDENTS (FATALITIES)	0	0	0
INJURY ACCIDENTS (INJURIES)	21	8	13
PDO ACCIDENTS (INVOLVEMENT)	14	14	0

ACCIDENT COST VALUES
SOURCE: NATIONAL SAFETY COUNCIL

SEVERITY	COST
FATAL ACCIDENT (FATALITY)	$ 240000
INJURY ACCIDENT (INJURY)	$ 9200
PDO ACCIDENT (INVOLVEMENT)	$ 1200

ANNUAL SAFETY BENEFITS IN DOLLARS SAVED, $\overline{B}$:

FATAL ACCIDENT BENEFIT	$	0
INJURY ACCIDENT BENEFIT	$	119600
PDO ACCIDENT BENEFIT	$	0

$\overline{B}$ = TOTAL = $ 119600

B/C ANALYSIS WORKSHEET PAGE 2

SERVICES LIFE, n: 10 YEARS

SALVAGE VALUE, T: 0 DOLLARS

INTEREST RATE, i: 10 % = 0.1

INITIAL IMPLEMENTATION: $ 283736

ANNUAL OPERATING COSTS: $ 0

EUAC CALCULATION:

CR_n^i = 0.1627 SF_n^i = 0.0627

$EUAC = I\,(CR_n^i) + K - T\,(SF_n^i)$ = $46163.85

EUAB CALCULATION:

$EUAB = \overline{B} =$ $ 119600

B/C CALCULATION:

B/C = EUAB/EUAC = 2.59

IT IS IMPORTANT TO NOTE THAT MAINTENANCE AND OPERATING COSTS ARE NOT BEING INCORPORATED INTO THIS ANALYSIS. FOR THIS REASON, THE REAL BENEFIT/COST RATIO IS ACTUALLY LESS THAN THE VALUE COMPUTED ABOVE.

Exhibit B-6
Effectiveness Evaluation

EFFECTIVENESS EVALUATION

INTRODUCTION

EVALUATION NO: 1987:E-6

PROJECT NO: 2613

DATE/EVALUATOR: 9/9/87/ST

PROJECT LOCATION(S): SR 516 - 152ND AVENUE NE

COUNTER MEASURE(S): SIGNAL AND CHANNELIZATION

F.A. FUNDING: HES

INITIAL IMPLEMENTATION COST: $283,736

ANNUAL OPERATING COST: $ 0 (UNAVAILABLE)

EVALUATION SUMMARY

(LIST MAJOR FINDINGS AND CONCLUSIONS OF THE EVALUATION STUDY)

1. THE ACCIDENT DATA USED IN THIS EVALUATION WERE THOSE FOR TWO YEARS BEFORE (05/01/82 TO 04/30/84) AND TWO YEARS AFTER (11/01/84 TO 10/31/86) THE PROJECT COMPLETION DATE.

2. ACCIDENT SUMMARY:

STATE ROUTE	NUMBER OF BEFORE ACCIDENTS			NUMBER OF AFTER ACCIDENTS		
	FATAL	INJURY	PDO	FATAL	INJURY	PDO
SR 516	0	21	14	0	8	14
TOTAL	0	21	14	0	8	14

PERCENT REDUCTION AFTER PROJECT COMPLETION

FATAL	INJURY	PDO
0 *	61.905 *	0 *

* TOO SMALL TO TEST

AADT BEFORE:14,400 AADT AFTER:16,350

3. THE BENEFIT COST RATIO OF THIS PROJECT WAS FOUND TO BE 2.59 THIS INDICATES THAT THE BENEFITS OF THIS PROJECT OUTWEIGH THE COSTS AND THE APPLIED COUNTERMEASURES WERE SUCCESSFUL. IT IS IMPORTANT TO NOTE THAT MAINTENANCE AND OPERATING COSTS WERE UNAVAILABLE. THE TRUE BENEFIT/COST RATIO IS LESS THAN THE COMPUTED VALUE.

APPENDIX C
ARTHUR ANDERSEN'S DATA FLOW DIAGRAMS

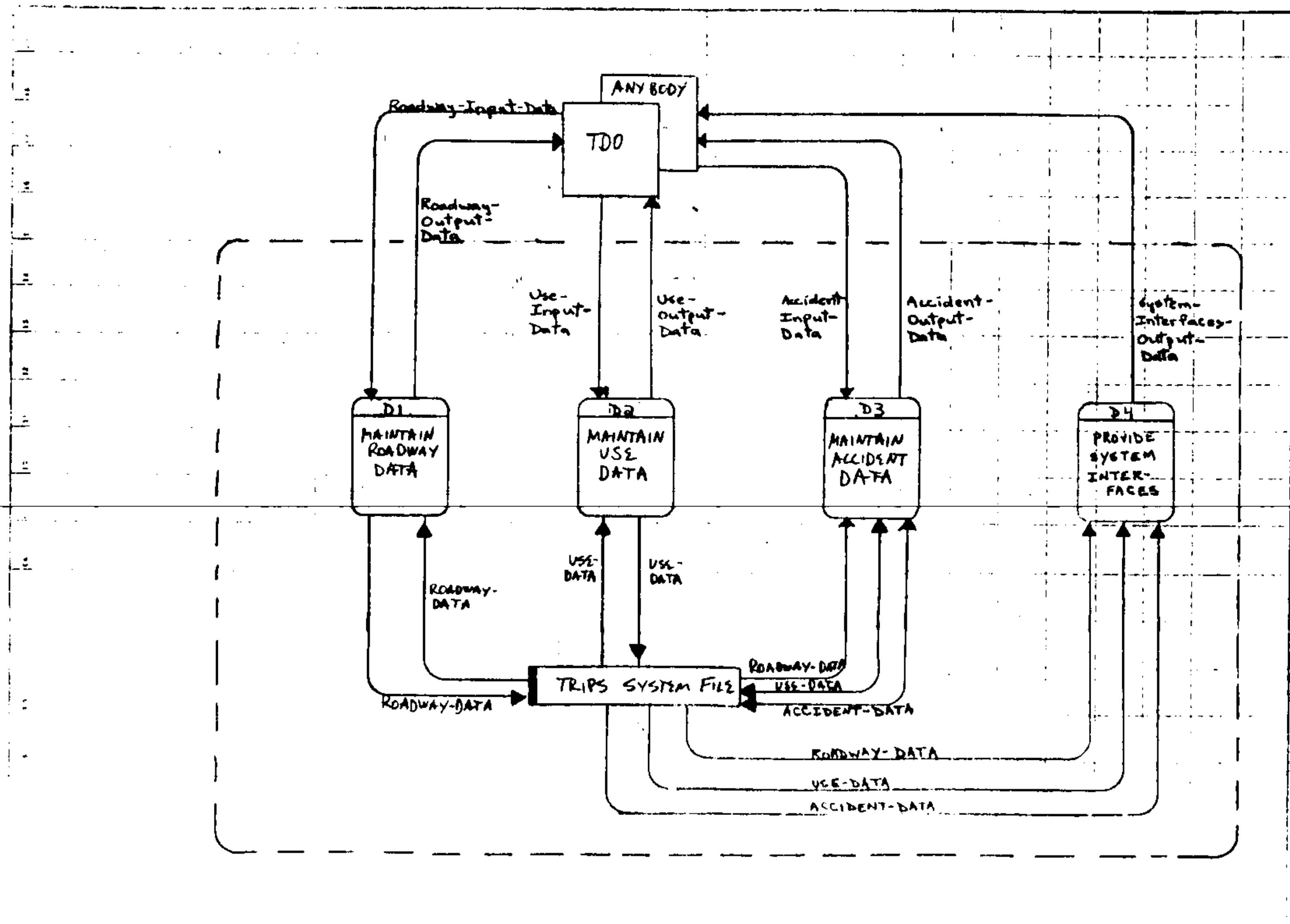


Exhibit C-1
TRIPS Overall

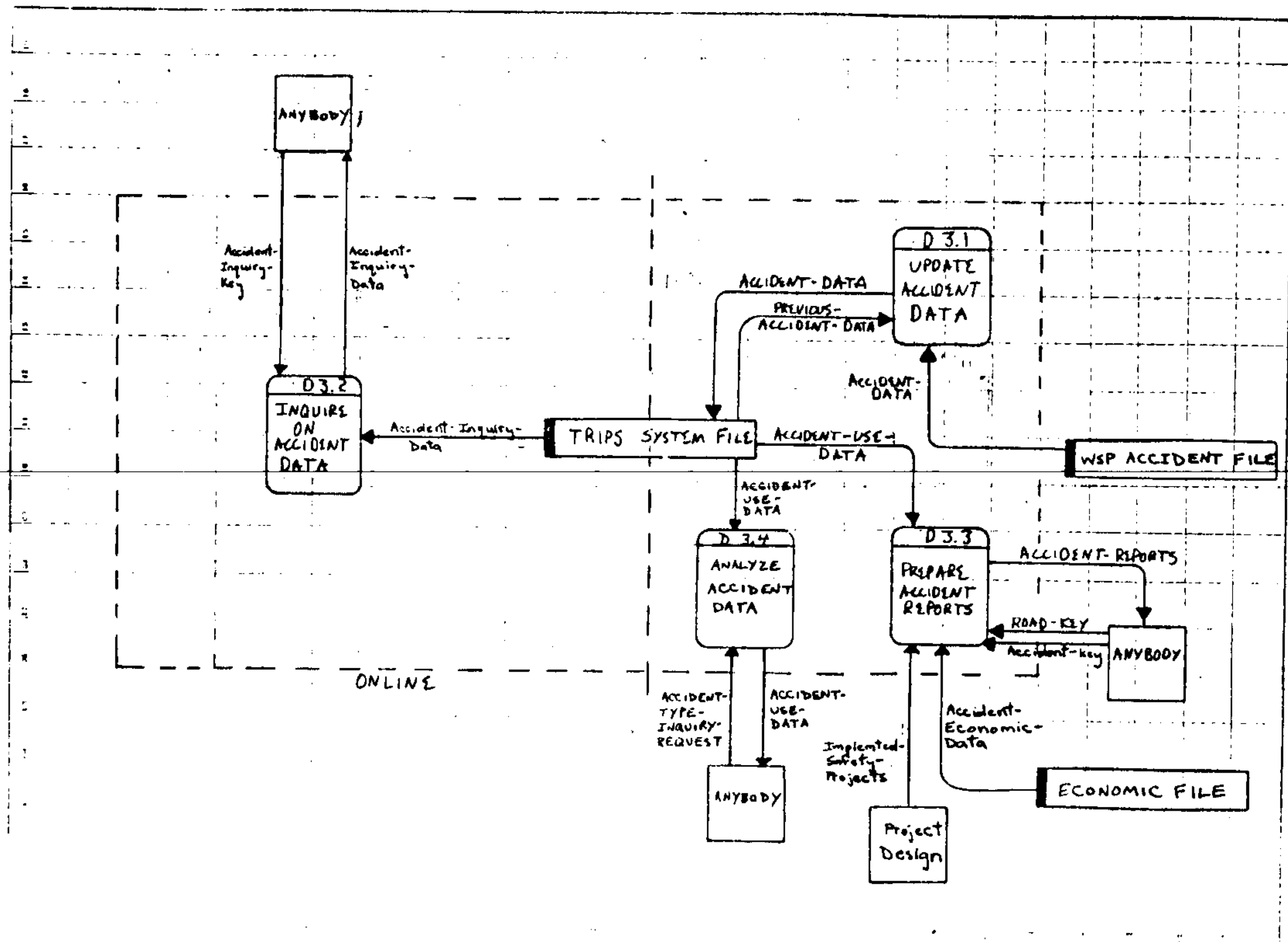


Exhibit C-2
D3 Maintain Accident Data

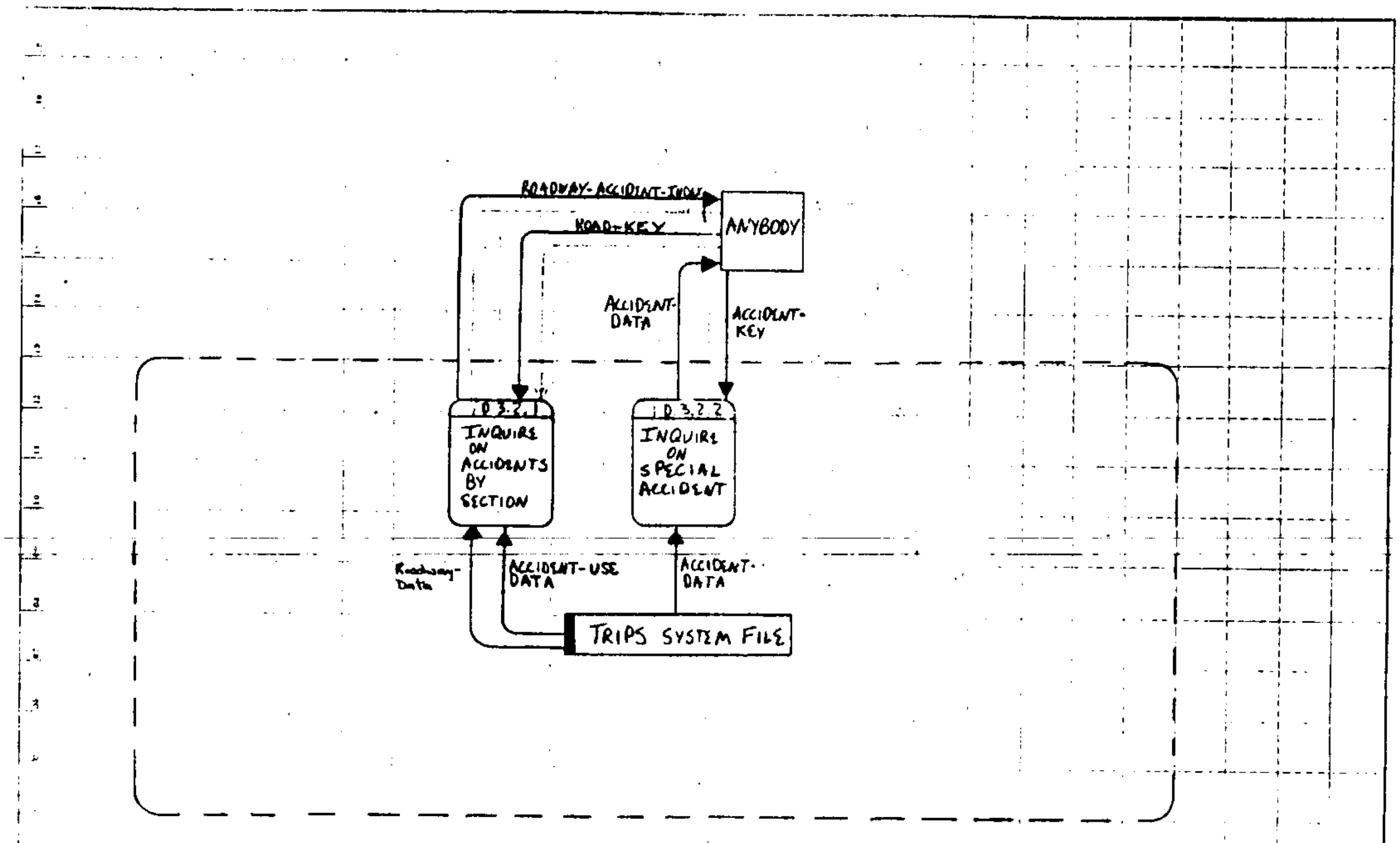


Exhibit C-3
D3.2 Inquire on Accident Data

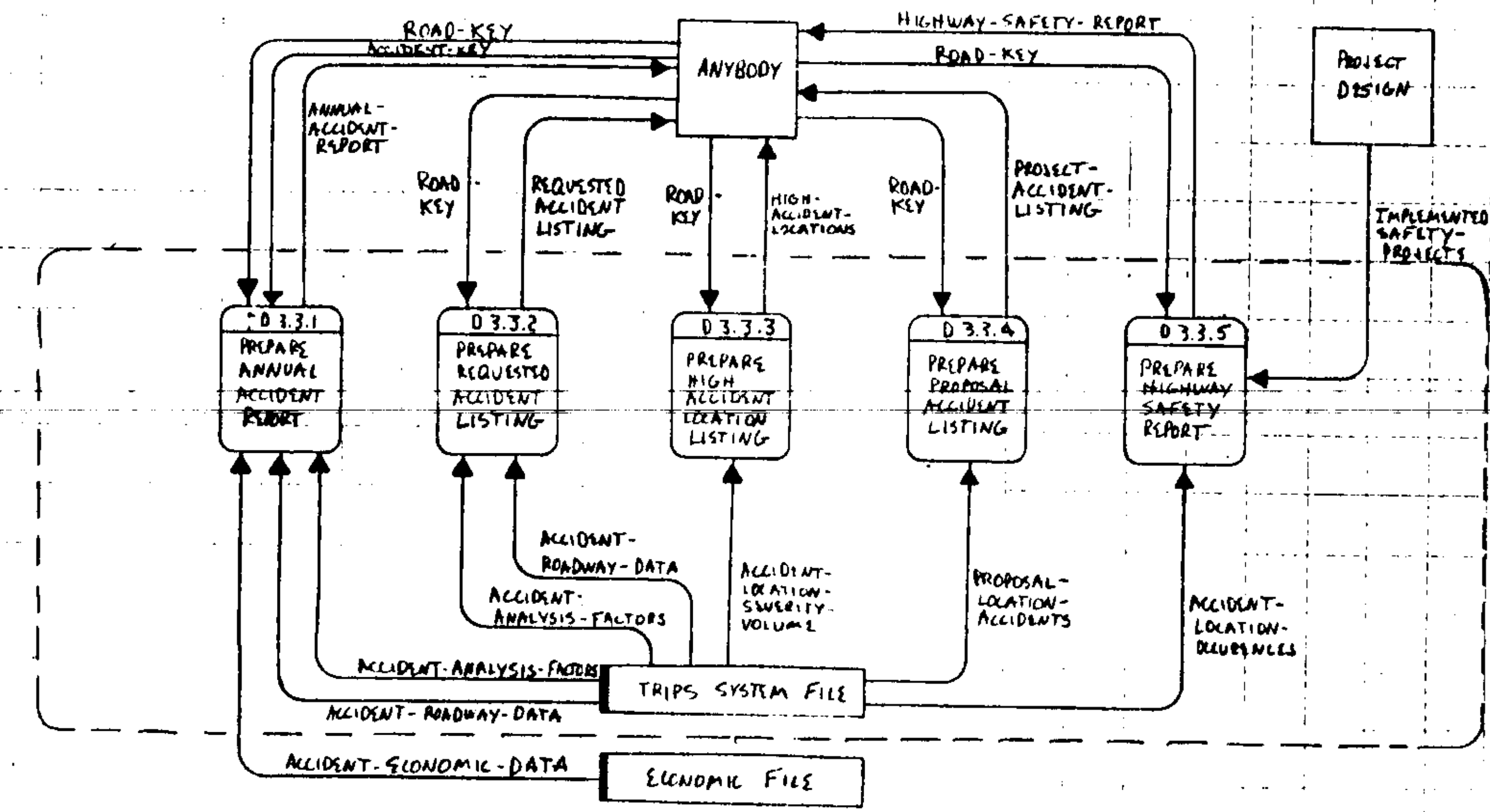


Exhibit C-4
D3.3 Prepare Accident Reports

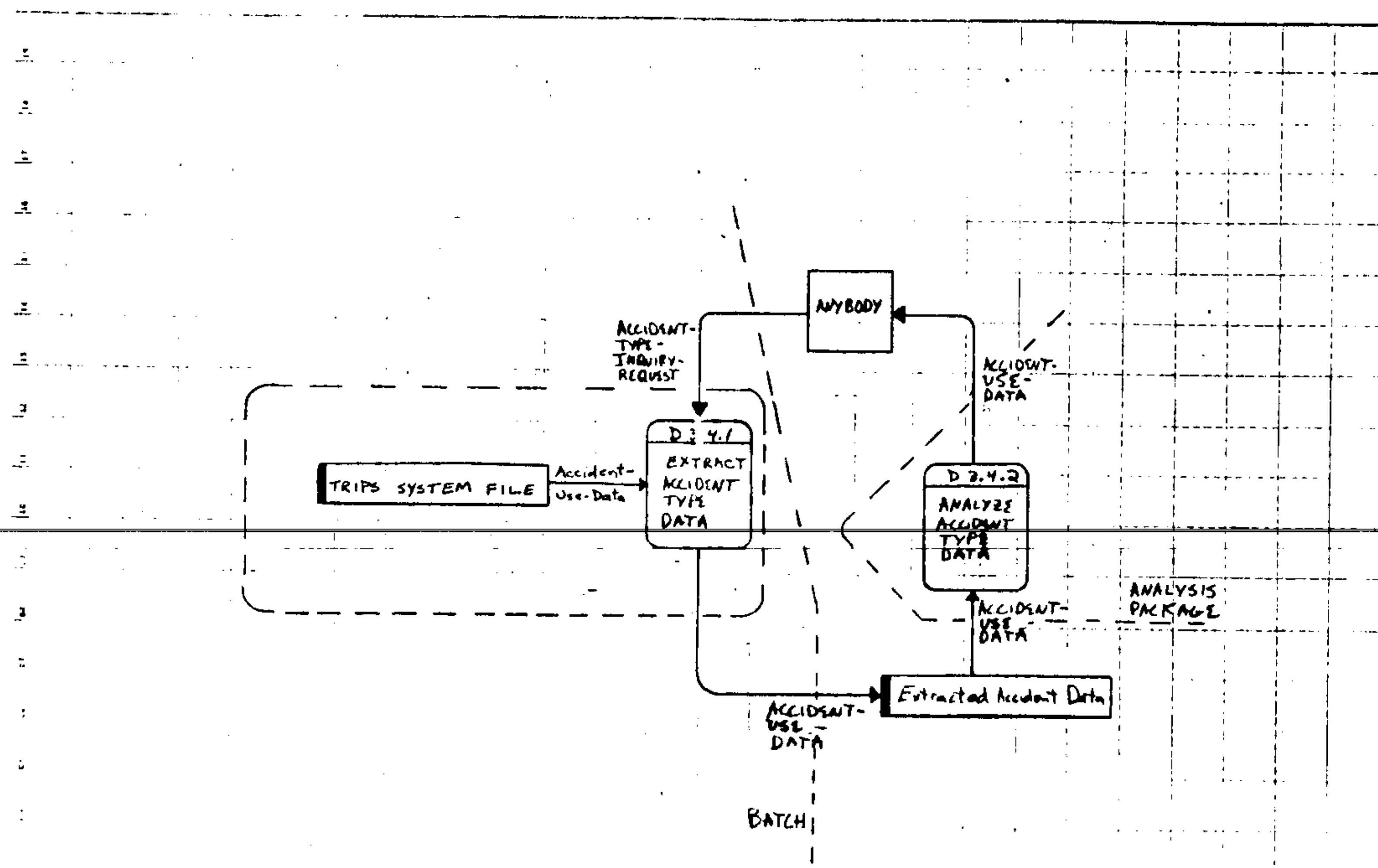


Exhibit C-6
D3.4 Analyze Accident Data

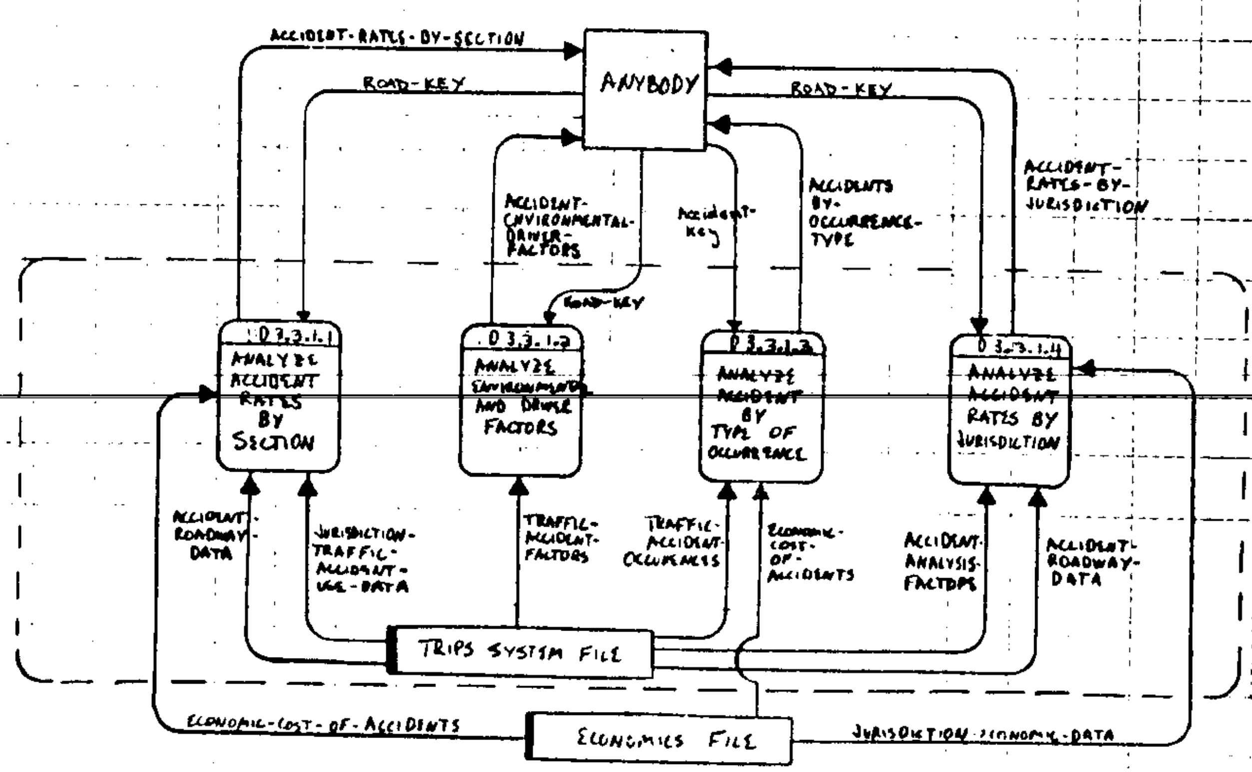


Exhibit C-5
D3.3.1 Prepare Annual Accident Report

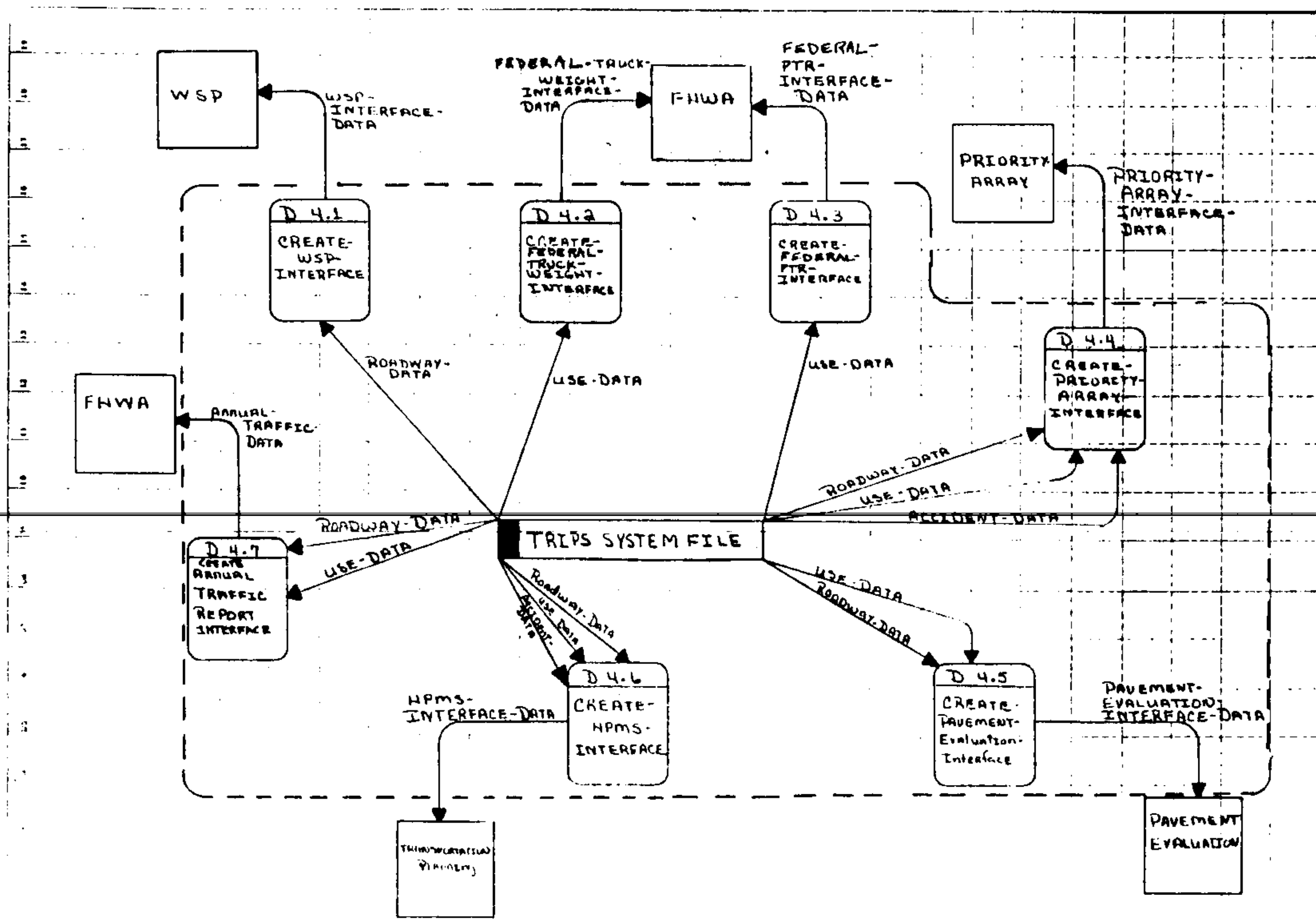


Exhibit C-7
D4 Phase I-II-III

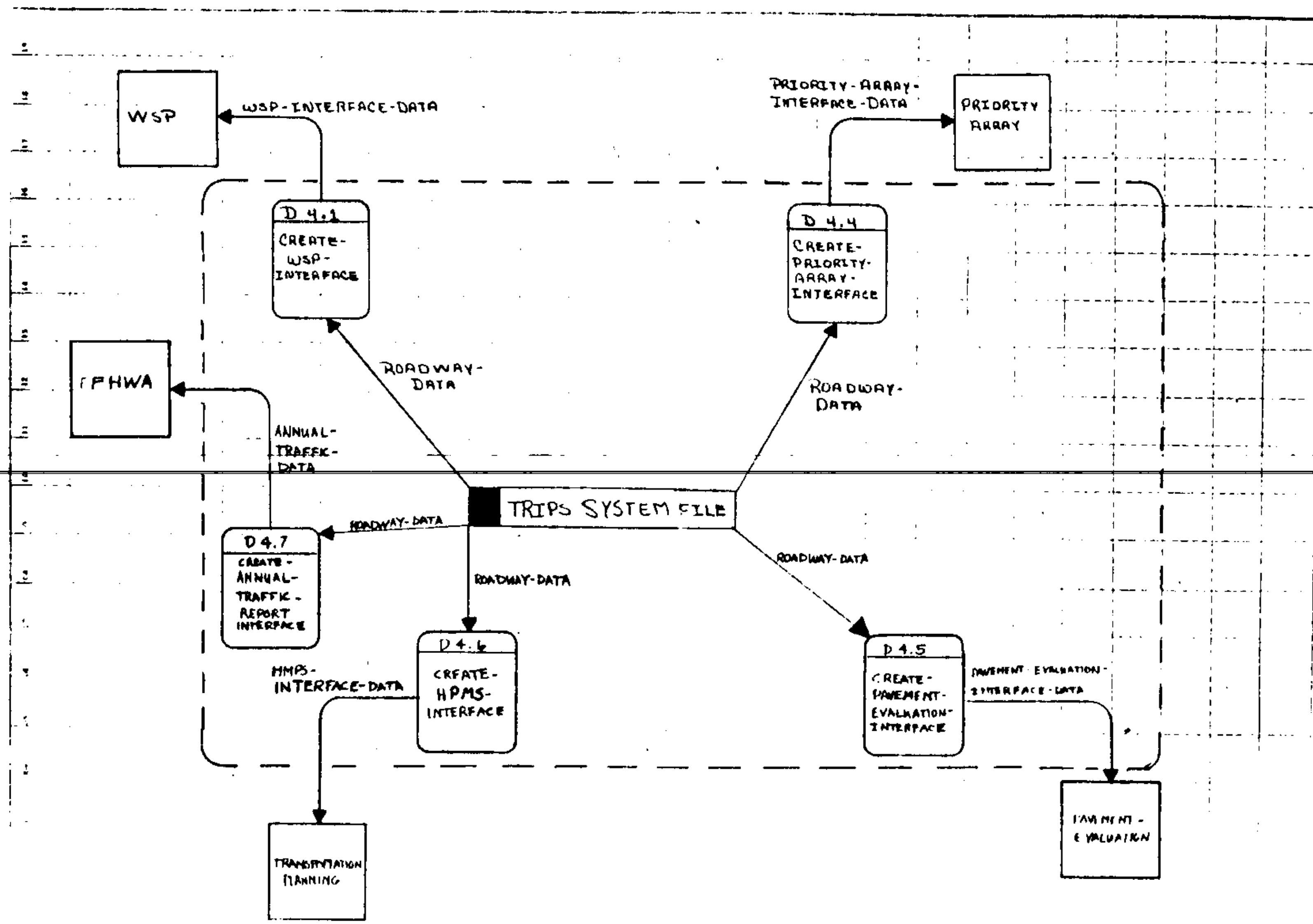


Exhibit C-8
Phase I -- Roadway

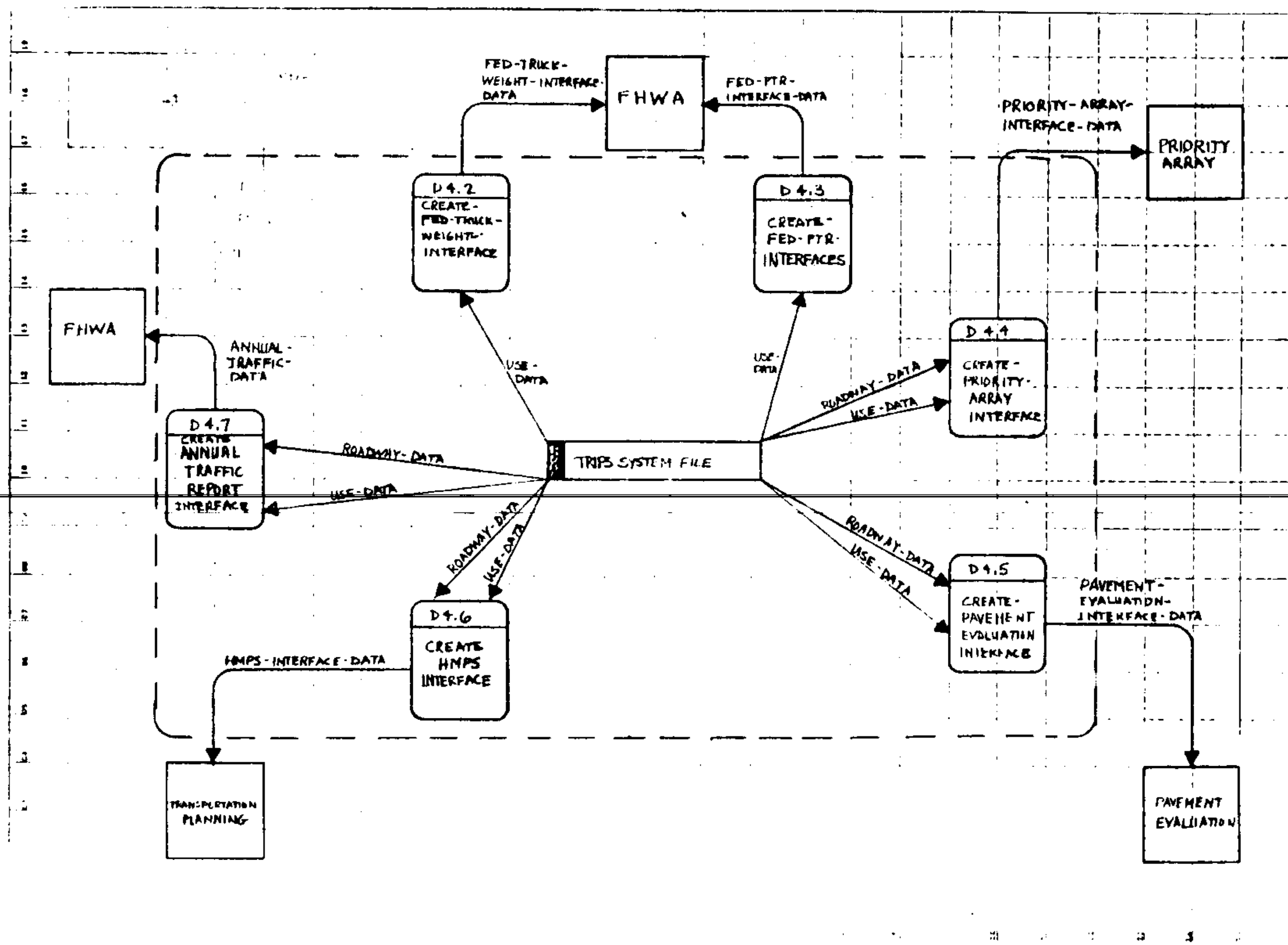


Exhibit C-9
Phase II -- TRIPS

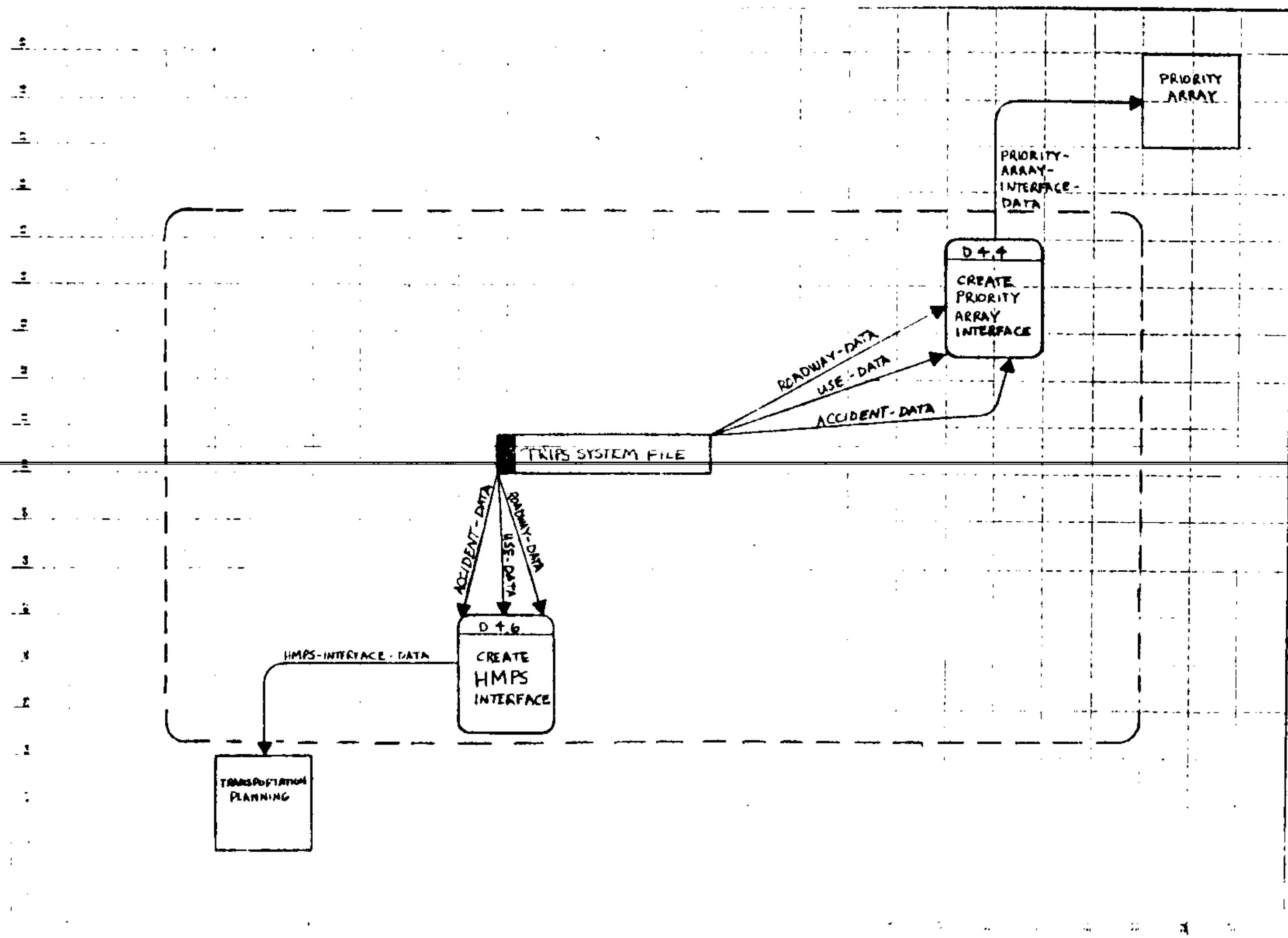


Exhibit C-10
Phase III -- Accident