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Data Available on the Impact of Drug Use on Transportation Safety

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Transportation Systems Center
Cambridge, MA

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May 1988
Final Report

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16. Abstract

This report was prepared by the Transportation Systems Center in support of the the Office of Transportation Regulatory Affairs. It assesses the available data on drug use in transportation, the relevant experimental research on the impacts of drugs, and the state of the art in drug analysis and toxicological quality control.

This report describes and evaluates: Information obtained from industry sources; State and local data; Data available in federal data bases; Laboratory and field studies of the effects of selected drugs on performance considered critical to transportation safety; and Drug testing technology and laboratory quality control.

Information Obtained from Industry Sources The majority of the information available from the transportation industry were obtained from staff members of employee assistance programs and individuals responsible for operational safety. These individuals see more drug-related problems than other transportation industry employees. Published reviews and studies on drug use and safety covering non-professional operators on the highways, in the air, and on the waterways were reviewed, and contacts were made with state and local boating safety officials.

Data Available in Federal Data Bases The Department of Transportation operates, sponsors, or maintains a number of accident and incident data collection systems that were sources of information on the involvement of drugs in accidents.

The Effects of Selected Drugs on Performance Considered Critical To Transportation Safety The drugs considered in this report were selected according to their potential for negatively modifying or degrading the behavior of vehicle operators and other transportation personnel engaged in safety-critical activities. Drugs also were selected based on their estimated degree of use in the general population and at the request of modal participants in the study.

Toxicological Testing The types of drug testing – screening and confirmation testing and the conditions under which testing must be carried out (pre-employment, on-the-job, and post-accident) are discussed in the body of the report.

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LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectares (he) = 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)

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[(x - 32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 hectare (he) = 10,000 square meters (m^2) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

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INCHES	0		1		2		3		4		5		6		7		8		9		10					
CENTIMETERS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

25.40

QUICK FAHRENHEIT-CELCIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and/or other conversion factors, see NBS Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10 286.

PREFACE

The U.S. Department of Transportation, as part of its efforts to evaluate the impact of the use of drugs on transportation safety has convened an inter-modal working group under the leadership of the Office of Regulatory Affairs. This report was prepared by the Transportation Systems Center in support of the working group. It assesses the available data on drug use in transportation, the relevant experimental research on the impacts of drugs, and the state of the art in drug analysis and toxicological quality control.

Most of the TSC literature search and discussions with industry personnel took place during the first half of 1986. The findings of the TSC investigators were reported regularly to the working Group and thus made available to the Department in consideration of the drug safety program. This report was compiled from these findings. Because the Administration and the Department has moved aggressively to combat the drug menace in the latter half of 1986 and in 1987, new developments have overtaken some of the original information. To the extent possible, material based on these new developments has been included where relevant.

The authors wish to acknowledge the contributions made by: the representatives of the transportation industry contacted, Michael Walsh and his staff from the National Institute of Drug Abuse, the staff at the College of American Pathology, and the many individual researchers contacted during this project.

We would also like to acknowledge the support of the program sponsor staff --John Harmon, Susan Gorsky and Lucia Lawrence; the many contributions made by the modal representatives to the working group -- Theodore Anderson, Ronald Boneau, Richard Compton, Andrew Horn, Dennis McEachen, John Murphy, Bruce Novak, and Stanley Gaffen; and the incisive and patient leadership provided by Robert Nutter.

Finally the authors wish to express their appreciation to Carol Gurvitz for editorial support and to Robin Barnes for her preparation of the manuscripts.

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EXECUTIVE SUMMARY

This report deals with the relationship between drug use and transportation safety. In August of 1984, the National Transportation Safety Board expressed concern over the incidence of drug use by persons involved in several transportation accidents investigated by the Board, as well as indications that drug impairment might have been a significant causal factor in other transportation accidents. The Board recommended to the Secretary of Transportation that the Department:

> Review the existing research and literature in this area and institute research to: (1) determine the potential effects of both licit and illicit drugs, especially marijuana, in both therapeutic and abnormal levels, on human performance; (2) obtain correlations between toxicological findings of drug levels in blood, urine and other specimens and various behavioral measurements; and (3) assess the effects of various drugs on the specific tasks performed by the operator in all transportation modes. (Class III, Longer-Term action) (A84-96)

In response to this recommendation, the Secretary of Transportation established an intermodal Working Group on Drug Use and Operator Performance under the leadership of the Assistant Secretary for Policy and International Affairs, Office of Transportation Regulatory Affairs, to determine what actions the Department should take. As a first step, the Working Group commissioned this study by the Transportation Systems Center to determine and summarize the state of technical information on the impact of drug use on transportation safety. This report concentrates on the problems posed by drug use in the transportation industry and, to a lesser extent, on recreational boating and general aviation. Little emphasis was given to collecting information on drug problems in non-commercial highway operations because this would duplicate extensive National Highway Traffic Safety Administration (NHTSA) efforts. However, the results of NHTSA data evaluation efforts are summarized in this report.

This report describes and evaluates:

- Information obtained from industry sources;
- State and local data;
- Data available in federal data bases;
- Laboratory and field studies of the effects of selected drugs on performance considered critical to transportation safety; and
- Drug testing technology and laboratory quality control.

Information Obtained from Industry Sources

The industry data discussed were obtained via telephone contacts with the following modes:

- Railroads
- Bus lines
- Trucking
- Airlines

Based on these contacts, it appears that there is little unbiased quantitative data from which drug use patterns in the transportation industry can be precisely determined. The majority of the information available from the transportation

industry were obtained from staff members of employee assistance programs and individuals responsible for operational safety. These individuals see more drug-related problems than other transportation industry employees. Because of their concentration on these problems, they may tend to overestimate the magnitude and the impacts of drug abuse.

Seven industry data sources were identified:

- Grievance procedures
- Employee Assistance Programs
- Periodic physical examinations
- Screening upon returning from furlough (layoffs)
- Tests conducted in the course of an investigation (an inquiry into an accident or incident, a violation of law, or a suspected infraction of drug-related work rules)
- Screening of job applicants
- Random on-the-job testing

Drug use patterns appear to be more influenced by factors such as employment status, age, geographic origin, and purpose of testing than by transportation mode. The most frequently detected drugs are THC (the active ingredient in marijuana) and cocaine, although the use of these drugs appears to be far less than the use of alcohol. There is evidence throughout the industry that the use of cocaine, in particular, is increasing -- especially among younger workers.

Although a number of serious accidents have occurred when operators were found to be using drugs prior to the accident, no statistical conclusions regarding the relationship between drug use and the incidence of transportation industry accidents were possible because:

- Most drug tests are conducted with advance warning;
- Little testing is done as part of the investigation of serious accidents.
- Drug screening is usually not comprehensive;
- Due to the lack of standardized testing, it is impossible to make useful comparisons regarding drug use in the different modes; and
- Most data available in the private sector have not been analyzed statistically.

Non-Industrial data

Published reviews and studies on drug use and safety covering non-professional operators on the highways, in the air, and on the waterways were reviewed, and contacts were made with state and local boating safety officials.

NHTSA has performed exhaustive evaluative reviews of studies which collected data on drug use by:

- Drivers who sustained fatal injuries;
- Drivers who sustained any injuries;
- Drivers who had been arrested by the police; and
- Non-accident involved drivers.

This data could potentially be used to link drug use and highway safety. However, in the most recent review conducted in 1985, NHTSA concluded that it was not

possible to determine the role of drug use in highway accidents from the data available.

The Federal Aviation Administration (FAA), in coordination with the National Transportation Safety Board (NTSB), collects toxicological data from most fatal general aviation accidents. This data indicates that only in a small percentage (4%) of such accidents was there evidence of drug use. However, because no analogous exposure data has been collected, the risk of fatal accidents as a function of drug use cannot be computed.

Although recreational boating accidents result in 1,200 fatalities annually in the U.S., few states routinely perform tests to determine if alcohol or drug abuse is involved in such accidents. To determine the extent of the data available, states known to have relatively vigorous alcohol enforcement programs were contacted. These states were:

- Alabama
- California
- Maryland
- Minnesota
- Ohio
- Pennsylvania
- Wisconsin

Three states were found to have particularly aggressive boating substance abuse programs: Minnesota, Ohio, and Wisconsin. They report that their major concern is alcohol abuse, but those investigations they conduct that do include urinalyses sometimes reveal the presence of marijuana, cocaine, and PCPs.

Other contacts revealed that there is little usable data because of the absence of implied consent laws for boaters and the absence of state laws requiring complete blood assays of waterway fatalities.

Data Available in Federal Data Bases

The Department of Transportation operates, sponsors, or maintains a number of accident and incident data collection systems that were considered potential sources of information on the involvement of drugs in accidents. They are the:

Name	Organization
Fatal Accident Reporting System	NHTSA
National Accident Sampling System	NHTSA
Bureau of Motor Carrier Safety Management Information System	FHWA
Accident Incident Data System	FAA
Aviation Safety Reporting System	FAA
Marine Casualty Information Reporting System	CG
Railroad Accident/Incident Reporting System	FRA
Safety Information Reporting System	UMTA

In addition, the National Transportation Safety Board (NTSB) maintains its own independent data base on transportation fatalities.

To assess their usefulness, the ten data bases identified above were examined, described, and evaluated in terms of the following:

- The data sources
- The years included
- The last year for which data was available for analysis at the time of this report
- The number of accident files available in last available year
- Provisions for entering drug-related information

Of the data bases examined, only the one maintained by the National Transportation Safety Board provides a multi-year source of drug involvement, but only for accidents occurring after 1983. The Federal Railroad Administration has required post-accident testing since February, 1986 and is accumulating a data base for that mode.

The Effects of Selected Drugs on Performance Considered Critical To Transportation Safety

The impact of selected drugs on human performance is described. The drugs considered in this report were selected according to their potential for negatively modifying or degrading the behavior of vehicle operators and other transportation personnel engaged in safety-critical activities. Drugs also were selected based on their estimated degree of use in the general population and at the request of modal participants in the study. The drugs reviewed included:

Opiates

Codeine
Heroin
Methadone

CNS Depressants

Sedative Hypnotics	Antihistamines	Tranquilizers
Chloral hydrate	Chlorpheniramine	Chlorpromazine
Meprobamate		Chlordiazepoxide (Librium)
Methaqualone (Quaalude)		Diazepam (Valium)
Pentobarbital		Flurazepam
Phenobarbital		
Secobarbital		

CNS Stimulants

Amphetamine
Cocaine
Dextroamphetamine
Methamphetamine

Antidepressants

Imipramine
Amitriptyline
3,4 Methlyenedioxyamphetamine

Hallucinogens

Marijuana
Phencyclidine (PCP)
Mescaline

Other Drugs

Antihypertensives

Dyazide
Propranolol

Published studies of the drugs listed above were reviewed with regard to their effects on selected behavior categories that were judged critical to transportation. The categories are as follows:

Behavior Categories	Number of Investigations Found
Sensory Function	14
Motor Performance	30
Vigilance	4
Cognitive Functions	25
Memory	2

Only a limited number of investigations were found that covered both the drugs and the performance categories of interest. The majority of these dealt with licit sedative hypnotic drugs and with tranquilizers. The only illicit drug to be studied extensively was marijuana. For the "hard" illicit drugs, however, their effects on behavior can be so severe as to leave little doubt that their use by transportation operating personnel constitutes a serious threat to safety. Moreover, the very fact that an individual uses such a drug indicates a lack of respect for the law that in itself is prejudicial to safety. Thus, the lack of experimentally derived performance data should not prevent development of a policy to deter the use of such drugs as an accident prevention measure. The lack of data linking dosage to performance will, however, hamper the positive establishment of causal links between individual accidents and drug presence revealed by post-accident toxicological testing.

For licit over the counter and prescription drugs the lack of dose performance data may increase the difficulty of developing regulatory policy.

The following problems make such a process difficult:

- Performances investigated in the laboratory cannot be readily calibrated to estimate quantitatively safety-related performance changes.
- One of the populations of the interest is composed of experienced drug users. Studies which concentrate on individuals who can meet the medical standards required by laboratory safety committees may not demonstrate the same effects found in the real world.
- The impact of a drug on safety is a function of the magnitude of its behavioral effect and the frequency of its use in a critical situation. Until we know accurately which drugs are used in which situations and at

what frequency, it will be impossible to determine where to concentrate our experimental studies.

Toxicological Testing

There are two major types of drug testing -- screening (testing to determine the presence of a variety of drugs) and confirmation testing (testing to confirm the presence of a particular suspected drug). The conditions under which testing must be carried out (pre-employment, on-the-job, and post-accident) are critical in the choice of testing methodology. The advantages and disadvantages of the available methodologies are discussed in the body of the report.

The methodology factors discussed include sample selection (body tissue or fluid), sample handling, and sample preservation, as well as the analytic procedures themselves. The analytic procedures currently available include:

- Immunoassay Techniques
- Thin Layer Chromatography
- Gas Chromatography
- High-Pressure Liquid Chromatography
- Gas Chromatography-Mass Spectrometry

The potential utility of non-chemical tests for drug related impairment are discussed. Based on a review of studies performed for NHTSA and the Los Angeles Police Department, it appears that the results of such tests are not likely to be of value as primary evidence in accidents or as a primary basis for dismissal from a job. With further development they may be useful in the detection of individuals suspected of impairment. Such tests may possibly be used to provide a basis for identifying impaired individuals for removal from duty as transportation operators.

Finally, the requirements to ensure the quality of laboratory procedures are discussed. The national alcohol testing laboratory proficiency program conducted for NHTSA is described. (In this program, calibrated blood alcohol samples are provided to laboratories throughout the nation to allow them to determine the accuracy of their testing procedures.) Information regarding a similar program conducted by the American college of pathologists, for drug testing laboratories is presented.

CONCLUSIONS

There is considerable concern in the transportation industry about the impact of drug use on safety, but few of the private organizations have (or will admit to having) analyzed the data they currently possess in a way that allows them to estimate objectively the safety-related risks associated with drug use in their operations.

In the aviation and railroad industries, data are now being collected that will support estimates of the prevalence of drug use by individuals involved in accidents. Federal regulations now require that toxicological data be obtained from almost all individuals involved in fatal aviation and railroad accidents.

Our understanding of the dimensions of the drug problem in the transportation industry could be significantly improved by requiring the testing of all transportation operating personnel directly involved in serious or fatal accidents and by obtaining and analyzing the data collected in screening programs now conducted by many

segments of the transportation industry.

The role of drug use in recreational boating accidents is of considerable concern to state boating officials. There is little quantitative accident data that can be used to estimate prevalence of drug use by individuals involved in boating accidents.

The only federal data base containing long-term information on the prevalence of drug use in civil transportation accidents is the one maintained by NTSB for aviation accidents. The Federal Railroad Administration has been collecting data from post accident tests since February, 1986. The data bases of other modes contain no useful drug information and have little or no provision for entering such data.

The review of experimental investigations of the effects of drugs on performance showed few relevant studies of illicit drugs, with the exception of marijuana. Of course as noted above, there is ample reason to believe that any use of "hard" drugs by transportation operating personnel would constitute a substantial safety risk. A number of studies were found that investigated the impact of licit drug use on the performance categories of interest. However, none of these studies could be used to directly quantify the transportation safety risk associated with the use of those drugs.

The technology for testing for the presence and amount of drugs in body fluids and tissues is well established and accurate, assuming that the laboratories employing them maintain high levels of quality control. However, the quality control for forensic drug testing laboratories is essentially unregulated.

RECOMMENDATIONS

There is a significant safety hazard in the use of any illicit drug by transportation personnel, as well as a potential hazard in the use of some illicit drugs. The need for more data to determine the precise extent of the threat should not interfere with efforts to eliminate the hazard. To the extent possible, data collection should be combined with a vigorous anti-drug program that will aim for personnel in safety-critical positions to be free of illicit drugs at all times and to be unimpaired by illicit drugs while on duty.

In order to better target the Department's anti-drug efforts, the following actions are recommended:

- The acquisition and analysis of industry Employee Assistance Programs and screening data;
- The testing of all transportation operating personnel directly involved in serious or fatal accidents;
- The use of the data collected in the random testing programs proposed by the US DOT to develop indices of risk;
- The creation of support and encouragement for state and local authorities to perform toxicological tests on all operators and victims involved in fatal highway or boating accidents;
- The ensuring of the modification of US DOT data bases to cover drug related elements and relevant toxicological data;
- The performance of epidemiological analysis using results of both post-accident and random testing efforts as new data becomes available;
- The conducting of experimental drug studies held under conditions that

closely simulate the transportation jobs of interest using subjects representative of the employee populations of interest; and

- Support and encouragement for drug testing laboratory participation in proficiency (quality control) programs.

1.0 INTRODUCTION

The influences of drug use, misuse, and abuse are felt at all levels of society. Media reports generally stress the personal tragedy of the drug abuser and the corrosive effect of the illegal activities associated with the drug trade. This report deals with a different but equally serious aspect of the drug problem -- the relationship between drug use and transportation safety.

The single most abused drug in American society is alcohol. There is strong evidence that alcohol abuse is a major factor in the Nation's 45,000 annual traffic fatalities, is involved in a significant proportion of the Nation's 1,200 annual recreational boating fatalities, and has been an important causal factor in railway accidents. To the extent that other illicit and licit drugs have been becoming more widely used by the general public, it is possible that their inappropriate use will similarly compromise transportation safety. This view was espoused in a 1984 National Transportation Safety Board recommendation A-84-96 noted later in this section.

Currently, our understanding of the relationship between drug use and transportation safety is considerably less detailed than our understanding of the impact of alcohol on safety. The reasons for this include the following:

- There is a wide variety of licit and illicit drugs that have a high potential for misuse or abuse.
- Drug abuse is generally illegal and abusers are stigmatized by society, which reduces their willingness to admit abuse.
- The relationships between the tissue concentration of most drugs and their impacts on safety-critical behavior have not been established.
- Testing for the presence of drugs requires a body fluid or tissue sample rather than the breath sample needed to establish a blood alcohol equivalent.
- The testing procedures used to determine drug tissue concentrations are considerably more difficult, time consuming, and more expensive than those for alcohol.
- The quality and accuracy of available laboratory drug testing programs appear to be highly variable.
- The only transportation modes that currently collect post accident drug data in a systematic manner are aviation and rail.
- There is no usable body of drug exposure data (data that characterizes the prevalence of drug use by operators within modes or as a whole).

The purpose of this report is to summarize the information available on the impact of drug use, misuse, and abuse on transportation safety, and to identify the major gaps in those data.

1.1 ORGANIZATION OF THE REPORT

The report consists of six sections including:

- An introduction;
- A discussion of information obtained from representatives in the transportation industry on drug use and related safety problems, and a discussion of the data sources available to the industry;

- A description of the drug-related data available in the accident and incident data bases collected by the Department of Transportation and other Federal entities;
- A discussion of the effects of drugs which have been identified as potential sources of problems, and a review of research on the effects of drug use on the safety-critical aspect of human performance and behavior;
- A description of the strengths, weaknesses, and applications of various drug testing methods and procedures; and
- Conclusions and recommendations.

This report deals with the relationship between drug use and transportation safety. In August of 1984, the National Transportation Safety Board expressed concern over the incidence of drug use by persons involved in several transportation accidents investigated by the Board, as well as indications that drug impairment might have been a significant causal factor in other transportation accidents. The Board recommended to the Secretary of Transportation that the Department:

> Review the existing research and literature in this area and institute research to: (1) determine the potential effects of both licit and illicit drugs, especially marijuana, in both therapeutic and abnormal levels, on human performance; (2) obtain correlations between toxicological findings of drug levels in blood, urine and other specimens and various behavioral measurements; and (3) assess the effects of various drugs on the specific tasks performed by the operator in all transportation modes. (Class III, Longer-Term action) (A84-96)

2.0 AVAILABLE INFORMATION ON DRUG USE IN TRANSPORTATION

The purpose of this section is to determine the extent of the available knowledge and data on drug use within selected transportation environments.

2.1 APPROACH

Telephone discussions regarding drug use in the following transportation modes were conducted:

- o Railroads
- o Bus lines
- o Trucking
- o Airlines
- o Recreational Boating

Because of the differences between job-related operations and recreational operations, the information gathered on recreational boating is discussed separately.

Knowledgeable transportation safety and employee assistance program (EAP) professionals were identified from the attendance rosters of recent conferences on drug abuse. Professionals[1] from each of the five transportation modes listed above were interviewed by telephone. The following topics were discussed in each interview:

- o Drug use
  - The most commonly used drugs
  - Changes in drug use patterns or drug preferences
  - Characteristics of users of different drugs
- o Available data
  - Data on file
  - Methods used to collect data
  - Representativeness of the data
  - Size and availability of data bases
  - Other known sources of data
  - Availability of data for analysis by the Government

2.2 LIMITATIONS OF THE DATA COLLECTED IN THE INTERVIEWS

While it is likely that the data bases identified in this study are the best and most comprehensive currently available, in all cases the data are biased in one way or another. For instance the EAP sources probably tend to overestimate drug use and management sources probably tend to underestimate. Our telephone interviews and discussions with alcohol and drug researchers indicate that there is little available unbiased data from which drug use patterns within the transportation industry can be determined. Professionals working in the substance abuse area within the industry are the first to admit that their opinions are strongly influenced by their close association with drug use.

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[1]Because the interviewees were promised anonymity prior to the discussions, their names cannot be included in this document.

Data collected in the transportation industry are not directly comparable from company to company or among transportation modes. Few companies within any mode systematically collect data on drug use, and those that do often do not collect it or organize it in a way that permits reliable comparisons to be made.

The opinions of transportation employee assistance program and safety officials about substance abuse in the industry are largely determined by their knowledge of problems caused by drugs in the workplace. Drug use which has not caused problems in the workplace is largely invisible to these officials. The officials are the first to admit this.

2.3 RESULTS OF DISCUSSIONS

When questioned about drug use in their own transportation mode, the respondents usually reported the following:

2.3.1 Drug Use

- Drug Use Patterns: Drug use patterns reflect the conditions in the communities served by that transportation industry.
- Alcohol: Alcohol is still, by a great margin, the substance that is most often misused. For example, the director of one employee assistance program reported that, whereas 33 percent of the program's clients had alcohol-related problems, only about nine percent of the admissions were drug-related.
- Marijuana: Several program directors reported that marijuana is, by far, the drug that is most frequently found in drug screens. It is known to be a popular social drug, and its metabolites remain in the body for longer periods of time than most other drugs.
- Cocaine: Cocaine is the second most commonly found drug in drug screens and among admissions to employee assistance programs. Approximately one percent of employee assistance program admissions are cocaine-related. A number of program directors believe that cocaine use is increasing within their companies. A 1982 telephone survey of 21 directors of railroad employee assistance programs indicated that cocaine use was a growing problem within the industry.
- Heroin: Heroin is found about half as often as cocaine, and some directors have seen no evidence of heroin use within their programs.
- Other Drugs: A director of an employee assistance program in the trucking industry stated that librium and valium were appearing as often as heroin in their program, and that certain central nervous system stimulants were appearing more often than heroin. Similarly, some stimulants were showing up in bus line drug screens, but their use is not believed to be widespread. The drugs most commonly found in these screens were legal and not unacceptable to the company. Signs of multiple drug use were rarely found.

2.3.2 Data Sources for Industry

There are seven major work-related situations that are sources of data on drug use in the workplace:

- Grievance procedures
- Employee Assistance Programs
- Periodic physical examinations
- Screening when returning from furlough (layoffs)
- Tests conducted in the course of an investigation (an inquiry into an accident or incident, or violation of law or a suspected infraction of drug-related work rules)
- Screening of job applicants
- Random testing

2.3.3 Data Base Contents

The contents of a given data base depend upon the drugs whose presence is being tested. Drug assays are expensive, with costs ranging from $25 to $100 per employee for the initial screening among the companies surveyed. A confirmation test can add another $200 to the cost. Individual companies determine the drugs for which they screen. As particular drugs come into fashion, they may be included in the search, and as assays fail to reveal evidence of the use of certain drugs, they may be excluded from the assay process because cost depends in part on the number of drugs being tested for.

The failure of a screening to reveal the presence of a particular drug may not mean that no one is using that drug. The drugs that are found are to some degree dependent on the methods that are used in the blood analysis, and current fashions in how drugs are being used will influence the effectiveness of analytic procedures for indicating drug presence. For example, one company recently stopped looking for cocaine because it was no longer showing up in the assays. The assay method employed by their testing laboratory used the presence of quinine as an indicator of the presence of cocaine, but cocaine is not as commonly cut with quinine as it used to be. Therefore, the data base being accumulated by this company probably no longer accurately indicates the extent of cocaine use within the company.

The surveyed companies screen for a broad range of drugs including the opioids, marijuana, cocaine, depressants, stimulants, and a variety of medicines. The data resulting from the screening procedure do not necessarily indicate all of the non-therapeutic drugs that appear in the workplace; recreational and operational drugs may be under-represented.[2]

Drugs that are detected by the employer are usually those that are misused to the extent that they directly or indirectly cause problems at work, and those that linger

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[2] Recreational drugs in this context include those substances used in the workplace to make time pass more quickly or more enjoyably. Operational drugs are those taken by the worker in the belief they will improve work performance or endurance.

in the system for long periods of time, e.g. marijuana; and legal medicines. Most of the available data are collected under conditions that gives the employee adequate notice that drug screening will occur so that those who have the ability to "come clean" have sufficient time to do so. For example, one company contacted indicated that it gives its employees two months notice before performing the mandatory biennial drug screening. Even in the case of pre-employment screening, applicants are often aware of when a firm requires testing prior to employment.

The first five of the seven data sources listed in Section 2.3.2 provide information on drug use within the industry. The extent of drug use revealed by these data may be expected to be less than that revealed in data from job applicants (many of whom are never hired because of positive drug indications), and the distribution of drugs within the data bases is probably different. Company officials report that the following individual characteristics influence the drug use information contained in the various data bases:

- Employment status (applicants, new hires, old employees)
- Age
- Geographic origin
- Purpose of testing

Job applicants tend to show a much higher rate of drug use than company employees (who were selected in part because they did not test positive for drugs at the pre-employment stage). As an example, approximately 25 percent of the applicants for driver positions with a major inter-city bus line tested positive for drugs; but approximately one percent of the company's employees tested positive for drugs during the company's periodic employee physical examinations and drug tests.

Two factors beyond the selection factor may explain the differences in these drug test results. First, company employees have been screened for drugs before, and, presumably, those who use drugs irresponsibly have been let go or know how to conceal their drug use. Second, the age of the employee is an important factor. Job applicants tended to be younger (between the ages of 24 and 35) than the current bus drivers, most of whom were over 40 years of age.

Most of the applicants who failed the drug test did so because of marijuana use; the preferred recreational substance among the older drivers is probably alcohol. When asked why members of one segment of a work force appear to prefer alcohol while those of another segment appear to prefer drugs, program directors usually state that the difference is mostly due to the ages of the employees. In at least one of the older airlines, drug-related work problems are extremely rare among the aircraft mechanic and pilot work forces, yet these employees have their share of problems with alcohol. At the same time, problems with cocaine are becoming increasingly evident among the flight attendants, who tend to be relatively young. (Airlines with an older flight attendant workforce would presumably find less evidence of drug abuse than would be found in an airline with a younger workforce.)

Discussions with program directors in the trucking industry revealed a similar belief in this age/substance abuse relationship, but the relationship may be changing. In the 1970's there appeared to be well-defined differences between the different age groups and their preferences for recreational substances. However, some directors have stated that as the younger employees get older they maintain their preference for drugs as opposed to alcohol.

Discussions with both railroad and airline personnel indicate that geographical characteristics influence the extent, and probably the type, of drug use by job applicants and industry employees. Job applicants from the New York City metropolitan area have been found to have higher drug-related rejection rates than have applicants from Kansas City. Similarly, it was reported in a recent survey in the railroad industry that substance abuse was notably lower among employees on routes originating from "bible belt" areas than it was from other locations around the country.

The various data bases on drug use also differ with regard to the purpose of the testing. The purpose of the testing determines the characteristics of the people who will be tested as well as the conditions under which testing will be conducted. For example, if testing was done with flight attendants upon their return from layoffs (as it is on some railroads with engineers), the attendants would know that they were going to be tested and would likely be as drug-free as possible.

The seventh technique, random testing, can yield the most accurate picture of employee drug use. In this procedure, at a randomly designated time, a worker can, without warning or job-related cause, be required to submit to a chemical test. The procedure is now used by the military but it has not been widely used by private organizations. Even where used by police departments, this procedure has been met with strong resistance and has been the subject of litigation. No data were available from this procedure for the transportation industry from the sources surveyed.

Table 1 indicates the characteristics of data collected from the main sources: grievance procedures, upon entering employee assistance programs, as part of periodic physicals, when returning from being laid off following an accident or some serious performance-related incident, upon applying for a job, or as part of a drug screening program involving unannounced random testing.

Telephone conversations with transportation safety personnel and employee assistance program directors revealed the existence of a variety of data bases. In some cases, the data have been analyzed and tabulated; in other cases, analyses have not been performed. The interviewees indicated that the data could be made available to DOT researchers if the proper safeguards could be provided for the data and the data source.

Table 2 describes data bases on drug use in the transportation industry. Although the tabulated information is incomplete and approximate, it does illustrate the range of information on drug use in transportation that exists within the private sector. The column in the left of the table lists the transportation elements that were examined for this report. The center and right columns indicate the situation in which the screening was conducted and the approximate number of employees who were tested in that situation, respectively.

2.4 CONCLUSIONS WITH REGARD TO DRUG ABUSE IN THE TRANSPORTATION INDUSTRY

2.4.1 Drugs Abused

The most frequently detected drugs are THC[3] and cocaine (although their use appears to be far less than alcohol). There is evidence throughout the transportation industry that the use of cocaine, in particular, is increasing, especially among younger workers.

Table 1
Overview of Transportation Industry Data Sources [4]

Source Availability	Voluntary Testing	Warning Given	Size of Base	Range of Ages	Relative Number of Bases
Grievance Procedure	some	some	small	broad	few
Employee Assistance Program	no	some	med	broad	many
Physicals	no	yes	large	broad	several
Layoff Return	no	yes	large	med	few
Incident Testing	no	no	small	broad	few
Job Applicant Testing	no	yes	large	med	several
Random Testing	no	no	not known	broad	not known

[3]THC (tetrahydrocannabinol) is the active ingredient in marijuana.

[4]"Voluntary" means that the employee does not have to submit to a test. "Warning" means that the day of testing is announced in sufficient time for the employees to get "clean" of most drugs. "Size" refers to the number of samples in the data base: less than 500 is considered small, over 1,000 is considered large. "Age Range" refers to the range of ages within the sample. A broad range will include young, middle-aged and older people; a medium range would include people from two of those categories. "Availability" refers to the number of such data bases that are likely to be available in the country.

Table 2
Data Sources Available by Transportation Mode

Mode	Data Source	Sample Size
Airline	Employee Assistance Program	1400
	Job Applicant	??
Railroad	Employee Assistance Program	1400
	Layoff Return	2500
Independent Trucking	Employee Assistance Program	+400
Union Trucking	Employee Assistance Program	+600
	Grievance Procedures	??
Bus line	Physical	+6000
	Job Applicant	+5000
Commercial Maritime	None Known	

2.4.2 Relationship Between Drug Use and Accidents

It was not possible to reach any conclusions with regard to the relationships between drug use and accident rates based on the contacts with industry representatives.

2.4.3 Data Needs

There are several factors impeding our full understanding of drug use within the transportation industry.

- Because of institutional factors, employees generally receive warning well in advance of testing, so that often only the most careless or hard-core abusers are detected.
- Little drug testing is done as part of the investigation of serious accidents, so no complete record of accident involvement is available.
- Drugs screening usually is not comprehensive. The drugs that are to be detected must be targeted; the more drugs that are tested for the more expensive the testing process becomes.
- Due to lack of standardized testing and to operational differences between modes, it is impossible to make useful comparisons regarding relative levels of drug use in the different modes.
- The data available in the private sector have not been analyzed.

Improving our understanding of the impact of drug use on transportation safety will require more uniformity in the collection and analysis of data.

2.5 NON-INDUSTRIAL DATA

Non-professional operators on the highways, in the air, and on the waterways are involved in the vast majority of serious transportation accidents.

2.5.1 General Aviation Accidents

The Federal Aviation Administration (FAA) in coordination with the National Transportation Safety Board (NTSB) collects toxicological data from most fatal general aviation accidents. This data indicates that only in a small percentage (five percent) of such accidents was there evidence of drug use. However, because no analogous exposure data has been collected, the relative risk of fatal accidents as a function of drug use cannot be computed.

2.5.2 Automobile Accidents

Motor vehicle accidents are by far the major source (about 90%) of U.S. transportation fatalities. As such, the relationship between drug use and highway safety has been the subject of many studies. While an exhaustive review of the available literature on this topic would be far beyond the resources available for this report, NHTSA has performed two excellent reviews.

In 1980, NHTSA, under contract, evaluated the data that could be used to assess the accident risk associated with drug use in highway operations (Joscelyn, Donelson, Jones, McNair, and Ruschman, 1980) and five years later NHTSA staff reexamined the area to determine if new data had become available (Compton and Anderson, 1985). In both the 1980 and the 1985 evaluations, NHTSA found insufficient exposure data (data on the use of drugs by non-accident involved drivers) to establish the risk of automobile accidents as a function of drug use.

NHTSA also reviewed relevant studies of drivers who sustained fatal injuries, drivers who sustained any injuries, and drivers who had been arrested by the police. NHTSA found that this data was also inadequate to use to compute risk. Compton and Anderson (op. cit.) found that drug use in the accident data available was confounded with alcohol use. They noted that, because "the majority of drug using drivers (53% to 77%) were found to have high levels of alcohol in combination with drugs," it was difficult to attribute accident causality to drug use.

As of 1985, NHTSA has concluded that it is not possible to determine the role of drug use in highway accidents based on the data available.

2.5.3 Recreational Boating

Although recreational boating accidents result in 1,200 fatalities annually in the U.S., few states routinely perform tests to determine if alcohol or drug abuse is involved in such accidents. To determine the extent of the data available, states known to have relatively vigorous alcohol enforcement programs were contacted. These states were:

- Alabama
- California
- Maryland
- Minnesota

- Ohio
- Pennsylvania
- Wisconsin

Wisconsin, Ohio, and Minnesota were found to have particularly aggressive programs regarding substance abuse on state waterways. Their primary concern is alcohol-impaired boat operation, but interest is developing in trying to curb drug use as well. All of the contacted state officials believed that many boaters use illicit drugs while boating, but there are few data available to validate this belief. Minnesota analyzes the blood of most adults who die in the water, and these analyses occasionally reveal the presence of THC, cocaine, and PCPs. Ohio water safety officials will request a urinalysis if boat operators who are arrested do not register high BACs on a breath test but still act impaired; four out of 77 Ohio boat operators who were arrested in 1985 tested positive for THC.

Although a complete survey of all states has not been conducted, there is little reason to believe that better data than that described above exists. Thus, essentially there are no data on the prevalence of drug use by boaters. Boat safety professionals are quick to point out that in the absence of implied consent laws for boaters and state laws requiring complete blood assays of all waterway fatalities, there is little chance that useful data bases on drug use by recreational boaters will be developed. However, as indicated by recent legislative activity in the three midwestern states discussed above, there does appear to be increasing realization that such laws are important adjuncts to state safety programs, and there is activity within a number of other states to enact such legislation.

3.0 SURVEY OF NATIONAL ACCIDENT DATA BASES

The purpose of this section is to assess available federal transportation safety data bases with regard to their use in statistical studies of the relationships between drug use and accident occurrence. To accomplish this, potentially useful data bases were identified, documentation describing the data bases and the actual report forms used to collect data for each data base were examined (the report forms are reproduced in Appendix A), and the information and the description of the data base is summarized under the following headings:

- Description of data base
- Data source and/or collection procedure
- Years covered
- Number of accidents in last complete year for which data is available at the time of this report
- Provisions for recording drug data in data base
- Availability of data for analysis
- The individual to be contacted in order to obtain data or analysis

The adequacy of a data base to provide a valid statistical description of drug involvement in transportation accidents is a function of the extent to which the data base provides the information of interest for a large proportion of the accidents covered in the data base. Ideally, a data base useful for determining the involvement of drugs in accidents would contain information such as the following:

- Drug(s) tested
- Assay medium: blood, urine, saliva, behavior, environment
- Level of drug/metabolite
- Time lapse between accident and sample collection

Based on the information developed for the summary, an evaluation of the usefulness of the data base in providing an accurate estimate of drug involvement in accidents is included at the end of each summary.

It must be noted that even if data bases were available that provided the results of broad drug screening tests for all the accidents in the data base, the information would still not be adequate to provide an estimate of the risk of an accident associated with the use of the drug. To obtain an estimate of risk it is necessary to know the extent to which the drug is present in all operators as well as the extent to which it is found in operators involved in accidents. The risk value is computed by dividing the estimate of the percent of all operators using the drug (the exposure value) into the percent of accident-involved operators found to be using the drug.

The following data bases were identified and examined (they are grouped according to mode):

HIGHWAY

Fatal Accident Reporting System (FARS)
National Accident Sampling System (NASS)
Bureau of Motor Carrier Safety Management Information System

AVIATION

Accident Incident Data System (AIDS)
Aviation Safety Reporting System (ASRS)
National Transportation Safety Board (NTSB)

MARINE

Marine Casualty Information Reporting System (CASMAIN)
Boating Accident Reporting System (BAR)

RAILWAY

Railroad Accident/Incident Reporting System (RAIRS)

URBAN TRANSIT

Safety Information Reporting and Analysis System (SIRAS)

HIGHWAY

3.1 FATAL ACCIDENT REPORTING SYSTEM (FARS)

Description:
FARS provides a census of data on all fatal traffic accidents in the United States. To be included in FARS, the accident must result in a death and the death must occur within 30 days of the accident. FARS allows researchers to analyze relationships between driver, vehicle, highway, and other characteristics and fatal accidents. Further, because it covers all fatal accidents, FARS provides an overall measure of highway safety in the U.S. It is maintained by the National Highway Traffic Safety Administration (NHTSA).

Data Source:
NHTSA establishes contracts with each state to provide information in a standard format. Contracts are managed by "Regional Contract Technical Managers" in the ten NHTSA regional offices. Regional analysts enter data collected by others directly onto a central computer file.

Years Covered: 1975-to present
There is a six-month lag between end of calendar year and availability of accident data for that year for analysis.

Last Full Year For Which Data is Available at Time of Report: 1985

Number of Accidents Reported in 1985: 39,284

Provisions for Recording Drug Data:[5]
There are three variables in the Person File that may contain drug-related information. These variables, Contributing Factors I, II, and III, may take on 93 possible

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[5]A data base consists of recorded data representing observations of an event, a condition, or an object. In safety data bases, the observations usually represent accidents or incidents. An observation is structured into data categories or variables. An example of a variable in the FARS data base is "Contributing Factors". A data base such as FARS may be thought of as a book, with the observations or accidents as pages. The variables can be thought of as columns on the pages. Data is encoded by entering values in the columns; these values are usually numerically coded for convenience in storing the data. In the FARS data base, under the "Contributing Factors" variable, the coding value 04 signifies that Drugs - Medication was a Contributing Factor to the Accident. In practice, data bases are usually computerized. The user of the data base may program the computer to determine the number of times a coded value is associated with other accident circumstances and to provide estimators of the statistical reliability and validity of this relationship.

values. Twelve of these values refer to the physical/mental condition of the operator. Two values reflect drug involvement: 04: Drugs - Medication, 05: Other Drugs.

Availability of Data and Data Analyses:
Data analyses are conducted on request. Data is provided on tapes for a small fee.

Contact: National Center for Statistics and Analysis (NRD-33)
Grace Hazzard
400 Seventh Street, S.W.
Washington, DC 20590
Tel.: (202) 366-5372

Evaluation:
There are no variables in FARS that deal exclusively with drugs. Also, there is no indication in each accident file of whether or not tests were done for drugs. Analyses using this data base may greatly underestimate the involvement of drugs in the accidents covered.

3.2 NATIONAL ACCIDENT SAMPLING SYSTEM (NASS)

Description:
NASS collects a statistically structured sample of minor, serious, and fatal accidents occurring on U.S. streets and highways. NASS samples only a small portion of the accidents (about 13,000 of the approximately 6,000,000 that are reported to police) that occur in the U.S. annually, but it samples a wide variety of accidents, thus enabling researchers to investigate the causal and contributing factors to accidents of varying levels of severity. NASS is maintained by NHTSA.

Data Source:
NASS investigators review police accident reports, investigate the accident scene, and collect information from other sources. Data are coded on standard forms, reviewed at area Zone Centers for quality and completeness, and then entered into a central automated data file.

Years Covered: 1980-present
There is a six-month lag between end of calendar year and availability of accident data for that year for analysis.

Last Full Year For Which Data is Available at Time of Report: 1985

Number of Accidents Sampled in 1985: 13,153

Drug Data:
Examination of the NASS Analytical User's Manual indicates three variables in the Driver Data File that may contain drug-related information. These variables, Other Driver Related Factors I, II, and III may take on 54 different values. Two values refer to drug involvement: (10) Drugs - medication (prescription, over the counter), and (11) Other drugs (excludes alcohol, includes uncontrolled as well as controlled substances).

Availability of Data and Data Analyses:
Data analyses are conducted on request. Data is provided on tapes for a small fee.

Contact: National Center for Statistics and Analysis (NRD-32)
Grace Hazzard
400 Seventh Street, S.W.
Washington, DC 20590
Tel.: (202) 366-5372

Evaluation:
There are no variables dealing exclusively with drugs. However, there are two code values that refer specifically to drugs. There is no indication in each accident file of whether or not tests were done for drugs. Analyses using this data base may greatly underestimate the involvement of drugs in the accidents covered.

3.3 MOTOR CARRIER SAFETY MANAGEMENT INFORMATION SYSTEM

Description:
This data base contains information on fatalities, accidents, and injuries of Motor Carriers of Property and Motor Carriers of Passengers operating in interstate or foreign commerce. The data base is maintained by the Federal Highway Administration (FHWA).

Data Source:
The carriers are required to report to the FHWA accidents involving: fatalities, injuries requiring treatment away from the scene of the accident, and property damage over a dollar threshold indexed to inflation ($4,200 in 1986).

Years Covered: 1976-to present

Last Full Year For Which Data is Available at Time of Report: 1985

Number of Accidents Recorded in 1985: 39,273

Drug Data:
Only one variable--Condition of Driver--can be used to reflect drug involvement. This variable has six possible codes, none of which specifically refer to drug involvement. Information on drug involvement may be entered in Code 5 (Other).

Availability of Data and Data Analyses:
Data analysis requires special arrangement with the FHWA. Requests for data analysis are honored under the Freedom of Information Act for a fee. Copies of data tapes may be made available.

Contact: Office of Management Information and Analysis
C. John MacGowan, HIA-10
400 Seventh Street, S.W.
Washington, DC 20590
(202) 366-4032

Evaluation:
There are no variables that deal only with drugs. There are no codes in pertinent variables that specifically identify drugs. Analyses using this data base can greatly underestimate the involvement of drugs in the accidents covered.

AVIATION

3.4 ACCIDENT INCIDENT DATA SYSTEM (AIDS)

Description:
AIDS records accidents and incidents involving general aviation and the carrier air lines. It is maintained by the Federal Aviation Administration (FAA).

Data Source:
The FAA often investigates accidents in cooperation with NTSB. Investigations may be conducted through on-the-scene visits or from the desk (by telephone), depending on the severity and nature of the accident or incident.

Years Covered: 1973-present

Last Full Year For Which Data is Available at Time of Report: 1985

Number of Accidents Recorded in 1985: 2,898

Drug Data:
There are five possible accident/incident cause variables: Cause Factors A and B, Contributing Cause A and B, and Supplementary Factor A. Examination of the codes under which data can be entered for the five variables did not reveal any that referred to the use of drugs.

Availability of Data and Data Analyses:
Tapes are made available to prospective users by arrangement with the FAA.

Contact: Larry Musser, AVN-120
Aviation Standards National Field Office
Mike Moroney Aeronautical Center
P.O. Box 25082
Oklahoma City, OK 73125
(405) 686-4391

Evaluation:
This data base cannot provide any indication of the extent of drug involvement in accidents.

3.5 NATIONAL TRANSPORTATION SAFETY BOARD (NTSB)

Description:
The NTSB aviation data base records accidents and in some cases incidents such as near mid-air collisions for both general aviation and the carrier air lines. The data base also contains records of some selected accidents in other modes. These non-aviation accidents are usually selected because they represent major disasters or because they are a type of accident under study by the NTSB.

Data Source:
NTSB investigates all air disasters--accidents involving the death of five or more people, major damage--and also investigates some incidents and some nonaviation accidents. The bulk of the aviation investigations are carried out by FAA staff. Most accidents are reported first to the FAA or appropriate modal staff.

Years Covered: 1964-present

Last Full Year For Which Data is Available at Time of Report: 1985

Number of Accidents Reported in 1985: 2,942

Drug Data:
In the data collected prior to 1983, one variable indicates whether toxicological testing was performed and a second variable indicates whether drugs were present (without specifying type or amount). Since 1983, Supplement K (Occupant, Survival, and Injury Information) requires an entry indicating if a toxicological analysis was performed. A second entry indicates if the results of the test for marijuana were positive. A third entry indicates the level of the drug found. An additional 14 variables may be entered on the form to indicate drugs found and their levels. Codes are provided for 69 substances.

Availability of Data and Data Analyses:
NTSB will conduct analyses on request and will provide data on the user's blank tapes.

Contact: Stan Smith, SP-30
800 Independence Ave., S.W.
Washington, DC 20594
(202) 382-6672

Evaluation:
Data collected prior to 1983 on fatal accidents where toxicological tests were performed, indicate whether drugs were present. The pre-1983 data does not specify the type, amount, or drug detected and therefore provides a minimal indicator of drug incidence.

The post-1983 portion of the data base contains specific indications of the presence and types of drugs detected in accident survivors and non-survivors. **This data base can provide a valuable and accurate indicator of drug use by individuals involved in those accidents covered by the data base.**

3.6 AVIATION SAFETY REPORTING SYSTEM (ASRS)

Description:
The ASRS is a system which permits aircraft pilots, air traffic controllers, aviation maintenance personnel, and other members of the aviation community to make voluntary reports of actual or potential aviation incidents, or infractions of aviation rules. Individuals who report to the system are guaranteed anonymity and immunity with regard to many minor violations. Data entry forms are provided in public areas which are frequented by pilots, controllers, and other individuals engaged in aviation activities. Data from the forms is entered into a data base which can be queried

using a "key word" system. ASRS is operated by NASA for the FAA.

Data Source:
Reports are received by mail from individuals who volunteer information.

Years Covered: Most recent five years are active; data older than five years is archived. Program began 1976.

Last Full Year for Which Data is Available: 1985

Number of Accidents Reported in 1985: zero

Number of Incidents Reported in 1985: 6,545

Drug Data:
The report is of the narrative type and no field exists for reporting of drugs. The computer retrieval software does not contain codes for drug involvement. However, the analyst is free to code drug key words if drugs are referred to in the narrative.

Availability of Data and Data Analysis:
NASA, through Battelle, its contractor, searches the data base and provides the narrative reports to the requester. The raw data is not currently available.

Contact: William Reynard, Chief
Aviation Safety Reporting System
NASA-Ames Research Center
P.O. Box 189
Moffett Field, CA 94035
(415) 694-6467

Evaluation:
The form used has no specific entries that deal with drug use. However, the open-ended nature of the system may support the gathering of such data. Professional pilots are the most frequent users of the system. If problems related to drug use are more characteristic of general aviation, such problems might be under-represented in the ASRS. However, because the system is strictly voluntary, only qualitative inferences can be drawn from the system.

3.7 MARINE CASUALTY INFORMATION REPORTING SYSTEM (CASMAIN)

Description:
A data reporting system for accidents involving waterborne, commercial vessels operated by licensed masters/mates. CASMAIN is maintained by the U.S. Coast Guard. The system contains two data files: one records vessel accidents and the other records injuries to people.

Data Source:
After an accident is reported to local Coast Guard jurisdiction, an investigating officer is appointed. The investigating officer fills out an accident form and forwards it to Coast Guard headquarters where it is coded and entered into the data file.
Years Covered: 1963-present

Last Full Year For Which Data is Available at Time of Report: 1985

Number of Accidents Reported in 1985: 3,435

Drug Data:
CASMAIN contains two variables that may refer to drug involvement. The first variable, "Casualty Cause", has 101 possible values; up to seven causes may be coded in reporting an accident. One of the 101 values, "Intoxication (Alcohol/Drugs)", can be used to refer to drug involvement. The second variable, "Cause of Injury", has 38 possible values. One of these values, "Narcotics (other than alcohol)," can be used to refer directly to drug involvement. Toxicological testing is not usually performed as part of the data gathering activities conducted under CASMAIN.

Contact: Lt. Cmdr. Theophilis Moniz III, G-MMI-3
2100 Second Street, S.W.
Washington, DC 20593-0001
Tel.: (202) 267-1424

Availability of Data and Data Analyses:
Data analysis requests are handled on a daily basis. Copies of data tapes are available for a fee of $36 per tape.

Evaluation:
Analyses using this data base can greatly underestimate the involvement of drugs in the accidents covered because toxicological testing is not currently being conducted.

3.8 BOATING ACCIDENT REPORT SYSTEM (BARS)

Description:
BARS contains data on recreational boating accidents. It records fatalities, injuries, and property damage of reported accidents and is maintained by the U.S. Coast Guard.

Data Source:
Boat operators submit accident reports to the local jurisdiction or to Coast Guard (in cases where it has jurisdiction). Reports of accidents in states without an approved boat numbering system are not required. Also, reports not meeting minimum requirements are not included. The Coast Guard investigates all fatal boating accidents under joint or federal jurisdiction.

Years Covered: 1974-present

Last Full Year For Which Data is Available at Time of Report: 1985

Number of Accidents Reported in 1985: 6,237

Drug Data:
No variable exists in BARS for the specific reporting of drug involvement in the accident. A single entry code or value, "Alcohol or Drugs Involved," may be entered under the BARS variable, "Accident Descriptors." The Accident Descriptors variable has 51 possible values, a maximum of three values may be chosen in completing the

form. No specific provision is made in BARS for the recording of the type or quantity of drugs present.

Availability of Data and Data Analyses:
Requests for data analysis are fulfilled for minimum fees. Data tapes may be made available upon arrangement with the Coast Guard.

Contact: Barbara Gray, G-BP-3
2100 Second Street, S.W.
Washington, DC 20593
Tel.: (202) 267-0949

Evaluation:
Analyses using this data base can greatly underestimate the involvement of drugs in the accidents covered.

RAILROAD

3.9 RAILROAD ACCIDENT INCIDENT REPORTING SYSTEM (RAIRS)

Description:
RAIRS contains data from the Railroad Equipment Accident/Incident Report and the Rail-Highway Grade Crossing Accident/Incident Report. It is maintained by the Federal Railroad Administration (FRA).

Data Source:
Railroads submit monthly accident and incident reports to the Office of Safety of the Federal Railroad Administration.

Years Covered: 1975-present

Last Full Year For Which Data is Available at Time of Report: 1985

Number of Accidents Reported in 1986: 2,619

Drug Data:
It is possible to enter drug involvement data under one RAIRS variable, "Accident/ Incident Cause." The Accident/Incident Cause variable has 261 possible codable values -- 59 of these values are listed under the human factors category. Of these, only one value (510 - Impairment of Efficiency and Judgment Due to Drugs or Alcohol) indicates drug involvement. Up to three cause codes may be entered for the accident/incident.

Availability of Data and Data Analyses:
Data analysis requires special arrangement with the FRA, requests for data analysis are honored under the Freedom of Information Act for a fee.

Contact: Stan Ellis, RRS-22
400 Seventh Street, S.W.
Washington, DC 20590
Tel.: (202) 366-0544

Evaluation:

Analyses using this data base can greatly underestimate the involvement of drugs in the accidents covered.

Other FRA Accident Data:
An FRA regulation that became effective early in 1986 required post-accident toxicological testing of railroad personnel involved in serious accidents or incidents and other events (such as the inadvertent release of hazardous material) qualifying under 49 CFR Part 219, Subpart C. Analyses done by the FAA toxicological unit in Oklahoma City for the period February 10, 1986 through January 15, 1987, yielded the following results:

Qualifying Events (Serious Accident or Incident)	175
Employees Sampled	759
Employees testing positive for alcohol and/or drugs[6]	38 (5%)
Employees testing positive for alcohol only	9
Employees testing positive for illicit drugs	23 (3%)
Marijuana	23
Cocaine	1
Methamphetamine	1
Employees testing positive for licit drugs	14 (2%)
Diazepam (Valium)	1
Opiate (Codeine)	4
Amphetamines	3
Barbiturates	1
Other	5

RAPID RAIL TRANSIT

3.10 SAFETY INFORMATION REPORTING AND ANALYSIS SYSTEM (SIRAS)

Description:
SIRAS is a voluntary safety reporting system developed by UMTA in cooperation with American Public Transit Association (APTA) and heavy rail transit systems in the U.S. It is maintained by the Transportation Systems Center (TSC).

Data Source:
Cooperating systems submit a Monthly Statistical Report. Railroads only submit a "Train Accident Report and Casualty Report" in months when reportable accidents occur.

Years Covered: 1983-1985

Number of Accidents in 1985: 12

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[6] Some employees tested positive for more than one drug therefore drug totals are not additive.

Drug Data:
Examination of the accident report forms used for direct entry of data in SIRAS shows that there are no provisions for entering drug data.

Availability of Data and Data Analyses:
Data will be supplied on tapes at cost on request.

Contact: A.L. Lavery, DTS-43
55 Broadway
Cambridge, MA 02142
Tel.: (617) 494-2577

Evaluation:
This data base cannot provide an indication of drug incidence.

4.0 REVIEW OF STUDIES OF THE EFFECTS OF SELECTED DRUGS

This section provides a review of studies of the effects of selected drugs on measures of performance related to transportation safety.

4.1 DRUGS

The drugs considered in this report were selected according to their potential for negatively modifying or degrading the behavior of vehicle operators and other transportation personnel engaged in safety-critical activities. Five criteria were used to select the drugs to be discussed in this report:

- The frequency with which drugs were found in Bray's (1983) "Worldwide Survey of Alcohol and Nonmedical Drug Use Among Military Personnel" and the National Institute of Drug Abuse's (NIDA) "Population Projections Based on the National Survey of Drug Abuse"
- The frequency of prescription of drugs, known to have behavioral side effects that might impact the safety of transportation operator performance, listed in the article published in the American Druggist entitled "The Top 200 Prescription Drugs of 1984"
- The frequency of sales of over-the-counter drugs known to have behavioral side effects that might impact the safety of transportation operator performance as listed in the Schlaadt and Shannon's (1982) "Drugs of Choice"
- Frequency of appearance of any drugs, known to have behavioral side effects that might impact the safety of transportation operator performance, in emergency rooms or coroners' reports as found in the NIDA's "Data from the Drug Abuse Network (DAWN)," (1984)
- Requests from the members of the Secretary's Working Group on Drug Use and Operator Performance

The list includes drugs whose use is illicit as well as those drugs which are basically therapeutic.

4.1.1 Drug Classification

The selected drugs were classified as follows.

4.1.1.1 Opiates

Codeine[7]
Heroin[8]
Methadone[9]

Opiates are among the drugs having the highest potential for abuse. The

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[7]Rx or OTC depending on concentration.

[8]Illicit.

[9]Rx only.

general effects of the opiates are to dull the perception of external and internal stimuli (particularly pain) and to induce a feeling of pleasant lethargy.

Heroin originally was developed as a "safe" (non-addictive) substitute for opium, which represented a major addiction problem in the nineteenth century. Similarly, methadone has been promoted as a substitute for heroin that has a lower abuse potential. Codeine finds therapeutic use as an analgesic in prescription cough medicines and pain relievers perhaps because of its relatively greater legal availability (as compared to other opiates), it is believed to be frequently abused. The use of these drugs by operating personnel will reduce their attentiveness to critical signals.

The opiates are related to a new group of drugs sometimes referred to as "designer" drugs. An example is the drug 3-Methyl Fentanyl, a powerful and dangerous drug, which is synthesized from Fentanyl (Sublimaze), an intravenous anesthetic. The term designer drug derives from the concept that slight changes to the molecular structure of drugs such as Fentanyl can both result in new and different psychological effects. Because such drugs have new formulae, they cannot be classified as illicit. Until their abuse potential has been demonstrated, these drugs can be used legally.

4.1.1.2 Central Nervous System (CNS) Depressants

Sedative Hypnotic	Antihistamines	Tranquilizers
Chloral hydrate[7]	Chlorpheniramine[7]	Chlorpromazine[9]
Meprobamate[7]		Chlordiazepoxide (Librium)[7]
Methaqualone (Quaalude)[8]		Diazepam (Valium)[9]
Pentobarbital[7]		Flurazepam[9]
Phenobarbital[7]		
Secobarbital[7]		

As a class, the CNS depressants tend to depress the function of the central nervous system, reducing the ability of the user to concentrate or focus attention, reducing sensitivity to stimuli, and slowing the processing of information. While all of the CNS depressants tend to make the user drowsy, it is the main therapeutic function of those drugs in the sedative hypnotics subgroup to induce sleep, and use of these agents is likely to result in relatively profound reductions in alertness.

Antihistamines, as a class, are widely used in non-prescription over-the-counter medications to reduce allergic symptoms, particularly those associated with hay fever and colds. The use of antihistamines characteristically results in drowsiness.

Drowsiness is also a side effect of tranquilizers, but the major desired effect of these agents is reduced response to anxiety-producing situations. The reduction in response to threatening situations undoubtedly is of value in reducing stress-related symptoms, but may be highly undesirable when the user must deal with an emergency. The drugs in this subgroup are among the most widely prescribed drugs. The use of these drugs may produce unwanted effects, such as hangovers. One of the tranquilizers listed, chlorpromazine, is far more powerful than the others. It finds use in the treatment of severely disturbed

institutionalized patients.

4.1.1.3 Central Nervous System (CNS) Stimulants

Amphetamine[9]
Dextroamphetamine[9]
Methamphetamine[9]
Cocaine[8]

The CNS stimulants, as a class, tend to increase mental activity, responsiveness to external stimuli, and in some cases restore concentration to fatigued individuals. The first subgroup of CNS stimulants, the Amphetamines, are prescribed for the treatment of narcolepsy, depression, hyperactivity in children, and as antidote for certain CNS depressant poisons. The major avowed therapeutic use of the amphetamines was the suppression of appetite as a diet aid. Due to the high potential for misuse of these pills amphetamines are no longer used in over-the-counter diet pills. Amphetamines frequently find illicit use in attempts to extend and improve the performance of fatigued individuals.

Of the drugs covered in this report, cocaine probably represents the most serious current public health hazard. Cocaine combines the euphoric effects of the opiates and the sensory disruption of hallucinogens with an increase in mental activity similar to that provided by amphetamines in fatigued individuals. Although laboratory studies of cocaine may not reveal conclusive evidence of physiological or physical dependence in the form of severe withdrawal symptoms, it has a high abuse potential. This is because it provides an immediate and strong positive reinforcement. The cessation of this positive reinforcement is believed to result in psychological dependence. This is particularly true when "crack," a purified form of the drug, is used.

As Jones (1984, p. 48) concludes, "The differences between so-called physical dependence and so-called psychological dependence may be more a matter of semantics and sensitivity of measures than of neurochemistry. Most investigators would concede that psychological dependence certainly is a consequence of repeated cocaine use."

4.1.1.4 Antidepressants

Imipramine[9]
Amitriptyline[9]
3,4-Methylenedioxyamphetamine (MDA, Ecstasy)[8]

The first two drugs (Imipramine and Amitriptyline) are classed as tricyclic antidepressants. They are prescribed therapeutically to combat mental depression, and their effect is to impede the user's ability to form thoughts. Treatment with these drugs over a period of weeks can yield a reduction in depression. This depression reduction process is in contrast to drugs that appear to elevate the user's mood such as the third drug in this group 3,4-Methylenedioxyamphetamine (MDA). MDA, sometimes referred to as "Ecstasy," is classed as an LSD-like drug with other properties. In the case of MDA, it is LSD-like in that it produces vivid and organized hallucinations, but its other properties include a marked euphoria or feeling of well being.

4.1.1.5 Hallucinogens

Marijuana[8]
Phencyclidine (PCP)[8]
Mescaline[8]

Although they differ widely in their specific effects, the hallucinogenic drugs have common features that are detrimental to safety. Rather than reducing or increasing the user's responsiveness to external or internal physical stimuli, they tend to distort the perception of internal and external stimuli. More significantly, they permit the user to disassociate himself or herself from external events, particularly the consequences of actions taken by the user.

Marijuana, which is believed to be the most widely used illicit drug, is relatively mild (as compared to other hallucinogens) in its effects. It combines the distortion of sensory information with a mild euphoric state.

The effect of PCP is to allow the user to achieve a profound disassociation from external reality. Under the influence of this drug, individuals are often totally incapable of perceiving even the most direct consequences of their actions, making them extremely dangerous to themselves as well as others. Mescaline severely distorts the cognitive processes and induces powerful, relatively long-lasting and vivid hallucinations.

4.1.1.6 Other Drugs

Antihypertensives
Dyazide
Propranolol

The anti-hypertensive drugs are of major therapeutic importance in controlling high blood pressure. While they have the relatively mild side effect of depression, their widespread use by older individuals increases the chance that their use may result in decrements in safety-critical performance.

4.1.2 Hazard Potential

The potential hazard associated with the use of inappropriate drugs by transportation personnel is a function of their acute and chronic impacts on safety-critical behaviors, and the extent to which the period of their effect overlaps with duty. The impacts of psychoactive drugs on behavior are very complex, with multi-dimensional main and side effects. To further complicate matters, such drugs frequently are used in combination, resulting in synergistic or antagonistic effects.

The use of the drugs listed above may alter the user's:

- Sensitivity to physical stimuli (external and internal);
- Quality of cognitive processing;
- Ability to concentrate on external stimuli;
- Ability to comprehend the relationship between internal mental states and external events; and
- Mood and emotional state.

Degradations in any of these factors can adversely affect operator performance when the period of the drug's effect overlaps the duty period. The following factors influence the likelihood of overlap:

- o High abuse potential - Drugs such as heroin are likely to cause psychological dependence because their use results in the rapid onset of high levels of pleasure. They also can result in physiological dependence, because cessation of use brings on an intense negative feeling. For these reasons, the user may not be able to limit drug use to off duty periods.

- o Distortion of the perception of the drug's effect - Drugs such as cocaine provide the user with strong feelings of well-being and the illusion of enhanced mental and physical performance. These effects increase the likelihood that individuals under the influence of the drug will engage in critical operations and even increase risk-taking behavior.

- o Reliance on the drug for treatment of chronic problems - Drugs such as Chlordiazepoxide (Librium) are widely used to combat the anxiety and the physical stress-related illnesses that are caused by anxiety.

- o Spontaneous reoccurrence of drug effects - There is some evidence that the users of drugs such as marijuana and LSD may experience drug effect "flashbacks" long after initial ingestion of the drug. This problem may occur in users of drugs whose active agents are absorbed by body tissues.

- o The desire of the user to mitigate negative aspects of the job - Individuals involved in low-event activity duty, such as long-haul rail freight operations, may use agents such as marijuana on the job to mitigate boredom. Individuals involved in extended and fatiguing duty may use CNS stimulants to maintain concentration and alertness.

4.1.3 Effects of Drugs on Performance

To understand the impacts of drugs on transportation safety, it is necessary to understand the extent to which the drugs affect behavioral processes that are essential to the performance of critical operations. While the safety-critical performances required of a general aviation pilot, a railroad freight engineer, and an urban bus driver differ widely, these performances depend on basic sensory, motor, cognitive, and emotional processes.

In this report, the effects of drug use on the following behavioral classes and subclasses were considered.

4.1.3.1 Sensory Function

This category refers to the ability of an individual to detect, feel, identify, discriminate between, and recognize objects and conditions. Because the information most critical to safe operation generally is visual in nature, the survey was restricted to visual functions. The exception is balance, which is a significant factor in many safety-critical activities.

Static Visual Acuity - The ability to resolve fine visual detail in relatively stationary targets. This is critical in tasks requiring the early detection and identification of small low contrast targets or discrimination between objects based on fine or low contrast features.

Dynamic Visual Acuity - The ability to resolve visual detail in moving targets. This is critical in situations where the operator must gain critical information from a rapidly changing scene or when operations take place in an environment with a high level of vibration.

Glare Recovery - The time required to regain "night vision" after exposure to high levels of illumination. This is critical in most night transportation operations where the data of interest are derived from a low light intensity field.

Color Discrimination - The ability to discriminate colors or to identify different color signals.

Peripheral Vision - The ability to detect objects, particularly those in motion, which are outside of the central area of visual concentration.

Critical Flicker Fusion - The maximum frequency at which a flickering light source is perceived as flickering. Strictly speaking, the ability to perceive flicker is not critical to any particular transportation job, but rather is often used as an easily measured concomitant of sensory function.

Balance - The normal function of the vestibular system is critical to tasks such as motorcycle and aircraft operations, and is a concomitant of sensory function.

4.1.3.2 Motor Performance

This category includes measures of the individual's ability to make timely, accurate, precise, and steady control movements.

Tapping Speed - Tapping speed is a frequently used simple laboratory measure of the ability to make rapid relatively coarse or "ballistic" movements.

Simple Reaction Time - Perhaps the single most frequently used indicant of psychomotor performance, simple reaction time measures the time required for an individual to make a planned ballistic movement[10] in response to an anticipated signal.

Complex Reaction Time - Complex or choice reaction time is a measure of the time required to discriminate between a small number of signals and make a simple ballistic response to one of them. While complex reaction time also

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[10] A ballistic movement is one which requires little or no positional feedback control. Examples include throwing a baseball or striking a key on a typewriter. Ballistic movements are contrasted with fine motor control movements. Examples of these include handwriting and the tuning of a radio.

measures simple information processing, it is included under motor performance because of the large psychomotor skill component.

Tracking - The ability to maintain a pointer or controlled marker on a moving target. Tracking tasks most frequently involve hand-eye coordination.

Steadiness - The ability to manually maintain a probe or pointer in a steady position. This measure has been used as an indicator of simple peripheral motor-function.

4.1.3.3 Vigilance

The term vigilance is used to describe the ability of an individual to detect and respond to extremely infrequent signals provided as part of a low event or boring task. Three measures generally are used to describe vigilance performance. They are:

False Alarm Rate - The proportion of the times the tested individual indicated that there was a signal when there was no signal.

Missed Signals - The times that the tested individual did not detect a signal when a signal was present.

Hit Rate - The proportion of the times the tested individual properly detected a signal.

4.1.3.4 Cognitive Functions

These are the functions that are commonly referred to as thought. They represent the abilities to classify, store, integrate, and recall information. In this report, the following sub-categories were considered:

Judgment - The ability to plan appropriate actions and responses to complex situations.

Risk-Taking Behavior - The extent to which individuals enter into or continue in behaviors that have potentially harmful outcomes.

Decision Making - The ability to identify an appropriate response to a choice situation in a timely manner.

Time Sharing - The ability to allocate mental resources to, and perform, two or more different functions during the same time period.

Mental Arithmetic - The performance of simple standardized arithmetic functions usually used as a secondary or "loading task" in studies of time sharing.

Information Processing - The ability to analyze and synthesize incoming and memorized information.

4.1.3.5 Memory

This term refers to the ability to store, retain, and access data mentally. The

following sub-categories were covered in this report:

Short-Term Memory - The ability to store and access data required for limited periods and to dispose of the data when they are no longer required. Examples include remembering the position of a momentarily obscured vehicle. Short-term memory is usually measured in minutes or parts of minutes.

Delayed Recall - The ability to access memorized data several minutes after learning.

Visual Retention - The ability to recall visual images.

4.2 EXPERIMENTAL STUDIES

One of the major purposes of this report was to determine the degree to which experimental studies of the effects of drugs on performance were adequate to support our understanding of the impact of drug use on transportation safety. To accomplish this, a survey of the literature was conducted and relevant investigations were synopsized.

Investigations were synopsized in this report only when they:

- Tested the drugs of interest;
- Tested behaviors that were related to the performance categories of interest;
- Used subjects who were representative of the normal population;
- Were experimental and quantitative in nature; and
- Provided unambiguous descriptions of the procedures, subjects, equipment, and statistical analysis used.

The material synopsized in this section represents the results of experimental investigations into the behavioral effects of the drugs listed in Sections 4.1 and 4.2. Each synopsis provides a brief description of the experimental design (including the drug dosages used, the number and types of subjects, and the dependent variables measured) and the results of the study. Where no germane studies were found, only a brief description of the general behavioral effects is provided.

4.2.1 Opiates

4.2.1.1 Codeine

Codeine's most frequent side effects are lightheadedness, dizziness, sleepiness, and nausea. Other possible effects are euphoria, headache, agitation, incoordination, faintness, hallucination, disorientation, and visual disturbances (Silverman and Simon, 1978).

The usual dose is 15 to 60 milligrams four times a day for relief of pain, or 10 to 20 milligrams every few hours to suppress a cough.

The literature search did not reveal any experimental investigations on the effects of codeine on performances of interest.

4.2.1.2 Heroin[8]

Heroin may produce a euphoric spasm or "rush" which many addicts compare to sexual orgasm. It may be followed by a "high" characterized by lethargy, withdrawal, relaxation, and a state of reverie (Coleman, Butcher, and Carson, 1984). Side effects may include mental clouding, inability to concentrate, drowsiness, apathy and inactivity (Blum, 1984).

The literature search did not reveal any experimental articles on heroin on the performances of interest. This is probably because of the legal, ethical, and practical difficulties of performing controlled studies on human subjects with such a dangerous drug. Although there were no relevant literature citations for heroin, as with other "hard" drugs with no recognized therapeutic uses, clinical observations indicate that the primary effect is so strong that there is little question that operator performance would be unacceptably degraded.

4.2.1.3 Methadone

Methadone's frequently observed side effects are "lightheadedness", dizziness, sedation, and nausea. Other adverse effects are euphoria, dysphoria, headache, agitation, disorientation, and visual disturbances (Physician's Desk Reference, 1985).

The usual dose is 5 to 15 milligrams to relive pain. The usual dose ranges from 20 to 120 milligrams per day for treatment of narcotic addiction.

The literature search did not reveal any experimental articles on methadone on the performances of interest.

4.2.2 CNS Depressants

4.2.2.1 Chloral Hydrate

Chloral hydrate's main side effect is reduction in alertness. It may also produce headache, hangover, hallucinations, drowsiness, feeling of excitement, lightheadedness, and dizziness (Silverman and Simon, 1978).

The usual dose is 500 mg to 1 gram as a sleeping medicine. As a sedative, the usual dose is 250 mg three times a day.

The literature search did not reveal any experimental articles on chloral hydrate on the performances of interest.

4.2.2.2 Meprobamate

Meprobamate's most likely side effects are drowsiness, sleepiness, dizziness, slurred speech, headache, and weakness. Other possible side effects are excitement and over stimulation (Silverman and Simon, 1978).

The usual dose as a tranquilizer is 1200 to 1600 milligrams per day.

Sensory Function

Townsend and Murphy (1960) investigated target recognition. This study also investigated a cognitive function which will be reported later in this section. Eight normal subjects, ages 18-22, ingested 800 and 1,600 milligrams of meprobamate or a placebo. They were tested two hours after ingestion. Their task was to recognize a target letter in a briefly exposed series of letters. Meprobamate, at the higher dose, impaired the ability to perceive the target letter.

Motor Performance

Kornetsky (1963) investigated simple reaction time and complex reaction time. Eight normal subjects, ages 18-22, ingested 800 and 1,600 milligrams of meprobamate and a placebo. They were tested 90 minutes after ingestion for 30-45 minutes. Meprobamate increased the time necessary to complete motor movements in simple and choice reaction time situations.

Kielholz et al. (1969) investigated choice reaction time. Two groups of 20 male subjects ingested either a placebo or 800 milligrams of meprobamate. Meprobamate increased choice reaction time.

In the same study Kielholz et al., (1969) investigated tracking. The subjects' task was to drive on a closed track and perform a maneuver which included turning, stopping, and parking. The experimenters recorded the number of major errors (knocking over wooden posts and crossing dividing lines). Meprobamate did not increase the number of major errors in this experiment.

Forney and Hughes (1964) also investigated the effects of meprobamate on tracking. Eight graduate students ingested 1,600 milligrams of meprobamate or a placebo. The medication was administered in four tablets over a 24-hour period preceding testing. They were tested one hour after ingesting the last capsule. The subjects' task is to keep a stylus in contact with a small spot on a moving turntable. Meprobamate did not degrade pursuit rotor tracking in this experiment.

Cognitive Functions

The study cited directly above (Forney and Hughes, 1969) also investigated performance on a number of arithmetic tasks under the stress of DAF. In this DAF procedure, the subjects' words are fed back through earphones slightly delayed. This process is known to be very irritating and disruptive to mental concentration. The subjects' tasks were progressive counting, simple addition, simple addition plus a mental seven, simple subtraction, and simple subtraction plus a mental seven. Meprobamate was not found to degrade performance on these simple arithmetic tasks in this study.

Kornetsky (1963), op. cit., also investigated the effects of meprobamate on a simple learning task. The subjects' task was to learn to associate a response button to the onset of a particular signal light. The dosages used were 800 and 1,600 milligrams of meprobamate. Meprobamate at the higher dose was found to degrade the subjects' simple learning ability.

Townsend and Mirsky (1960), op. cit. investigated digit symbol substitution. The subjects' task here was to associate and record symbols from a code. The

dosages used were 800 and 1,600 milligrams meprobamate. Meprobamate at the higher dose degraded the learning ability required in digit symbol substitution.

4.2.2.3 Methaqualone

Methaqualone may cause headache, hallucinations, hangover, fatigue, dizziness, nausea, restlessness, and anxiety. Continued use may result in loss of memory, inability to concentrate, tremors, loss of reflexes, and general sense of depression (Silverman and Simon, 1978).

Methaqualone has no currently accepted medical use.

The literature search did not reveal any experimental articles on methaqualone on the performances of interest.

4.2.2.4 Pentobarbital

Pentobarbital's main side effects are drowsiness, lethargy, dizziness, and hangover. Its recognized effect is the slowing down of physical and mental reflexes (Silverman and Simon, 1978).

The usual sedative dose is 30 milligrams three to four times per day. The usual hypnotic dose is 100 milligrams at bedtime.

Motor Performance

Goodnow et al. (1951) investigated tapping speed. Thirty normal male subjects, ages 18-26, ingested a placebo or 100 milligrams of pentobarbital. The medication was ingested at 1:45 a.m. The subjects were tested at 6:00 a.m. and 4:00 p.m., 7:00 p.m., and 10:00 p.m. The subjects' task was to tap as rapidly as possible on a telegraph key for ten seconds. Pentobarbital impaired tapping speed at the 6:00 a.m. and 4:00 p.m. testing sessions, i.e., four and fourteen hours after ingestion.

This same study (Goodnow et al., 1951) investigated simple reaction time. The subjects' task was to react as quickly as possible by pressing the telegraph key to the presentation of an auditory stimulus. Pentobarbital impaired simple reaction time to the auditory stimulus four hours after ingestion.

Memory

This same study (Goodnow et al., 1951) also investigated short-term memory. The subjects' task was to repeat digits backward immediately after they were presented. Pentobarbital degraded the ability to repeat digits backward four hours after ingestion.

4.2.2.5 Phenobarbital

Phenobarbital's main side effects are drowsiness, lethargy, dizziness, and hangover. It is recognized as having the effect of slowing down physical and mental reflexes (Silverman and Simon, 1978).

The usual anticonvulsant dose is 15 to 30 milligrams per day.

Sensory Function

Townsend and Mirsky (1960) investigated target recognition. Eight normal subjects, ages 18-22, ingested 60 or 120 milligrams of phenobarbital or a placebo. They were tested two hours after ingestion. Their task was to recognize a target letter in a series of briefly exposed letters. Phenobarbital did not impair target recognition in this study.

Motor Performance

Kornetsky (1963) investigated simple and complex reaction time. Eight normal subjects, ages 18-22, ingested 60 or 120 milligrams of phenobarbital or a placebo. They were tested 90 minutes after ingestion. Phenobarbital did not impair either simple or complex reaction time. in this study.

Kielholz (1969), op. cit., also investigated choice reaction time. The dosage was either a placebo or 200 milligrams of phenobarbital. Phenobarbital did not impair choice reaction time in this experiment. This study also investigated tracking. The subjects drove an automobile and the experimenters recorded major errors such as knocking over wooden posts and crossing dividing lines. Phenobarbital increased the number of major errors as measured by knocking over wooden posts and crossing dividing lines. It is concluded that phenobarbital degrades tracking skill.

Cognitive Functions

Townsend and Mirsky (1960), op. cit., investigated digit symbol substitution. The subjects' task here was to write down symbols from a code. The dosages were 60 or 120 milligrams phenobarbital or a placebo. Phenobarbital did not impair digit symbol substitution.

Kornetsky (1963), op. cit., investigated a simple learning task wherein the subject learns to associate a response button to a signal light. The dosages were 60 or 120 milligrams of phenobarbital or a placebo. Phenobarbital did not impair this simple learning task.

4.2.2.6 Secobarbital

Secobarbital's main side effects are drowsiness, lethargy, dizziness, and hang-over. It is recognized as slowing down physical and mental reflexes (Silverman and Simon, 1978).

The usual dose for sedation is 30 to 50 milligrams. The usual hypnotic dose is 100 to 200 milligrams at bedtime.

Motor Performance

Smiley, Moskowitz, and Ziedman (1985), op. cit., in their complex study, investigated tracking. The dosages were a placebo, 1.1 milligrams, or 1.2

milligrams of secobarbital per kilogram of body weight. The subjects were tested one hour after ingestion. Secobarbital adversely affected lane position variability and variability in maintaining headway to leading car. This may be considered evidence of degradation of tracking performance.

Cognitive Functions

Smiley, Moskowitz, and Ziedman, 1985, op.cit., investigated time sharing. The subjects' task was to extinguish peripheral light signals by turning the proper switch while engaged in driving a simulator. Secobarbital degraded performance on this time sharing task.

Smiley, Moskowitz, and Ziedman (1985) also investigated decision making. The subjects' task was to swerve or stop in reaction to a simulated emergency situation. Secobarbital increased the number of "crashes" at the higher (1.2mg) dosage.

4.2.2.7 Chlorpheniramine

The possible side effects of chlorpeniramine include sensitivity to light, headache, sleeplessness, dizziness, incoordination, confusion, restlessness, euphoria, blurred vision, double vision, nausea, and ringing in the ears (Silverman and Simon, 1978).

The usual dose for allergy or colds is four milligrams three to four times a day.

The literature search did not reveal any experimental articles on chlorpheniramine on the performances of interest.

4.2.2.8 Chlorpromazine

Chlorpromazine's main side effect is drowsiness. It can also produce symptoms that resemble Parkinson's disease and it can sometimes increase psychotic symptoms. Other side effects include tiredness, lethargy, restlessness, hyperactivity, confusion, depression, and euphoria (Silverman and Simon, 1978).

The usual dose is 30 to 1000 milligrams per day. This wide range of medication is used in treatment of disorders ranging from anxiety to severe psychosis. As noted above it is rarely prescribed for use outside of mental institutions.

Motor Performance

Milner and Landauer (1971) investigated dot tracking, pursuit rotor tracking, and reaction time and errors in a simulated driving test. Neither the tracking test nor the simulator were described. Two groups of seven subjects each received chlorpromazine or a placebo. The dosage used was one milligram per kilogram of body weight. Subjects were dosed both on the night preceding and on the morning of testing. Chlorpromazine impaired pursuit rotor tracking and reaction time in this study.

Manton (1977) investigated tracking. Four normal, male subjects, college students, ingested a placebo, or 20, or 40 milligrams of chlorpromazine. They

were tested one and five hours after ingestion. The subjects' task was to keep the needle of one meter in alignment with the needle of a second meter. Chlorpromazine, at both doses, decreased the total time on target one hour and five hours after ingestion. The decrease of total time on target is evidence that chlorpromazine degrades tracking ability.

Cognitive Functions

Montou, op. cit., also investigated time sharing. The subsidiary task was to detect peripheral signals while engaged in a tracking task. Chlorpromazine, at both doses, resulted in fewer signals being detected at both one and five hours after ingestion. This is evidence that chlorpromazine degrades time sharing.

4.2.2.9 Chlordiazepoxide

Chlordiazepoxide's major side effect is drowsiness. It may also produce confusion, lethargy, disorientation, headache, inactivity, tremor, and slurred speech (Silverman and Simon, 1978).

The usual dose is 5 to 100 milligrams per day as a tranquilizer.

Motor Performance

Kielholz, et al., (1969) investigated choice reaction time. The subject's task was to press a key with the left hand to the presentation of a green light and to press a key with the right hand to the presentation of a red light. Twenty male police officers ingested either a placebo or 20 milligrams chlordiazepoxide. It was found that chlordiazepoxide increased the number of choice errors.

The same study investigated tracking. The subject drove a vehicle on a closed track and performed such maneuvers as stopping, turning, and parking. Serious errors such as touching wooden posts and crossing dividing lines were recorded. Chlordiazepoxide did not have a deleterious effect on these measures in this study.

Schroeder et al. (1974) investigated tracking. The subjects' task was to drive an interactive film simulator for six minutes. Thirty normal, naive male subjects ingested either a placebo or 0.2 milligrams chlordiazepoxide per kilogram of body weight. The experimenters measured steering, brake, and accelerator errors. Chlordiazepoxide in this study did not affect steering, brake, or accelerator errors.

4.2.2.10 Diazepam

Diazepam (Valium) is a very widely used tranquilizer. Diazepam's major side effect is drowsiness. It may also produce confusion, depression, lethargy, disorientation, headache, inactivity, dizziness, tremor, slurred speech, and stupor (Silverman and Simon, 1978).

The usual dose is 2 to 40 milligrams per day.

Sensory Function

Berchou and Block (1983) investigated the effects of diazepam on critical flicker fusion. Their study used ten normal, naive subjects, ages 22-42, who ingested either a placebo or 15 mg diazepam. The subjects were tested eight times at half hour intervals following exposure to the drug. The task was to state whether an intermittent light stimulus appeared as intermittent or continuous. Diazepam decreased the critical flicker fusion frequency (i.e., the minimum frequency at which an intermittent light appears continuous). A decrease in this frequency is taken as an indication of reduced mental function. A second sensory task was to recognize a target digit in a series of digits presented for very short time intervals. Diazepam increased the time necessary to recognize the target digits. Diazepam, therefore, impaired signal recognition.

Motor Performance

Ghoeim, Newaldt, and Thatcher (1975) investigated the effects of diazepam on tapping speed. In this study, ten normal male subjects, ages 21-25, received drugs or placebos intravenously. They received 10 or 20 mg diazepam, 0.1 or 0.2 mg fentanyl, or a placebo. Performance was measured two, six, and eight hours after administration of the drug or placebo. The effect of diazepam at both doses was to impair tapping speed two hours after the drug was administered.

The same study also found that both doses of diazepam increased simple and complex reaction time variability. The increase in reaction time variability can be considered a performance impairment.

This study investigated a number of other safety-critical performance categories, including short-term memory, delayed recall, and visual retention. These results are described later in this section.

Three studies investigated the effects of diazepam on tracking. Smiley, Moskowitz, and Ziedman (1985) studied the effects of diazepam on tracking-related driving tasks. Forty-five male, normal subjects, ages 21-45, were divided into three equal groups. Subjects were tested at three dosage levels (0, 0.11, and 0.22 mg/kg of body weight) on three different occasions. Testing started one hour after ingestion. The task was to drive an interactive, electronic automobile simulator over a simulated 23.6 mile course for 45 minutes. The task included curve following, maintaining constant headway between a lead car that was varying speed, avoiding road obstacles, passing a lead car with obstacles in adjacent lane, distinguishing road signs, and making the appropriate turnoff. In addition to the primary driving task, the subjects were required to extinguish a peripheral light stimuli. This task was used to simulate attentional distractions. Diazepam increased lane position variability under all simulated highway conditions at both doses. The effects of diazepam on performances falling into the other categories of interest are described below.
Hughes, Forney, and Richards (1965) studied the effects of diazepam on pursuit rotor tracking. In this study, 18 normal subjects, ages 20-31, ingested either a placebo or six mg of diazepam per day for three days. They were tested one hour after their last drug dose. Diazepam was found to have no effect on pursuit rotor tracking.

O'Hanlon et al. (1982) studied the effects of diazepam on lateral position control in highway driving. The study used nine male police instructors, ages 24-34. Each subject drove an instrumented automobile for two 50 km laps over a four-lane rural highway course. They were exposed to five and ten mg doses of diazepam and a placebo control, or no placebo control. Lateral road placement variability increased in eight of the nine subjects given the ten mg dose. Lateral position placement taps tracking skills; therefore, an increase in position variability indicates tracking degradation.

Cognitive Functions

The simulated driving study (Smiley et al., 1985) measured highway passing performance, which may be considered risk taking. Subjects who were given diazepam were involved in a greater number of crashes. The same study investigated decision-making. The decision involved choosing to brake or swerve in response to a simulated emergency. Exposure to diazepam increased the time necessary to react.

This study also investigated timesharing. The task here was to detect and extinguish peripheral light signals as rapidly as possible. Diazepam did not affect either the number of peripheral lights detected or the mean reaction time to detect the signals.

Hughes et al. (1965), studied the effects of diazepam on mental arithmetic. This performance was conducted under the stress of DAF. In this procedure, the subject's words are slightly delayed and fed back through earphones. Diazepam was not found to have an effect on mental arithmetic performed under the stress of DAF.

Memory

Ghoneim et al., (1975) also investigated short-term memory. The subject's task here was to repeat digits backward. Both doses of diazepam impaired the performance of this task.

The same study investigated delayed recall by having the subjects reproduce a series of digits after an intervening task. Both doses of diazepam impaired delayed recall two hours after drug ingestion.

This study also investigated visual retention (i.e., the ability to report the detail of visual images) and found that this capability was not impaired by diazepam.

4.2.2.11 Flurazepam

Flurazepam's major side effect is drowsiness. It may also produce confusion, depression, lethargy, disorientation, inactivity, dizziness, tremor, and stupor (Silverman and Simon, 1978).

The usual dose is 15 to 30 milligrams at bedtime.

Motor Performance

Pishkin (1980) investigated simple reaction time. Ten normal, male subjects, ages 21-30, ingested 30 milligrams of flurazepam at their normal bedtime. Pre-drug performance was compared with performance the morning after drug administration. The subjects' task was to respond with the nonsense syllable TAT to the presentation of a brief stimulus light. Flurazepam did not impair simple reaction time in this study.

Saario and Linnoila (1976) investigated choice reaction time. Forty normal subjects, ages 21-26, ingested 30 milligrams of flurazepam or a placebo before bedtime for a period of two weeks. All subjects received a placebo on the first of seven nights. Thereafter one half of the subjects continued receiving a placebo and the other half received flurazepam. They were tested at 30, 90, and 150 minutes after ingesting a placebo at 8:30 a.m. over a 19 day period. Flurazepam did not impair choice reaction time in this study

Church and Johnson (1979) used the same experimental design as Saario and Linnoila (1976), op. cit. They used 24 subjects with an average age of 21. Twelve of the subjects were good sleepers and twelve were poor sleepers. The dosage was 30 milligrams of flurazepam per day, and testing was done in the morning 30 minutes after waking. The choice reaction time task was to press one of the four buttons corresponding to four stimulus lights. Flurazepam impaired choice reaction time throughout its period of administration. It is concluded that the degrading effect of flurazepam is not subject to tolerance development, i.e., the subjects reaction time does not recover to its pre-drug levels with continued use of the drug.

Saario and Linnoila (1976), op. cit., also investigated eye-hand coordination (the experiment was not described in the reference). Flurazepam was not reported to impair eye-hand coordination in this study.

Pishkin, et al. (1980), op. cit., also investigated pursuit rotor tracking. The dosage was 30 milligrams flurazepam. The subjects' task was to keep a stylus in contact with a small spot on a rotating turntable. Flurazepam was not found to impair pursuit rotor tracking in this study.

Cognitive Functions

Church and Johnson (1979), op. cit., investigated digit symbol substitution. The subjects' task was to associate and write down symbols from a code. Flurazepam degraded digit symbol substitution. There was a tendency to habituation, i.e., subjects tended to recover their original performance after several days on the drug.

Pishkin, et al., (1980), op. cit., also investigated the recognition of stimulus similarities and differences. The subjects' task was to state whether a physical feature in two successively presented stimuli were present or absent. Flurazepam degraded the ability to recognize stimulus differences.

Memory

Church and Johnson (1979), op. cit., investigated short-term memory by having subjects repeat a series of eight digits. Flurazepam did not impair this short-term learning ability in this study.

4.2.2.12 Flurazepam Residual ('Hangover') Effects

Flurazepam is generally administered at bedtime in the treatment of anxiety. This drug is known to have both acute and hangover effects. The acute effects are related to the presence of the drug in body tissues and fluids. Hangover describes the after effects of the use of an intoxicant on the body.

A study by O'Hanlon et. al (1983) describes both acute and hangover effects of flurazepam on subjects who had been long term users of the drug as part of the therapy to manage insomnia.

In the part of the study dealing with acute effects of flurazepam, 15 or 30 mg of the drug was ingested at 10:00 p.m. for two nights by 24 subjects. On the following day, subjects drove an instrumented vehicle in the morning and afternoon over a 100 kilometer highway circuit while attempting to maintain a constant speed of 95 kilometers per hour. Lateral position variability exhibited by subjects under the influence of flurazepam and under placebo was compared. Flurazepam impaired the subjects' ability to maintain the vehicle within lane boundaries. The impairment varied with the dosage. A residual or 'hangover' effect was also noted. This effect was stronger in the morning, but evident 17 hours after administration.

In the experiment investigating chronic use, four of the same subjects were administered placebos for two nights, 30 mg of flurazepam for eight nights, and a placebo for three days. Residual or 'hangover' effects were again evident; tolerance developed slowly and was not complete after seven days. The 'hangover' effects of flurazepam washed out after three days on placebo.

This study is important because it indicates that the impact of drug use continues after tissue concentrations return to normal levels.

It should be noted that, although the only drug study that investigated the hangover effect was on flurazepam, it should not be inferred that such an effect is not possible with other substances.

4.2.3 CNS Stimulants

4.2.3.1 Amphetamines (Amphetamine, Dextroamphetamine, and Methamphetamine)

The following material is abstracted from Wiener's (1985) overview of the pharmacological effects of amphetamines, powerful CNS stimulants which have found therapeutic use in the treatment of narcolepsy (a disorder characterized by frequent periods of involuntary sleep), depression, obesity, hyperactivity in children, and as an antidote to poisoning with CNS depressants.

The usual dose of dextroamphetamine is 5 to 60 milligrams per day to treat narcolepsy. The usual dose is 5 to 30 milligrams before meals for weight control.

The major illicit use of amphetamines is as a mental stimulant. In moderate doses, the oral ingestion of the amphetamines can increase wakefulness, elevate mood, increase initiative, enhance concentration, and improve the performance of simple mental tasks. The use of amphetamines can increase the amount of work accomplished on simple tasks, but does not decrease the errors committed during the performance of the tasks.

The most striking impact of amphetamines is in the reversal of the effects of fatigue on performance. While use of this class of drugs is not likely to improve the performance of rested, motivated individuals, it can aid individuals who are fatigued and/or suffering from lack of sleep. However Wiener notes that "beneficial effects of the drug have to be repaid in the coin of fatigue". They note that after heavy use, sleep patterns may take up to two months to return to normal. Another property of the amphetamines, which may be related to illicit use is their ability to increase the threshold at which individuals react to pain; particularly when used in combination with drugs such as morphine.

The amphetamines have a number of negative side effects including restlessness, increased anxiety, confusion, and, sometimes, paranoia and delirium. This is a particular problem because a tolerance to the primary effect of the drug is rapidly developed requiring the user to increase dosage to achieve the desired results.

The experimental literature indicates that under laboratory conditions amphetamines may enhance performance. However, the subject of this report is the impact of drug use on "real world" performance, and for reasons cited below, the extension of the laboratory results to transportation operations may not be appropriate.

Laboratory studies, which do not use individuals who habitually use amphetamines, do not reveal any degradations in performance, but frequently reveal enhanced performance. In an early review of the effects of amphetamines, Leake (1957) concluded that, based on experimental data and war time experience, amphetamine use could enhance safety and is a useful tool for the sleepy driver.

In his review of the effects of amphetamines on driving behavior, Hurst (1975)

indicates that due to the difficulty of data collection, epidemiological studies similar to those which established the increased risk of fatalities as function of alcohol intoxication have not been performed for amphetamines. In his review, Hurst finds only one driving-related study that reveals the negative potential effect of amphetamines on driving safety. In this study of thirty drug abusers, the eight amphetamine abusers studied were found to have four times the number of traffic accidents that would be expected statistically from demographically matched non-abusers.

The laboratory studies that indicate the beneficial effects of amphetamine use are not in conflict with the study cited by Hurst (op. cit. 1975). Although the laboratory studies revealed potentially beneficial short-term effects, the use of these drugs in uncontrolled, real-world situations may provide negative side effects. Amphetamines are believed to be used by operators to extend performance beyond safe duty limits. Under uncontrolled conditions, the operators may rely on such drugs to sustain alertness and concentration for periods that go beyond the period of effectiveness of the drugs. As the effects of fatigue and lack of sleep increase, the operator may increase the dosage resulting in the build-up and finally predominance of the negative side effects of the drug. These include blurred vision, dizziness, loss of coordination, paranoia, and irregular heartbeat followed ultimately by physical collapse.

Motor Performance

Bye et. al. (1973) studied the effects of Dextroamphetamine on motor performance. In tests using 12 paid normal subjects, they found no significant improvement or degradation in the performance of motor tasks such as tapping speed and hand steadiness by subjects exposed to doses of 2.5 mg, 5.0 mg, and 7.5 mg dextroamphetamine and those given placebos.

Schroeder and Collins op. cit. (1974) investigated the effects of d-amphetamine on compensatory tracking performance under stationary conditions and during angular acceleration. Thirty male college students were exposed to 10 mg d-amphetamine, 100 mg of secobarbital, or a placebo. They were required to maintain a pointer (an aircraft localizer/glide slope indicator) in the middle of a scale through the use of a joy-stick. Under static conditions, the apparatus subjects were seated in remained stationary; under dynamic conditions, the device rotated at 10°/sec= The subjects' tracking performances showed statistically significant improvement after the ingestion of d-amphetamine under both static and dynamic conditions.

Vigilance

Bye et al. op. cit. (1973) studied the effects of Dextroamphetamine on vigilance. In tests using 12 paid normal subjects, they found significant improvement in the performance of an auditory signal vigilance task by subjects exposed to doses of 5.0 mg and 7.5 mg dextroamphetamine relative to subjects given placebos.

Cognitive Performance

Bye et al. op. cit. (1973) studied the effects of Dextroamphetamine on cognitive performance. In tests using 12 paid normal subjects they found no significant improvement or degradation in the performance of cognitive tasks such as counting and mental arithmetic by subjects exposed to doses of 2.5 mg, 5.0 mg, and 7.5 mg dextroamphetamine and those given placebos.

Hughes and Forney (1964) investigated the effects of d-amphetamine, ethanol and d-amphetamine and ethanol in combination on the performance of simple cognitive tasks such as reading, reverse reading, reverse counting, and simple arithmetic under DAF produced stress. Eight paid college students received a placebo, 20 mg d-amphetamine, 45 ml ethanol/68 kg body weight, or both d-amphetamine and the alcohol. The blood alcohol levels achieved (0.04-0.05 percent) resulted in decreased levels of performance. Ingestion of d-amphetamine by itself did not improve performance and it did not counteract the effects of the ethanol.

4.2.3.2 Cocaine

Cocaine's mental effects are very similar to those of the amphetamines. The effects include euphoria and inappropriate perceptions of confidence, competence, greater precision of thought and action, and immunity to fatigue. Other effects are unclear speech, tremors, excitability, confusion, dizziness, and sleeplessness. Use may result in amphetamine-like psychosis with paranoid indication and delusions of persecution and omnipotence (Coleman, J.C., Butcher, J.N., and Carson, R.C., 1984).

The literature search did not reveal any experimental articles of cocaine on the performances of interest. A major danger to transportation is the extreme overconfidence and euphoria which is likely to lead to increased risk taking.

4.2.3.3 Antidepressants

Imipramine and Amitriptyline are used in the treatment of depression. When administered to individuals suffering depression, they can provide relief after a few weeks of treatment. When administered to normal individuals, they cause a feeling of unpleasant dullness, lightheadedness, and/or sleepiness. In general they interfere with thought processes and have a number of unpleasant physical side effects such as a drying of the mouth.

The usual dose for imipramine is 75 to 200 milligrams per day. The usual dose for amitriptyline is 25 to 50 milligrams, three times per day.

Sensory

Seppala (1977) studied the effects of Amitriptyline on Critical Flicker Fusion Frequency (CFFF). Twenty normal medical students were dosed with 25 mg Amitriptyline alone and in combination with alcohol at a dosage of 0.5 g/kg body weight. Performance with Amitriptyline and Amitriptyline taken with alcohol was compared to performance with a placebo, Mianserin alone (another antidepressant), and Mianserin in combination with alcohol, impaired CFFF (the

minimum frequency at which flicker could be perceived was increased) in subject groups which received Amitriptyline alone and in combination with alcohol.

Motor Performance

Landauer et. al. (1969) investigated the effects of Amitriptyline and Amitriptyline in combination with alcohol on simulated driving, and DOT tracking, and Pursuit rotor tracking. Twenty-one subjects received 0.8 mg/k body weight, a placebo, alcohol sufficient to reach a 0.8 percent BAC, or both Amitriptyline and alcohol. Pursuit rotor performance was impaired by the Amitriptyline (relative to performance under placebo), all three types of performance were impaired by the combination of alcohol and Amitriptyline (relative to the Amitriptyline, or alcohol alone, or the placebo).

Seppala (1977) op. cit. studied the effects of Amitriptyline on choice reaction performance, and tracking in a driving simulation. Twenty normal medical students were dosed with 25 mg Amitriptyline alone and in combination with alcohol at a dosage of 0.5 g/kg body weight. Performance with Amitriptyline and Amitriptyline taken with alcohol was compared to performance with a placebo, another antidepressant Mianserin alone, and Mianserin in combination with alcohol. There were significant increases in errors in both the choice reaction time task and the tracking task, in subject groups which received Amitriptyline.

Vigilance

Wittenborn et. al. (1976) studied the effects of Imipramine on vigilance. Ninety paid male college students were dosed with a placebo, 25 mg of Imipramine, or 25 mg Nomifensine (another antidepressant). The subjects who received Imipramine showed significant degradation in their ability to perform a vigilance task relative to those receiving the placebo.

Cognitive Function

Clayton et al. studied the effects of Imipramine on a measure of risk taking, gap acceptance in automobile driving. Forty normal male subjects were dosed with a placebo, 25 mg Imipramine, or 50 mg Viloxazine. The administration of Imipramine increased significantly the risks the subjects were willing to accept.

Wittenborne et. al. (1976) op. cit. studied the effects of Imipramine on digit symbol substitution (a test component of adult intelligence tests). Ninety paid male college students were dosed with a placebo, 25 mg of Imipramine, or 25 mg of Nomifensine (another antidepressant). The subjects who received Imipramine showed significant degradation in their ability to perform a vigilance task relative to those receiving the placebo.

3,4-Methylenedioxyamphetamine

3,4-Methylenedioxyamphetamine (MDA), sometimes referred to as "Ecstasy," is classed as an LSD-like drug with other properties (Jaffe 1985). In the case of MDA, it is LSD-like in that it produces vivid and organized hallucinations. Its

other properties include producing a marked euphoria or feeling of well being.

No experimental articles on the influences of 3,4-Methylenedioxyamphetamine on the performances of interest were found.

4.2.4 Hallucinogens

4.2.4.1 Marijuana

Small doses of marijuana produce euphoria, relaxation, a shortened attention span, and distortion of the sense of time and space. Larger doses impair motor response, motion coordination, and logical thinking, as well as producing illusions, hallucinations, and transient psychotic reactions (Benjamin, 1972).

Sensory Function

Brown, Adams, Haegerstrom-Portnoy, and Jones (1975) investigated the effects of marijuana on the ability to perceive detail in moving objects. Their study used ten normal, experienced subjects, ages 18-28. The subjects received a placebo, or an eight or 15 mg THC in an 800 mg cigarette to be smoked within a 10-15 minute period. They were tested one hour before smoking and five times after smoking for a period of six hours. High and low contrast targets were presented. The higher marijuana dosage produced significant decrements for both types of targets. This indicates that subjects under the influence of marijuana cannot perceive fine detail. The effect was dose-related for the high contrast target, i.e., there was a greater decrement with the higher dosage than the lower dosage.

Adams, Brown, Haegerstrom-Portnoy, and Flom (1976) investigated the effects of marijuana on color discrimination. Nine normal, experienced marijuana users, ages 19-28, were given marijuana. They smoked eight or 15 mg THC or a placebo over a ten minute period in an 800 mg cigarette. The placebo was THC-extracted marijuana. The subjects were tested 30 and 90 minutes after smoking. The task was to match color standards over the entire color spectrum. There was no time limit. The lower dose had no effect. The higher dose increased overall errors with the main decrement occurring in the blue region and a secondary decrement in the red region. The effect is strong at 30 minutes and back to pre-smoke levels after 90 minutes.

Kiplinger, Manno, Rodda, and Forney (1971) investigated balance. Balance or standing steadiness was tested with the eyes open or shut and with or without platform vibration. Eight experienced and seven naive, normal subjects smoked marijuana.

Three subjects were exposed to each dosage, and a total of 15 subjects smoking 0.0, 6.25, 12.5, 25, and 50 micrograms of THC per kg of body weight were used. Doses were administered at one week intervals at the same time of day on the same day of the week. This study also investigated the effects of marijuana on tasks other than balance which are reported in other parts of this section. The doses of marijuana were directly related to the decrement produced. The ability to stand steadily was impaired, and the extent of impairment increased with marijuana dosage. Differences between naive and experience subjects were

not reported.

Motor Performance

When Milstein, MacConnel, Karr, and Clark (1975) investigated finger and toe tapping, marijuana was found to have no effect.

Eight studies reported below investigated a variety of tracking tasks conducted in the laboratory on simulators, on closed tracks, and in the field.

Dott (1972) investigated tracking. The subject's task was to drive an interactive, optical automobile simulator. An experimental, electronic passing aid system provided visual and auditory information which the subject could use to pass the lead car he/she was following. The track of the selected path during the pass of the lead vehicle was recorded. Marijuana did not affect the track during the pass.

Janowsky, et al., (1976) investigated the "flying" of four holding patterns of four minutes each in an ATC-510 instrument flight simulator. This is considered a tracking study since the goal is achieved by nulling displays representing course, altitude, and heading. In the study, ten normal, experienced male subjects, ages 21-40, smoked marijuana. Seven professional pilots and three private pilots received either a placebo or 0.09 milligrams THC per kilogram of body weight in a pipe. They were tested for 30 minutes, two, four, and six hours after smoking. Marijuana increased major errors (e.g., taking the airplane out of designated air space) and minor errors (e.g., course deviation, altitude error, and heading error) 30 minutes after smoking.

Manno, Kiplinger, Haine, Bennett, and Forney (1970) investigated pursuit rotor tracking. The task here was to keep a light-sensitive probe in contact with a moving spot on a rotating drum. Eight normal, experienced subjects, ages 23-29, smoked either a placebo of THC-extracted marijuana or 10 mg THC. Other tasks investigated by this study will be reported below. Marijuana was found to impair pursuit rotor tracking.

Moskowitz, Hulbert, and McGlothin (1976) investigated tracking on a film automobile simulator. Performance on a subsidiary task was also investigated in this study and will be reported in the section on time-sharing. Twenty-four normal, experienced male subjects smoked marijuana in dosages of 0, 50, 100, or 200 micrograms THC per kilogram of body weight. Two cigarettes were smoked in 20 minutes in sessions one week apart. One subject dropped out of the experiment. Marijuana was not found to have an effect on this simulated driving task.

Smiley, Moskowitz, and Ziedman, (1985) investigated the effects of marijuana on tracking in their very complex study. Forty-five normal, experienced subjects, ages 21-45, smoked a placebo of THC-extracted marijuana, 100 or 200 micrograms of THC in a 1,000 milligram cigarette within ten minutes. Testing began five minutes after smoking. Marijuana adversely affected lane position variability and headway variability under all simulated conditions.

Roth, Tinkleburg, Whitaker, Darley, Kopel, and Hollister (1973) investigated

tracking. The subject's task was to maintain a cross in the center of vertical lines that were moving horizontally. Forty-one normal, experienced male subjects, ages 18-22, ingested 20 milligrams of THC or a placebo. They were tested before ingestion and 30-60 minutes after ingestion. It was found that tracking error increased.

Weil, Zinberg, and Nelsen (1968) investigated pursuit rotor tracking. In this task, the subject had to keep a stylus in contact with a small spot on a moving turntable. Nine normal, naive subjects, ages 21-26, and eight normal, experienced subjects, also ages 21-26, smoked marijuana in two cigarettes in a period of 8-12 minutes. The naive subjects were tested with doses of 4.5 and 18 mg THC, whereas the experienced subjects were tested at the higher dose only. All subjects were tested 15 and 40 minutes after smoking. The performance of the experienced subjects was not affected. Marijuana impaired the pursuit rotor performance of the naive subjects. The larger dosage caused greater tracking degradation than the lower dosage.

Klonoff (1974) investigated driving on a closed-track and on Vancouver city streets. In both experiments, an observer in the front seat rated the subjects' driving performance. Sixty-four subjects (43 male and 21 female) participated in the closed-course experiment. Thirty-eight of the same subjects (25 male and 13 female) participated in the Vancouver city streets experiment. Dosage was a placebo or 4.9 or 8.4 mg of THC. Marijuana produced decrements on the closed course that increased with dose. In the city streets, marijuana produced a decrement at the high dose only. No differences were found due to sex, driving experience, or previous marijuana use.

Milstein, MacConnell, Karr, and Clark (1975) investigated hand steadiness. The subjects' tasks were to move a stylus in vertical or horizontal grooves, and to place the stylus in progressively smaller holes. The dosage was either a placebo or 600 milligrams of 1.3 percent THC. Marijuana increased the number of errors and total contact time with the sides of the grooves and holes.

Vigilance

Moskowitz (1974) investigated auditory signal detection. The subjects' task was to sit in a sound proof booth with earphones which sent signals in noise to one ear and digits to the other ear. In the concentrated attention condition, the subject was to report the signal and ignore the noise. In the divided attention condition, the subject was to report the signal and the digits. Twenty-three normal, experienced male subjects, ages 21-32, received five dosages. These doses were no marijuana, THC-extracted marijuana, 50, 100, and 200 milligrams THC per kilogram of body weight. Marijuana produced decrements in signal detection on both the concentrated and divided attention conditions. The degradation of signal detection was greater when the subject's attention was divided. The impairment in signal detection was due to both missed signals and false alarms. The increase in false alarms was twice as great as that of missed signals.

Sharma and Moskowitz (1974) investigated visual signal detection. The subject's task was to report the single and double jumps of a stimulus light. In the low attention or low arousal condition, the subject responded with the right hand to

the double jump. In the high attention or high arousal condition, the subject responded with the right hand to the double jump and with the left hand to the single jump. Twelve normal, experienced male subjects, ages 21-34, smoked either a placebo of detoxified marijuana or 200 micrograms of THC per kilogram of body weight. Marijuana produced impairment in both high and low attention conditions. The errors in signal detection were due to an increase in missed signals and not an increase in false alarms.

Cognitive Functions

Dott (1972) investigated risk-taking by comparing the number of passes attempted or completed with and without marijuana. The dosages in this study were no smoking or smoking 11.25 and 22.5 milligrams of THC per kilogram of body weight. Marijuana did not affect the number of passes attempted or the number of crashes, but it did result in fewer passes being completed. This result was interpreted as an indication that marijuana subjects are less likely to accept risk.

Smiley, Moskowitz, and Ziedman (1985) also investigated risk-taking in their very complex study. Risk-taking was measured by the number of passes attempted in the electronic, graphic display simulator. Marijuana resulted in fewer passes being attempted. The passes attempted, however, resulted in more crashes.

Moskowitz, Ziedman, and Sharma (1979) investigated time-sharing. The subjects' task was to watch a filmed driving scene and to release a switch at the occurrence of important traffic events. Their subsidiary task was to report the position of an arrow presented left or right by activating the turn signal right or left.

Ten normal, experienced male subjects, ages 21-26, smoked dosages of placebo (detoxified marijuana), or 50 and 200 micrograms THC per kilogram of body weight. Marijuana did not have an effect on detection of the peripheral signals.

Moskowitz, Hulbert, and McGlothin (1976) also studied time-sharing in their film simulator. The dosages were a placebo of THC-extracted marijuana, 50, 100, and 200 micrograms of THC per kilogram of body weight. Their time-sharing task was to activate one of four levers corresponding to four light signals. Marijuana increased the reaction time to the light signals. It is concluded that marijuana degrades time-sharing.

Smiley, Moskowitz, and Ziedman (1985) also investigated time-sharing. The subjects' time-sharing task was to extinguish peripheral light signals by turning the proper switch. The dosages used were a placebo of THC-extracted marijuana, 100 and 200 micrograms of THC per kilogram of body weight. Marijuana, though not decreasing the number of signals detected, did result in increased reaction time to the signals. The increased reaction time was interpreted as indicating degradation of the time-sharing.

4.2.4.2 Phencyclidine

Phencyclidine at low doses and moderate doses produces feelings of floating, euphoria and emotional liability. It may also produce agitation, withdrawal, incoordination, distorted perception of one's own body, misinterpretation of sensory data, disorientation, incoherent speech, and a "blank stare." Higher doses may result in coma, confusional states, schizophrenic behavior of long duration, respiratory depression, and death (Altrocchi, J., 1980).

The literature search did not reveal any experimental articles on phencyclidine on the performances of interest.

4.2.4.3 Mescaline

Mescaline's effects include tremors, anxiety, hyperreflexia, and may be followed by distortions of color and space and visual hallucinations (Hoffman, F.G., 1975).
The literature search did not reveal any experimental articles on mescaline on the performances of interest.

4.2.5 Other Drugs

4.2.5.1 Hydrochlorothiazide and Triamterene (Dyazide)

Dyazide's side effects are drowsiness, lethargy, headache, and mental confusion. Dyazide may also produce restlessness, sensitivity to sunlight, dizziness, weakness, and blurred vision.

The usual dose is one capsule twice per day.

The literature search did not reveal any experimental articles on Dyazide on the performances of interest.

4.3 UTILITY OF EXPERIMENTAL INVESTIGATIONS REVIEWED

Relatively few relevant quantitative investigations of the behavioral effects of the drugs of interest were identified. Table 3 summarizes the investigations by drug and performance category. For each entry, the first number represents the number of relevant articles found, the second whether the effect found in the investigation was an enhancement or a degradation of performance, and the third entry is the number of articles which found the effect.

The majority of the relevant investigations found were performed with licit drugs whose major effects are on the central nervous system. No relevant investigations were found on the side effects of licit drugs on the central nervous system.

Of the illicit drugs, only marijuana has been the subject of relevant investigations. This may be because of its popularity, because it is believed to provide less of a risk to the experimental subjects than harder drugs, or because continuing debate of decriminalization has raised questions about its effects.

The investigations identified measured behavior using traditional laboratory procedures such as tracking, complex reaction time, and vigilance. These procedures are

Table 3 Drug/Performance Matrix

	SENSORY FUNCTION	MOTOR PERFORM.	VIGILANCE	COGNITIVE FUNCTIONS	MEMORY
OPIOIDS					
CODEINE					
HEROIN					
METHADONE					
CNS DEPRESSANTS					
SEDATIVE/HYPNOTICS					
CHLORAL HYDRATE					
MEPROBAMATE	(1)deg[1]	(2)deg[1]		(3)deg[2]	
METHAQUALONE [QUAALUDE]					
PENTOBARBITAL	(2)deg[2]				(1)deg[1]
PHENOBARBITAL	(1)deg[0]	(3)deg[1]		(2)deg[0]	
SECOBARBITAL		(1)deg[1]		(2)deg[2]	
ANTIHISTAMINES					
CHLORPHENIRAMINE					
TRANQUILIZERS					
CHLORDIAZEPOXIDE*[LIB]		(3)deg[1]			
DIAZEPAM [VALIUM]	(2)deg[2]	(5)deg[4]		(6)deg[3]	
FLURAZEPAM	(4)deg[1]			(2)deg[2]	(1)deg[0]
CHLORPROMAZINE		(3)deg[3]		(1)deg[1]	
CNS STIMULANTS					
AMPHETAMINE					
DEXTROAMPHETAMINE		(2)enh[1]	(1)enh[1]	(2)enh[0]	
METHAMPHETAMINE					
COCAINE					
ANTI-DEPRESSANTS					
IMIPRAMINE*			(1)deg[1]	(2)deg[2]	
AMITRIPTYLINE	(1)deg[1]	(2)deg[2]			
3,4 METHYLENEDIOXYAMPHET.					
HALLUCINOGENS					
MARIJUANA	(3)deg[3]	(9)deg[6]	(2)deg[2]	(5)deg[3]	
PHENCYCLIDINE [PCP]					
MESCALINE					
OTHER					
DYAZIDE					
PROPRANOLOL [INDERAL]					

* and other similar drugs
(N) = Number of laboratory investigations found
Enh = Investigation revealed enhanced performance
Deg = Investigation revealed degraded performance
[N] = Number of investigations indicating enhanced or degraded performance

known and used throughout the world to provide comparable measures of the effects of various factors on performance. However, because performance is always profoundly affected by factors such as the context of the study and the prior experience and training of the subject population, differences in scores on such tasks provide a relative rather than an absolute measure of the effects dependent variables such as drug dose level.

Some of the studies examined the effects of drugs on the performance of simple, highly controlled laboratory tasks. Other studies attempted to simulate actual driving situations by use of extra laboratory facilities such as closed driving courses. However, none of the investigations reviewed provided evidence which would allow a direct assessment of the risk associated with the use of the drug in a transportation setting.

The review did find a number of well conducted studies which demonstrated that certain licit drugs did cause significant degradations in safety critical behaviors. Considering the wide use of drugs such as librium it would appear that any regulatory program concerned with the impact of drug use on transportation safety must deal with these drugs as well as the illicit substances, such as cocaine, that are featured so prominently in the media.

5.0 TOXICOLOGICAL TESTING

Drug screening, which determines the presence of drugs, and drug confirmation, which confirms the presence of suspected drugs, are the two major types of toxicological testing. The most widely-used drug screening and confirmation techniques are:

- Thin layer chromatography;
- Immunoassay techniques;
- Gas chromatography;
- High-pressure liquid chromatography; and
- Gas chromatography-mass spectrometry.

Testing may be performed before an employee in hired or returned from a furlough (pre-employment testing), while an employee is working (on-the-job testing), or after an accident has occurred (post-accident testing). The circumstances under which the testing is administered are a major factor in determining the kinds of toxicological testing that are required. Other important considerations include:

- Type of information required (i.e., whether or not a drug is present in the testing sample, or the amount of the drug in the sample);
- Types of samples required for the testing (i.e., body tissue or fluid);
- Types of samples available;
- Available sample handling and preservation procedures; and
- Available facilities and testing costs.

5.1 SAMPLE REQUIREMENTS

5.1.1 Pre-employment Screening

Pre-employment screening can be used by employers to determine whether prospective employees have a history of drug use or have been using drugs during an extended furlough. Indications that drugs are being used usually result in the candidate's not being hired or rehired.

Most pre-employment screening is performed on urine samples immunoassay and thin layer chromatography screens. These screens provide only qualitative analysis; i.e., information on what drugs are present above some threshold level, rather than information on the quantity of each drug. Care must be taken that the samples are properly labelled, contain urine from the proper subject, and that the labels are not lost or transposed when the samples are in transit. (More detailed information on urine testing procedure may be found in Appendix 2.)

5.1.2 On-the-job Screening

On-the-job screening is a procedure that has been proposed for use with employees whose job performance may affect public safety. For these types of positions, it has been proposed that employers require periodic or random on-the-job drug testing as a condition of employment.

The combination of on-the-job screening followed by confirmation testing may be used when there is a good reason to suspect that an employee is using drugs, when an employee is participating in some form of mandatory drug rehabilitation program,

or when a serious accident has occurred. Confirmation testing must be performed in cases when the drug test results must be admissible as evidence in a court of law and should be performed whenever an individual tests positive for a prohibited drug.

On-the-job screening has the same requirements, and may be performed using the same techniques, as the pre-employment screening described in Section 5.1.1. In addition, if disciplinary action is anticipated, a confirmation must be performed for each drug detected in the preliminary screening.

If legal action is anticipated as a result of an on-the-job test, a comprehensive drug screen is recommended. This type of screen provides both confirmation and an indication of the concentration of each drug present. Acceptable comprehensive screening techniques are gas chromatography, liquid chromatography, and gas chromatography-mass spectrometry. Samples of urine, serum, or gastric fluid are required for these types of comprehensive drug screens, with the most complete analysis available when serum and urine are submitted together. (More detailed information on the requirements for comprehensive drug screening can be found in Appendix 2.)

5.1.3 Post-accident Screening

Drug screening followed by confirmation testing may be performed in the aftermath of a serious accident or incident. Post-accident testing may involve an injured party, a fatally injured person, or an uninjured party involved in the accident. For an uninjured party, the sample and test requirements and considerations would be the same as those for the comprehensive drug screen described for on-the-job testing.

With regard to fatally injured persons, there are two time periods of interest. The first is the time between the occurrence of the accident and the occurrence of death. During this time, any drugs in the system continue to be metabolized. The second time period is the time between death and the drawing of specimens. During this period, bodily tissues and fluids begin to decompose.

The first time period is of great importance because an accurate measurement of the concentration of drugs at the time of the accident is needed to indicate their possible role in that accident. In addition, medical treatment may introduce other drugs into the body fluids. Some investigators believe that specimens should not be collected more than four hours after an accident.

With regard to the second period of interest, it is imperative that samples be collected as soon as possible after death. Badly decomposed specimens complicate drug testing because substances that interfere with screening increase greatly with time.

In any case, any and all specimens that can be taken from a fatally injured person should be collected. Collection of a urine sample may be impossible, since urine normally is voided upon death. The preferred sample is a properly collected and stored blood sample taken directly from the heart. Confirmation of a drug's presence in other specimens lends credibility to results obtained from analyzing a blood sample. Specimens which may be available from autopsies of highway fatalities include the bile, liver, gastric contents, brain, cerebrospinal fluid, and the vitreous humor of the eye. However, the practicality and utility of collecting these tissue

and fluid samples from fatally-injured samples from fatally-injured operators may depend on how traumatic the death was, since some specimens may be rendered useless due to destruction or contamination.

Obtaining a sample from an injured person can present serious problems, particularly if those injuries are serious and require immediate medical attention. Medical attendants will properly be concerned with saving the person's life and life-saving measures will take priority over obtaining a sample for drug testing. The patient may be given medication that would give false drug indications or mask the presence of pre-accident drug use. The injured person may be transported away from the accident scene and out of the jurisdiction of those charged with drug testing. Often blood or urine samples are taken for testing to aid in the medical treatment; ideally, some portion of those samples should be reserved for toxicological testing as well. Until the drug test becomes an accepted part of the medical routine in an accident case, it seems likely that useful samples may not always be obtained from injured people.

It should be noted that properly collected and frozen samples can be stored almost indefinitely and analyzed at a later date with no loss of analytical accuracy. Careful collection, storage, transportation, and record keeping are necessary if correct analytical results are to be obtained.

5.2 DRUG ANALYSIS TECHNIQUES AND THEIR ADVANTAGES/DISADVANTAGES

Following are brief descriptions of the major types of toxicological analysis techniques. More detailed information on these techniques may be found in Appendix 2.

5.2.1 Immunoassay Techniques

The immuno-chemical methods are characterized by their use of antibodies obtained from animals that are injected with drug-attached antigens or haptens. This procedure is based on the detection of the reaction between an antibody and an antigen, which generates an antibody. An antigen is a chemical (hapten) which, when injected into an experimental animal, provokes an immune response in an animal's blood.

To detect the antibody associated with a given drug, labeled antigens must be added. Of the techniques available for labeling antigens, only the Radioimmunoassay Technique (RAI) and the Enzyme Multiplied Immunoassay Technique (EMIT) have been successfully applied to drug testing. However, the RAI technique has been applied to only seven drugs, is expensive, requires the use of radioactive isotopes and expensive radioactive counting equipment, and involves considerable operator skill. Therefore, the discussion of immunoassay techniques is limited to EMIT.

The EMIT system provides good sensitivity and precision along with good specificity. The main disadvantage of the EMIT system is that a labeled antigen must be available for each different drug to be detected; development of the labeled antigen may be very time-consuming, costly, and in some cases may not be possible. (More detailed information on the immuno-chemical methods can be found in Appendix 2.)

5.2.2 Thin Layer Chromatography (TLC)

Chromatography is a physical method for separating or partitioning the various components in a mixture. TLC, like gas chromatography (GC), is one of the few methods available that is versatile enough to test for an entire array of drugs. Unlike gas chromatography, more than one sample at a time can be run with TLC, and TLC is much cheaper to run. However, TLC has a number of disadvantages. It requires large sample volume to obtain the degree of specificity required. In addition, the extraction of drugs from a urine sample is a prerequisite for TLC. The variation in extraction and clean-up among laboratories makes TLC a qualitative technique under the worst conditions and, at best, a semi-quantitative technique. Thus, the use of TLC systems seems to be restricted to the preliminary identification of drug substances. (More detailed information on TLC can be found in Appendix 2.)

5.2.3 Gas Chromatography (GC)

Gas chromatography applied to general drug screening has won increasing acceptance. The primary advantage of gas chromatography over TLC, which also can be used to test for an entire array of drugs, lies in the greater variety and sensitivity of the detectors used in gas chromatography. One disadvantage is that samples must be volatile to be analyzed by gas chromatography; i.e., a sample must be capable of being vaporized. Some drug samples cannot be vaporized under normal gas chromatography conditions or are thermally unstable and must be analyzed by other techniques, such as high-pressure liquid chromatography. (More detailed information on gas chromatography can be found in Appendix 2.)

5.2.4 High-pressure Liquid Chromatography

High-pressure liquid chromatography (HPLC) is a restricted form of liquid chromatography. As noted in Section 5.2.3, the main advantage and use of HPLC (as compared to GC) is in the analysis of non-volatiles and thermally unstable compounds. The applicability of currently available HPLC techniques to drug analysis in biological fluids does not seem great, and there is little possibility that HPLC will replace GC where the latter is performing acceptably. HPLC remains a separation technique that supports GC methods. HPLC also has specific applications for the analysis of samples screened by TLC; because HPLC is very similar to TLC, samples that cannot be separated using TLC usually can be separated by HPLC. (More detailed information on HPLC can be found in Appendix 2.)

5.2.5 Gas Chromatography-Mass Spectrometry

The most widely used technology for quantitative drug analysis is the combined technique of gas chromatography-mass spectrometry (GC-MS). This combination of analytical instruments brings together the capability of GC separations with the sensitivity and structural specificity of MS. The quantitative potential of the GC is enhanced by several orders of magnitude, with analysis in the picogram (one-trillionth of a gram) range being performed. The GC-MS technique is direct, very fast, very sensitive, and provides a result that puts identification beyond dispute.

Computer-assisted operation of relatively low-cost commercial GC-MS instruments has further extended the analytical power of this method. Computers can plot mass spectra information, on which a library search can be executed to identify the

compound that is most likely to produce a given mass spectrum. The reference spectra, in combination with known GC-retention times, serve to identify unknown drugs and drug metabolites beyond the need for confirmatory procedures. Thus, a GC-MS analysis can serve as both a screen and a confirmation with quantitative results.

The main disadvantage of GC-MS is the initial high cost of the equipment. However, a laboratory with a large sample turn-around would find that such equipment would quickly pay for itself because of the analytical method's speed and accuracy. Automated GC-MS is the only method that can rapidly and specifically provide a legally viable analysis of a blood sample for a broad range of drugs. A system capable of picogram drug analysis is available now for approximately $65,000, a cost low enough so that almost every laboratory performing toxicological analysis can afford it. Thus, this technique should be in nearly universal use within five years as the accepted standard for quantitative and qualitative analysis of biological fluids for drugs and drug metabolites.

5.3 EVIDENTIARY PROCEDURES

The only analytical results now acceptable in court are those obtained from the gas chromatography-mass spectrometry technique. As discussed in Section 5.2.5 above, this technique is both very sensitive and very selective, and its results are without question when the technique is properly executed. This technique should be used for drug testing related to all transportation activities involving fatalities, great property damage, or injuries to third parties and bystanders, and when lawsuits are likely.

5.4 ACCURACY OF DRUG TESTING LABORATORIES

Many questions have been raised in the news media regarding the accuracy and general quality of drug testing. The procedures described in Section 5.2 indicate that it is technically feasible to perform precise, accurate testing for the presence and quantity of drugs in blood and other body fluids and tissues. However, there is no way to assess the overall or individual reliability and general quality of drug testing as it is performed today.

It is obvious that some testing facilities perform better than others. Beyond questions associated with the quality of the laboratory's performance, laboratories can be categorized according to their primary mission of clinical or forensic testing.

Clinical laboratories generally deal with fresh samples taken from living or recently deceased individuals with known histories. The testing generally is undertaken in the course of a patient's treatment or as part of a postmortem to evaluate the treatment. Forensic laboratories usually deal with a wide variety of samples collected under a broad range of conditions from living and dead individuals whose history often is not available. Forensic testing is commonly carried out to develop evidence for legal or regulatory activities.

In many states, clinical laboratories are far more regulated than forensic laboratories. For instance, in New York state, while clinical laboratories are required to participate in a proficiency testing program to receive accreditation, forensic laboratories are not. There are now no national standards for the performance of forensic laboratories.

Because of the potential for inaccuracy at every stage of the complex process described above, a laboratory may be producing inaccurate results and not realize it without participation in a proficiency program. Testing for the presence of drugs is significantly more difficult in practice than testing for alcohol, due both to the relatively lower concentrations of drugs, and to the wide and ever-changing variety of drugs of interest. Nevertheless, it is useful to examine the DOT's development of a proficiency program for laboratories engaged in blood alcohol testing.

In support of DOT's efforts to reduce alcohol-related traffic fatalities, TSC established a national alcohol testing laboratory proficiency program under the sponsorship of NHTSA. In this program, calibrated blood alcohol samples are provided to laboratories throughout the nation. The purpose of this program is to allow the laboratories performing forensic testing to evaluate the quality of their own procedures by comparing their results to target values.

A study conducted by TSC when the program began found that some of the participating laboratories provided accurate results, while others were grossly inaccurate. The reactions of the surveyed laboratories varied. Some did not believe that the inaccuracy presented a problem, but the more conscientious laboratories were concerned and felt that a continuing proficiency program was valuable.

The College of American Pathologists (CAP) currently operates two proficiency programs for drug testing: a qualitative program for urine samples and a quantitative program for both urine and serum samples. In practice, the participating laboratories periodically are sent samples. The labs analyze the samples, and return the results to the CAP. The CAP then sends the participating laboratory a list of the contents of the samples and statistics comparing the performance of the lab with that of other participating laboratories using similar testing procedures.

These proficiency testing programs are available at relatively low cost from the CAP (less than $600 for the quantitative program and less than $300 for the qualitative program). However, of the approximately 15,000 drug testing facilities eligible for the program, less than four percent (313 for the quantitative program and 642 for the qualitative program) choose to participate.

The Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA) of the Department of Health and Human Services (HHS) has recently (February, 1987) issued "Scientific and Technical Guidelines for Drug Testing Programs" which sets standards for toxicological testing laboratories involved in federal employee testing programs. Currently HHS is developing a laboratory accreditation program. In this program, the laboratories which desire to participate in federal employee testing programs will be evaluated on the basis of site visits to examine their facilities and on their performance on proficiency tests. Those laboratories which meet the requirements will be accredited to perform tests for federal agencies.

5.5 NON-INTRUSIVE AND BEHAVIORAL TESTS

Drug tests that do not require analyses of body fluids or tissue samples would be of tremendous benefit to the detection of drug use in an industrial setting. The lack of privacy involved in obtaining a urine sample and the physical intrusion involved in obtaining a blood sample are significant impediments to the conduct of industrial drug testing programs. However, at this time, there do not appear to be any non-

intrusive chemical tests that can detect a broad spectrum of drugs.

5.5.1 Behavioral Tests for Drug Intoxication

A number of observational techniques now used to detect alcohol intoxication might be adaptable for drug detection. Such techniques use the careful observation of behaviors such as maintaining balance, and the measurement of overt symptoms of the physiological concomitants of intoxication such as gaze nystagmus and blood pressure. Several NHTSA-sponsored laboratory and field studies have demonstrated that police officers can be trained to estimate blood alcohol levels based on observation of the suspected intoxicant's psychomotor performance of three readily administered tests ("gaze nystagmus", "walk and turn", and "one leg stand"). In practice, these estimates are used to help the officer determine if a breath or other chemical test for intoxication is warranted. (More information on these tests is available in Appendix 2.)

A number of studies have investigated the applicability of non-chemical tests for the detection of drug use. Bigelow et al. (1985) reported on laboratory research evaluating non-chemical tests for drug detection. In this research, officers of the Los Angeles Police Department's Drug Recognition Program were tested on their ability to discriminate between experimental subjects who had been dosed with marijuana, Diazepam, Secobarbital, d-Amphetamine, or a placebo. The methodology involved an interview of the subject, access to data on the subjects' physiological signs such as pulse rate and blood pressure, and the use of a field sobriety battery similar to that used for detecting alcohol intoxication.

The officers were able to detect correctly the presence of drugs at levels of accuracy ranging from a low of 12.5 percent for a low dose of d-Amphetamine to 95 percent for secobarbital and 95 percent for a placebo. While the officers' performance was relatively good, their task was made easier knowing that the subjects had not ingested alcohol and had not taken more than one drug. Such knowledge usually is not available to the police officer; however, other data such as the presence of drugs or drug-related paraphernalia often are available.

Compton (1986) reports on a field evaluation of non-chemical tests for detecting drug use. This study evaluated the ability of trained and qualified Los Angeles Police Department (LAPD) Drug Recognition Experts (DRE) to detect the effects of specific drugs in individuals who were arrested in Los Angeles for driving while intoxicated (DWI) and were suspected of drug use. The subjects in this study were individuals arrested for DWI who were believed to be using drugs because the results of breath alcohol or other tests for alcohol intoxication were not consistent with their behavior. The individuals who were arrested were evaluated by LAPD DREs in a three-part procedure that included an interview, observation of physiological symptoms, and behavioral tests. In the interview portion of the evaluation, the DRE evaluated the general behavior of the suspect and attempted to obtain information on the medical/drug history of the individual. In the physiological examination, the DRE evaluated factors such as blood pressure, oral temperature, and nystagmus, and also examined the subjects for skin signs of drug use such as needle marks or perforation of the nasal septum. The behavioral tests consisted of four balance and coordination tests which evaluate the subjects' ability to stand steadily with eyes closed, balance on one leg, touch finger to nose, and walk and turn steadily and precisely.

If, based on the results of the test, the DRE felt that the suspect was indeed under the influence of a drug or drugs, the DRE strongly admonished the subject to provide a blood sample for analysis. Of the 201 suspects so admonished, 172 did provide blood samples. The DREs, all of whom had formal certification, were the most senior and most skilled available in the LAPD.

The performance of the officers was very good considering that, in many cases, the chemical tests revealed the presence of more than one drug and/or alcohol.

- The DREs were particularly accurate in detecting PCP. In 92 percent of the cases, when they said PCP was present the blood tests corroborated their finding. In 88 percent of the cases, when they said that it was not present, they were correct.

- The DRE performance was nearly as good for opiates. In 85 percent of the cases where they detected opiates they were correct, and in 99 percent of the cases where they indicated no opiates were present they were correct.

- The DRE performance in detecting stimulants, including cocaine, was not as good. While they were accurate in 89 percent of the cases when they said no stimulant was present, they were accurate only 33 percent of the time when they indicated a stimulant was present.

In the near-term, behavioral tests are not likely to be adequate as primary evidence in court procedures or as a primary basis for dismissal from a job. With further development, behavioral tests may be useful in the detection of drug use in on-the-job situations. However, it should be noted that such tests, if developed, will require carefully trained staff for administration. The primary use of non-chemical tests may be in detecting impairment and getting the suspected drug user out of a safety-critical position until chemical confirmation or refutation can be obtained. If non-chemical tests that are both sensitive and specific to rapidly metabolized substances such as cocaine can be developed, they may be of great value in eliminating unfit operators from duty. The use of such tests to support disciplinary procedures is more problematical. Because of the seriousness of the charge of on-the-job drug use, and the time lag between behavioral testing and chemical confirmation or refutation of results, the use of the results of such tests for disciplinary procedures finds only limited acceptance.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to identify and evaluate data that could be used to determine the impact of drug use on transportation safety, and to evaluate the methodology by which such data can be collected. Two basic data types were evaluated statistical and experimental, and drug testing methodologies and laboratory quality control procedures were reviewed.

6.1 STATISTICAL DATA

To establish risk indices that relate drug use to accident occurrence, it is necessary to have both accident data and exposure data. The accident data establishes the prevalence of drug use by operators involved in accidents and the exposure data establishes the prevalence of the use of a drug by operators as a whole.

The accident data required are the proportion of operators involved in accidents who show evidence of drug use prior to the accident. The exposure data required are the proportion of all operators who show evidence of drug use. In this context, risk is an index of the over-representation of drug use by individuals involved in accidents.

Both accident and exposure data can be expected from three sources:

- Industry data bases that deal with professional operators
- State data bases that deal with highway operators and recreational boating operators
- Federal data bases that cover all transportation operators

The material reviewed in this study indicates that the data required to establish transportation safety risk as a function of drug use are not readily available for any mode.

6.1.1 Industry Data

There is considerable concern in the transportation industry about the impact of drug use on safety, but few of the private organizations have (or will admit to having) analyzed the data they currently possess in a way that allows them to estimate objectively the safety-related risks associated with drug use in their operations.

In the aviation and railroad industries, data are now being collected that will support estimates of the prevalence of drug use by individuals involved in accidents. Federal regulations now require that toxicological data is obtained from almost all individuals involved in all fatal aviation and railroad accidents.

These industries are also now accumulating data that could be used to identify those drugs that have most severe effects on job performance and to provide rough estimates of exposure. Identification of the drugs that are the most disruptive to the employee may be possible from analysis of data collected by Employee Assistance Programs (EAPs). Analysis of screening program data can shed some light on those drugs which are most frequently used. It cannot be too strongly emphasized, however, that these data sources are very highly biased because of the ways in which the data are obtained.

With regard to highway based industries such as trucking and busing, the availability of drug related accident data is a function of the completeness of toxicological data collected by state and/or local authorities. At this time states do not, as a matter of course, collect toxicological data from individuals involved in serious accidents. In these highway based industries identification of problem drugs and rough estimates of exposure may be possible based on the analysis of EAP and screening data.

Our understanding of the dimensions of the drug problem in the transportation industry could be improved significantly by requiring testing of all transportation operating personnel directly involved in serious or fatal accidents and by obtaining and analyzing the data collected in screening programs now conducted by many segments of the transportation industry.

6.1.2 Non-Industrial Data

Non-professional operators on the highways, in the air, and on the waterways are involved in the vast majority of serious transportation accidents. NHTSA has twice evaluated the data that could be used to assess the accident risk associated with drug use in highway operations. In their latest (1985) evaluation they found insufficient data on the use of drugs by non-accident involved drivers to establish risk. Further, they noted that because "the majority of drug using drivers (53% to 77%) were found to have high levels of alcohol in combination with drugs" it is difficult to attribute accident causality to drug use. NHTSA has concluded that it is not possible to determine the role of drug use in highway accidents, from the data available.

The role of drug use in recreational boating accidents is of considerable concern to state boating officials. There is little quantitative accident data that can be used to estimate prevalence of drug use by individuals involved in boating accidents. Toxicological data from the operators of boats involved in serious accidents is very difficult to come by. Because boating is a recreational activity, regulatory processes that aid in obtaining blood or tissue samples, and are taken for granted in highway operations, such as operator licensing, per-se laws, and implied consent laws, are still unusual in recreational boating.

No sources of the exposure data required to establish estimates of accident risk associated with drug use in recreational boating have been found. This is due both to the logistical problems caused by the relatively unregulated nature of boating and the problems involved in obtaining voluntary body fluid samples from recreational boaters.

6.1.3 Federal Data Systems

The only federal data base containing long-term information on the prevalence of drug use in civil transportation accidents is the one maintained by NTSB for aviation accidents. The FAA routinely performs toxicological testing on fatal aviation accident victims and the NTSB accident investigation form includes drug incapacitation as a possible causal or contributing factor. Post-accident toxicological tests had not routinely been made in any other transportation model until 1986 when new regulations required it for rail accidents. The FRA now collects and has one year's data on drug presence in employees involved in serious accidents. The data bases of

other modes contain no useful drug information and have little or no provision for entering such data. There is currently no federal data base for any mode that contains exposure data.

If the data bases maintained by the DOT are to be useful in the development of a quantitative understanding of the extent to which drugs are involved in transportation accidents, the collection forms must be modified to include drug related elements and relevant toxicological data must be collected from the operators and victims of a statistically selected sample of serious accidents. Similarly, if risk estimates are to be developed, data must be collected from a representative sample of operators regardless of accident involvement.

6.2 EXPERIMENTALLY DERIVED DATA

Experimental studies can potentially permit the identification and quantification of the effects of drug use on safety related performance. An improved understanding of drug effects on operator performance can both improve our ability to understand the role of drugs in accidents and permit the development of workable methods for regulating the use of licit drugs in the work-place.

6.2.1 Current Status of Data

The material reviewed for this report revealed little information that could be related directly to transportation safety.

The review of experimental investigations of the effects of drugs on performance showed few relevant studies of illicit drugs[11], with the exception of marijuana. A number of studies were found that investigated the impact of licit drug use on the performance categories of interest. However, none of these studies could be used to directly estimate the safety-related risk associated with drug use. This was because:

- The laboratory performance measures employed in the studies cannot be related directly to the performance of transportation tasks or the risk of accidents associated with a given drug level;
- The subject populations of the studies all were in normal health and were neither habitual drug users nor those with illnesses for which licit use of the drug might be indicated. There is good reason to believe that the effect on performance of a drug differs profoundly between normal persons and habitual users, or those with a medical need; and
- The subject populations of the studies were not representative of the populations of interest in the transportation industry (i.e., airline pilots, bus drivers, or transit vehicle operators).

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[11]One might speculate that for the "hard" illicit drugs, the practical difficulties of research are so great, and the anticipated direct effect on performance is so strong that there has been relatively little interest in performing the laboratory type performance studies to quantify the dose response relationships for safety critical performances. This relative lack of research cannot be taken as evidence that the use of hard drugs has no effects on safety critical performance but rather that the effects are so profound as to make such research less critical than research on more subtlely acting agents.

6.2.2 Potential Uses for Experimentally Derived Data

An alternate method for understanding the role of drugs in accident causation is accident reconstruction. Potentially, knowledge of the effects of drugs might be combined with information on pre-accident conditions, the contribution(s) of the operator(s) to the accident, toxicological data, and pre-accident history of the operator to develop an improved understanding of the role that drug use might have played in the causation of the accident.

The relationships between drug dosage or drug presence and the decrements in job performance are also important in developing usable drug control regulations.

6.2.3 Requirements for New Experimental Studies

While there were no relevant performance studies of any of the "hard" drugs (e.g., heroin), studies of these drugs may not be critical for use in the establishment and enforcement of industry work rules, considering that use of these drugs is already a criminal act. However, information on the specific effects of these drugs on transportation job performance may be of great value in accident reconstruction.

Studies of the effects of the more casually used drugs such as marijuana and frequently used licit drugs can provide data that could be critical both for accident reconstruction and on-the-job regulation.

These studies, if they are to be useful, must be conducted under conditions that closely simulate the transportation jobs of interest and use subjects who are representative of the employee populations of interest. The military and the aviation industry make excellent use of high quality simulation facilities both for training and for safety equipment development. Such simulation facilities would be of great value in determining the effects of drugs on operator performance.

6.3 TOXICOLOGICAL TESTING PROCEDURES

Drug testing may be divided into two basic categories -- screening and confirmation. Screening involves the search for the presence of drugs, and confirmation involves the detection of the presence and measurement of concentration of drugs identified in the screening procedures.

Drugs may be detected and measured in body fluids and tissues. The most commonly tested fluids are urine and blood. Testing of urine can be used to determine whether a drug has been used, in some cases, up to several weeks in the past. Testing of blood can be used to determine if an individual has used the drug in the past few hours. In cases when the body of a victim is not quickly recovered and blood and urine samples are not available, tests can be conducted on appropriate body tissues.

While use of appropriate testing technology will permit the determination of the concentration of the drug in the fluid or tissue sample, this information is of limited usefulness in determining accident causation because accurate quantitative relationships between body fluid or tissue concentration and behavioral response have not been established.

6.3.1 Technology

The technology for testing for the presence and amount of drugs in body fluids and tissues is well established. The methods now in use are:

- Immuno-assay;
- Thin layer chromatography;
- Gas chromatography;
- High pressure liquid chromatography; and
- Gas chromatography-mass spectrometry.

These methods were reviewed in terms of their value in drug screening and confirmation testing. The review indicated that these methods were well established and accurate, assuming the laboratories employing them maintained high levels of quality control.

6.3.2 Quality Control

The quality control for forensic drug testing laboratories is essentially unregulated. Because of the highly competitive nature of the drug testing industry, it may be expected that some firms will try to use the most economical procedures possible, and will expend only limited resources on quality control. To ensure quality control, it is vital that laboratories participate in a quality control or drug testing proficiency program, such as the program operated by CAP. The DOT has supported a voluntary proficiency program for forensic laboratories performing blood alcohol testing. Such support could be of great value in improving the accuracy and credibility of drug testing.

6.4 RECOMMENDATIONS

There is a significant safety hazard in the use of any illicit drug, by transportation personnel, as well as a potential hazard in the use of some illicit drugs. The need for more data to determine the precise extent of the threat should not interfere with efforts to eliminate the hazard. To the extent possible, data collection should be combined with a vigorous anti-drug program that will aim for personnel in safety-critical positions to be free of illicit drugs at all times and to be unimpaired by illicit drugs while on duty.

In order to further the development of more readily enforceable regulations, the following actions are recommended:

- Acquisition and analysis of EAP and screening data.
- Testing of all transportation operating personnel directly involved in serious or fatal accidents.
- Use of the data collected in the random testing programs along with post accident test results to develop indices of risk.
- Support and encouragement for state and local authorities to perform. toxicological tests on all operators and victims involved in fatal highway or boating accidents.
- Modification of US DOT data bases to include drug related elements and relevant toxicological data.
- As new data becomes available, performance of epidemiological analyses using results of both post-accident and random testing efforts.

- The performance of experimental drug studies under conditions that closely simulate the transportation jobs of interest using subjects representative of the employee populations of interest.
- The creation of support and encouragement for drug testing laboratory participation in proficiency (quality control) programs.

APPENDIX 1
SAMPLES OF SAFETY DATA BASE CODING AND REPORTING FORMS

Fatal Accident Reporting System (FARS)

Data Name: RELATED FACTORS

Representation: 2-position numerics (or blanks) occurring 3 times

Function: Data

Definition:

The RELATED FACTORS code represents additional information based on the investigating officer's report.

Code	Value
Blanks	Value not coded (FARS.MASTER only)
00	None
	Physical/Mental Condition
01	Drowsy, Sleepy, Asleep, Fatigued
02	Ill, Blackout
03	Depression
04	1978 to present - Drugs - Medication 1975 to 1976 - Drinking
05	1978 to present - Other Drugs 1975 to 1977 - Drugs - Medication
06	1978 to present - Inattentive (talking, eating, etc.) 1975 to 1977 - Other Drugs
07	1978 to present - Physical Impairments 1975 to 1977 - Inattentive (talking, eating, etc.)
08	1978 to present - Died Prior to Accident 1975 to 1977 - Physical Impairments
09	1975 to 1977 - Died Prior to Accident
	Miscellaneous Causes
19	1981 to present - Legally Driving on Suspended or Revoked License
20	Leaving Vehicle Unattended with Engine Running Leaving Vehicle Unattended in Roadway

APPENDIX 1
SAMPLES OF SAFETY DATA BASE CODING AND REPORTING FORMS

National Accident Sampling System (NASS)

POLICE, HOSPITAL/MEDICAL, OR OTHER OFFICIAL

60. 61. 62. Other Driver Related Factors

___ (00) No other driver related factors

Physical/Mental Condition:

___ (01) Nonphysical (i.e., mental or emotional factor)
___ (02) Drowsy, sleepy, asleep, fatigued
___ (03) Depression
___ (04) Illness, disease, blackout

Physical Impairments

___ (05) Deaf
___ (06) Restricted to wheelchair
___ (07) Paraplegic
___ (08) Previous injury
(09) Other physical impairments: _____

_____

Drug Impairments

___ (10) Drugs-medication (prescription, over-the-counter)
___ (11) Other drugs (excludes alcohol, includes uncontrolled substances): _____

Operator Related Factors:

___ (20) Inattention
___ (21) Interference with driver by other passenger
___ (22) Operator inexperience
___ (23) Unfamiliar with roadway
___ (24) Overloading or improper loading of vehicles with passengers or cargo
___ (25) Operating vehicle in erratic, reckless, careless or negligent manner
___ (26) Improper or erratic lane changing
___ (27) Failure to keep in proper lane or running off roadway
___ (28) Making improper entry to or exit from trafficway
___ (29) Failure to obey traffic signs, traffic control devices or traffic officers, failure to observe Safety Zones
___ (30) Failure to signal intentions
___ (31) Giving wrong signal
___ (32) Making right turn from left lane, making left turn from right lane
___ (33) Making other improper turn
___ (34) Driving wrong way on one-way roadway
___ (35) Driving on wrong side of roadway
___ (36) Failure to dim lights or to have lights on when required
___ (37) Operating without required equipment
___ (38) Creating unlawful noise or using equipment prohibited by law
___ (39) Passing where prohibited by posted signs, pavement markings, hill, curve or school bus displaying warning not to pass
___ (40) Passing on wrong side
___ (41) Passing with insufficient distance or inadequate visibility or failing to yield to overtaking vehicle
___ (42) Passing through or around barrier positioned to prohibit or channel traffic
___ (43) Failure to observe warnings or instructions on vehicles displaying them
___ (44) Driving less than posted minimum
___ (45) Operating at erratic or suddenly changing speeds
___ (46) High speed chase with police in pursuit
___ (47) Illegal driving on road shoulder, in ditch, on roadside, or on sidewalk or path
___ (48) Starting or backing improperly
___ (49) Stopping in roadway (vehicle not abandoned)
___ (50) Opening vehicle door into moving traffic or while vehicle is in motion
___ (51) Towing or pushing vehicle improperly

___ (98) Other: _____
___ (99) Unknown

(60) ___ 91 ___ 92
(61) ___ 93 ___ 94
(62) ___ 95 ___ 96

63. 64. 65. Other Environmental Related Factors

___ (00) No other environmental related factors

Vision Obscured By:

___ (01) Rain, snow, fog, smoke, sand, dust
___ (02) Reflected glare, bright sunlight, headlights
___ (03) Curve, hill or other design features (including traffic signs, embankment)
___ (04) Building, billboard, etc.
___ (05) Trees, crops, vegetation
___ (06) Moving vehicle (including load)
___ (07) Parked vehicle
___ (08) Other object not classifiable above

Swerving or Loss of Control Due to:

___ (20) Severe crosswind
___ (21) Wind from passing truck
___ (22) Slippery surface
___ (23) Avoiding debris or objects in roadway
___ (24) Ruts, holes, bumps in roadway
___ (25) Avoiding animals in roadway
___ (26) Avoiding vehicle in roadway
___ (27) Avoiding pedestrian, pedalcyclist, other nonmotorist in roadway
___ (28) Avoiding standing water, snow, oilslick or ice patch on roadway

Roadway Features:

___ (30) Inadequate warning of exits, lanes narrowing, traffic controls, etc.
___ (31) Pavement marking obscured or absent
___ (32) Surface washed out (caved in, road slippage)
___ (33) Shoulder too low or high
___ (34) Inadequate construction or poor design of roadway, bridge, etc.
___ (35) Vehicle unattended in roadway

___ (98) Other: _____
___ (99) Unknown

(63) ___ 97 ___ 98
(64) ___ 99 ___ 100
(65) ___ 101 ___ 102

APPENDIX 1
SAMPLES OF SAFETY DATA BASE CODING AND REPORTING FORMS

Motor Carrier Safety Management Information System

Form Approved
OMB No. 004-R2394

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
BUREAU OF MOTOR CARRIER SAFETY

MOTOR CARRIER ACCIDENT REPORT

Original and two copies of MCS 50-T shall be filed with the Director, Regional Motor Carrier Safety Office, FHWA, as required by 394.9. Copy shall be retained in carrier's file. Circle or (X) appropriate boxes below.

1. Name of carrier (*Corporate business name*) (7–21)

2. Principal Address (*Street and no., City, State, ZIP Code.*) (22–50)

3. Type of carrier (51–66) [A] Private, Employer ID No. (IRS) ____ [B] ICC authorized, MC ____ [C] Other (*Specify*) ____ Employer ID No. (IRS) ____

4. Type of trip (67) [A] Over-the-road [B] Local pick-up and delivery operation

5. Place accident occurred (*Nearest Town or City, State*) (68–78)

5A. Type of district (79) [A] Residential [B] Rural [C] Primarily business

6. Street or highway (*Route or Name*) (7–16)

6A. Location if off highway (17–26)

7. Day of week (27) [A] M [B] T [C] W [D] TH [E] F [F] S [G] S

8. Date accident occurred (28–33) ...../...../.....

9. Time accident occurred (*Military time to nearest hour*) (34–35)

10. ACCIDENT TYPE (*Primary Event*)

10A. Collision (*Check appropriate box*) (36) [A] Not applicable [B] Collision with moving object [C] Collision with fixed or parked object

10B. Collision (*Check other object involved*) (37–45)
[A] Not applicable
[B] Commercial truck
[C] Fixed object
[D] Automobile
[E] Pedestrian
[F] Bus
[G] Train
[H] Bicyclist
[I] Animal
[J] Motorcycle
[K] Other (*Specify*) ____

10C. Collision with another vehicle—Accident Classification (*Check appropriate box*) zzz [ ] not applicable

(46–48) VEHICLES 1 2 3	ACTION	(46–48) VEHICLES 1 2 3	ACTION
A	Slowing—Stopping	L	Intersection
B	Stopped	M	Passing
C	Parked	N	Changing Lanes
D	Rear-end	O	Sideswipe—Opposite Direction
E	Backing	P	Head On—Crossed Into Opposing Lane
F	Making Right Turn	Q	Skidding
G	Making Left Turn	R	Vehicle Out Of Control
H	Making U-Turn	S	Roll-Away
I	Proceeding Straight	T	Controlled Railroad Crossing
J	Merging	U	Uncontrolled Railroad Crossing
K	Entering Traffic From Shoulder, Median, Parking Strip or Private Drive	V	Other (*Specify*) ____

10D. Non-collision (*Check primary event*) (49–57)
[A] Not applicable
[B] Ran off road
[C] Jackknife
[D] Overturn
[E] Separation of units
[F] Fire
[G] Loss or spillage of cargo
[H] Cargo shift
[I] Other (*Specify*) ____

10E. If not primary event, did accident result in (58)
[A] Not applicable
[B] Spillage of hazardous cargo
[C] Fire
[D] Spillage of non-hazardous cargo
[E] Explosion

11. DRIVER INFORMATION

11A. Name of your driver (59–72) ____

11B. Age (73–74)

11C. Social Security No. (7–15) / /

11D. How long employed as your driver (*To nearest year*) (16–17) ____

11E. Hours actually driving since last period of 8 consecutive hours off duty (18)
[A] 1 hr. [B] 2 hrs. [C] 3 hrs. [D] 4 hrs. [E] 5 hrs. [F] 6 hrs. [G] 7 hrs. [H] 8 hrs. [I] 9 hrs. [J] 10 hrs. [K] 11–12 hrs. [L] Not applicable

11F. Estimated hours of driving for entire trip or portion of trip, since last period of 8 consecutive hours off duty (19)
[A] 1 hr. [B] 2 hrs. [C] 3 hrs. [D] 4 hrs. [E] 5 hrs. [F] 6 hrs. [G] 7 hrs. [H] 8 hrs. [I] 9 hrs. [J] 10 hrs. [K] 11–12 hrs. [L] Not applicable

11G. Condition of driver (20–28)
[A] Apparently normal
[B] Sick
[C] Had been drinking
[D] Dozed at wheel
[E] Medical waiver
[F] Other (*Specify*) ____

11H. Date of last medical certificate (29–34) ...../...../.....

Form MCS 50—T (Property-Carrying) (Rev. 8–72) Previous editions of this form are obsolete
(over)

APPENDIX 1
SAMPLES OF SAFETY DATA BASE CODING AND REPORTING FORMS

Accident Incident Data System (AIDS)

FEDERAL AVIATION ADMINISTRATION

AIDS CODES REPORT

TABLE ID: CAUSA CAUSB TABLE NAME: CAUSE FACTOR A & B TABLE NO: 77

--CODE--	---- SHORT FORM ----	---------- DESCRIPTION ----------
AA	APT/COND	FAIL ADVISE UNSAFE APT COND
AF	APT/FAC	IMPROPER MAINTENANCE APT FAC
AI	AWY/FAC	INADEQUATELY MAINTAIN AWY FAC
AL	ASG/ALT	DIDN'T FLY ASG ALT IFR CLRNS
AP	APCH/FAC	INADEQUATELY MAINTAIN APCH FAC
AS	FLY/SPD	FAIL TO MAINTAIN ADEQ FLY SPD
AT	TFC/ADV	FAILED TO ADV OF OTHER TRAFFIC
AU	EQP/DEF	ATTEMPT OPERATION WITH DEF EQP
AW	WX/COND	FAIL TO ADV OF UNSAFE WX COND
BS	STRUCK/BIRD	STRUCK BIRDS IN FLIGHT PATH
BW	BLOWN OVER	BLOWN OVER BY STRONG WIND
CE	ENG/GL	DIDN'T CLEAR ENGINE IN GLIDE
CH	CARBHT/DEIC	MISUSE CARBHT/DEIC PROC TB ENG
CI	IMPR/INSTR	ISSUED IMPR CONFLICTING INSTR
CP	STUD/PAX	STUD PILOT CARRIED PASSENGERS
CS	COOL/OIL	IMPROP OPER COOL SYS OIL ENG C
DC	DRIFT	FAILED TO CORRECT FOR DRIFT
DE	EQUIP/SERV	DEFIC, CO MAINTAIN EQUIP/SERV
DP	DISPATCH	FAIL COMPLY DISPATCH PROC REGS
DR	ALCOHOL	DRANK ALCOHOLIC BEVERAGE
DW	TAKEOFF/DW	DOWNWIND TAKEOFF OR LANDING
EL	EXPER LEVEL	ATTEMPTED OPS BEYOND EXP LEVEL
EQ	EMEG/EQUIP	IMPROPER OPERATION EMEG/EQUIP
ES	ENG/START	STARTED ENG W/OUT ASSIST/EQUIP
FA	COLLIDE/APP	COLLIDED WITH OBJ ON FINAL APP
FC	DEST/FAC	CLEARED FLIGHT INADED FAC/DEST
FE	FIRE/EXT	FAILED TO USE ENGINE FIRE/EXT
FN	UNSAFE/COND	UNSAFE/COND & FAIL TO MSRK OBS
FO	FUEL/SYS	MISCELLANEOUS MISUSE FUEL SYS
FP	PROC/INSTR	FAIL FOLLOW APPROVED PROC/INSTR
FR	RELINQ/CNTL	FAILED TO RELINQUISH CONTROL
FT	MGT/FUEL	IMPROPER MGT/FUEL TANK SELECTO
FX	FUEL/LOW	CONT FLT LOW/FUEL/EXHAUSTION
GA	INIT/GOAR	DELAYED IN INIT/GOAR
GC	BRAKE/GRDCTL	IMPROPER OPER BRAKE/FLT CLTGRD
GE	EMEG/GEAR	MISUSED EMERGENCY GEAR SYSTEM
GF	GEAR/POSCK	GEAR SWITCH/CONT FAIL CK POS
GI	RET/GEAR	INADVERTANT RET LANDING GEAR
GL	GEAR/LATE	EXTENDED GEAR TOO LATE
GN	GEAR/NONE	FORGOT TO EXTEND LANDING GEAR
GP	GEAR/EARLY	RETRACT GEAR EARLY ON TAKEOFF
HA	AVOID/AC	FAIL AVOID AC NON AB/ONLY 1AB
HG	GRND/WTR	FAIL AVD COLLISION GRDN OR WTR
HO	OBJECT/AVOID	FAIL AVD OBJS OR OBSTRUCTIONS
HT	TOWER/AVOID	FAIL TO AVD TV OR RADIO TOWER
IA	RWY/ALIGN	AC IMPROPERLY ALIGN WITH RUNWAY

APPENDIX 1
SAMPLES OF SAFETY DATA BASE CODING AND REPORTING FORMS

National Transportation Safety Board (NTSB)
(Pre-1983)

HUMAN FACTORS

Results of Toxicology Examination (Pilot Only) — Cols. 17-20
(Note: Select up to 4 items)

Card No. 20

Code

A - Carbon Monoxide - 10% or less

B - Carbon Monoxide - over 10%

C - Lactic Acid - 200% or less

D - Lactic Acid - over 200%

E - Drugs - Yes

F - Drugs - No

G - Alcohol - Yes (code alcohol content-range on following page)

H - Alcohol - No

I - Toxicological samples inadequate for testing

J - Carbon Monoxide test not accomplished

K - No test made for Lactic Acid

L - No test made for drugs

M - No test made for alcohol

N - Toxicological test results considered unreliable

Z - Unknown/Not Reported

June 1, 1970

SPEED AT IMPACT

Columns 67-69
Card No. 20

Speed at Impact (Kts)

Enter Direct

Code Z for unknown/not reported - enter last space to right.

AUTOPSY/TOXICOLOGY EXAMINATION PERFORMED

Column 70
Card No. 20

Note: To be coded on all Fatal Accidents.

Code

A - Autopsies performed (Pilot).

B - Autopsies performed (Pilot and/or other crew members).

C - Autopsies performed (Passengers).

D - Autopsies performed (Passengers and crew).

E - Toxicology examinations performed (Pilot).

F - Toxicology examinations performed (Pilot and or other crew members).

G - Toxicology examinations performed (Passengers).

H - Toxicology examinations performed (Passengers and crew).

I - No toxicology examinations or autopsies performed.

J - Autopsy and toxicology examination performed (Pilot).

Z - Unknown/Not Reported.

Also code results of toxicology examinations card 20, columns 17-2.

APPENDIX 1
SAMPLES OF SAFETY DATA BASE CODING AND REPORTING FORMS

National Transportation Safety Board (NTSB)
(1983-Present)

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement K—Occupant, Survival and Injury Information (continued)

Complete this section for accidents involving fire. 24 ☐ No fire involved *(Go to block 29)*

25 Fire First Sighted *(Location)*
1 ☐ Inside aircraft
2 ☐ Outside aircraft
3 ☐ Both
A Other

26 Smoke Mask/Goggles Used *(Multiple entry)*
1 ☐ No
2 ☐ Yes
3 ☐ Both
4 ☐ Difficulty in use
A Other

27 Material of Clothes Worn *(Multiple entry)*
1 ☐ Synthetic
2 ☐ Nonsynthetic
3 ☐ Fire resistant
4 ☐ Mix-synthetic and nonsynthetic
A Other

28 Exposure to Heat/Fire *(Multiple entry)*
1 ☐ Head/face
2 ☐ Arm(s)
3 ☐ Hand(s)
4 ☐ Leg(s)
5 ☐ Torso
6 ☐ Feet
A Other

Complete this section for accidents involving ditching/water impact. 29 ☐ No water impact *(Go to block 36)*

Flotation Devices	A Available			C Used			E Familiar With Use			G Problems In Use			I Malfunctioned With Use			K Equipment Damaged		
	1 Yes	2 No	B Other	1 Yes	2 No	D Other	1 Yes	2 No	F Other	1 Yes	2 No	H Other	1 Yes	2 No	J Other	1 Yes	2 No	L Oth
30 Liferaft																		
31 Vest-Inflatable																		
32 Vest-Non-Inflatable																		
33 Cushion																		

34 Time in Water
A ____ Hrs.
B ____ Mins.
C Other

35 Rescued by
1 ☐ Boat
2 ☐ Airplane
3 ☐ Helicopter
4 ☐ None
A Other

Occupant Injuries—*Complete applicable parts for survivors and nonsurvivors.*

Items 36 thru 39 apply ONLY to flight crewmembers.

36 Medication Prescribed
1 ☐ No
A Yes *(Specify:* _____*)*
B Other

37 Medication Being Taken
1 ☐ No
A Yes *(Specify:* _____*)*
B Other

38 Medication/Drugs Found
1 ☐ No
A Yes *(Specify:* _____*)*
B Other

39 Pre-existing Disease Found at Autopsy
1 ☐ No autopsy performed
2 ☐ None reported
A Yes *Specify:* _____
B Other

Results of Toxicological Analyses—*Complete as applicable for survivors and nonsurvivors.*

40 Toxicology *(Multiple entry)*
1 ☐ Not ordered
2 ☐ Not ordered—performed
3 ☐ Ordered—performed
4 ☐ Ordered—not performed
5 ☐ Embalmed
6 ☐ Specimen not available/unsuitable for analysis
A Other

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB Accident/Incident Number

Supplement K—Occupant, Survival and Injury Information (continued)

Results of Toxicological Analyses—*(Complete as applicable for survivors and nonsurvivors.) (continued)*

Substances	A Test Results			C Level of Substances Found
	1 Positive	2 Negative	B Other	
41 Ethanol (Alcohol)				Mg
42 CO (Carbon Monoxide)				% Saturatic
43 hb (Hemoglobin)				gm
44 HCN (Hydrogen Cyanide)				Microgram/r
45 Acidic and Neutral Drugs				
46 Basic Drugs				
47 Marijuana				
48 (Specify) _____				

List any additional toxicological substances discovered below.

A Substance Code	B Level of Substances Found	A Substance Code	B Level of Substances Found
49		56	
50		57	
51		58	
52		59	
53		60	
54		61 (Specify)	
55		62 (Specify)	

Toxicological Substances/Codes

Acetamenoonen	001	Cocaine	018	Imipramine	035	Menthol	052
Acetaldehyde	002	Codeine	019	Isopropanol	036	Morphine	053
Acetone	003	Desipramine	020	Ketamine	037	Medazepam	054
Amoxapine	004	Diazepam	021	Lidocaine	038	Nicotine	055
Amitriptyline	005	Dihydrocodeinone	022	Loxapine	047	Nortriptyline	056
Amobarbital	006	Diphenhydramine	023	Meclocualone	039	Oxazepam	057
Amphetamine	007	Diphenylhydantoin	024	Mepenzine	040	Pentazocine	058
Benzoylecgonine	008	Doxepin	025	Mephenermine	041	Phenobarbital	059
Bromphenirramine	009	Desalkylflurazepam	026	Meprobamate	042	Procaine	060
Butalbital	010	Demoxepam	027	Methanol	043	Propoxyphene	061
Butabarbital	011	Ethchlorvynol	028	Methadone	044	Secobarbital	062
Caffeine	012	Flunitrazepam	029	Methamphetamine	045	Thioridazine	063
Cannabinoids	013	Flurazepam	030	Methaqualone	046	Temazepam	064
Chlorazepate	014	Fluphenazine	031	Methylenedioxyam	048	Nordiazepam	065
Chlordiazepoxide	015	Glutethimide	032	Phenamine	049	Pentobarbital	066
Chlorphenermine	016	Haloperidol	033	Methylphenidate	050	Phencyclidine	067
Clonazepam	017	Hexobarbital	034	Methyprylon	051	Phenothiazine	068
						Prazepam	069

APPENDIX 1
SAMPLES OF SAFETY DATA BASE CODING AND REPORTING FORMS

Marine Casualty Information Reporting System (CASMAIN)

"Wake damage"	"WAK"
"Swamping"	"SWAMP"
"Weather Damage"	"WTHRDM"
"Well Blowout"	"WELBLO"

The following codes represent the selections for the "Casualty Cause" fields. In these codes the first character (P,V,E, or M) denote whether the cause was specific to:

P--Personnel fault
V--Vessel related
E--Environment related
M--Management fault.

Screen 1

"Unknown"	"UNKNOWN"
"P Bypassed avail safety devices"	"PBPSASD"
"P Inattention to duty"	"PINATT"
"P Intoxication(Alcohol/Drugs)" ←	"PDRUNK"
"P Calculated risk"	"PCALRSK"
"P Carelessness"	"PCRLSNS"
"P Error in Judgment"	"PERRJDG"
"P Lack of Knowledge"	"PLCKKNO"
"P Lack of Training"	"PLCKTNG"
"P Lack of Experience"	"PLCKEXP"
"P Operator Error"	"POPERER"
"P Fatigue"	"PTIRED"
"P Smoking"	"PSMOKD"
"P Open flame"	"POPNFL"
"P Stress"	"PSTRESS"
"P Physical Impairment"	"PPHYSIM"
"P Psychological Impairment"	"PPSYCHO"
"P Failed comply w/rule,reg,pro"	"PFALRUL"
"P Inadequate supervision"	"PINADSP"
"P Improper casualty control pro"	"PIMPCCP"

Screen 2

"P Improper safety precautions"	"PIMPSFP"
"P Failed to acct for crnt/wx"	"PFALACW"
"P Failed to acct for tide/riv sg"	"PFALATR"
"P Failed to ascertain position"	"PFALPOS"
"P Failed to use avail nav equipt"	"PFALANE"
"P Failed to use charts and pubs"	"PFALCAP"
"P Failed to use radiotelephone"	"PFALRTE"
"P Relied on floating AtoN"	"PRELFAN"
"P Failed to yield right of way"	"PFALTY"
"P Failed to est passing agreement"	"PFALEPA"
"P Failed to keep to right of chnl"	"PFALKRC"
"P Failed to proceed at safe speed"	"PFALSPD"
"P Failed to stop"	"PFALSTP"
"P Failed to keep proper lookout"	"PFALKPL"
"P Improper/faulty lights/shapes"	"PIMPFLT"
"P Improper/missing whistle signals"	"PIMPMWS"
"P Improper maintenance"	"PIMPMNT"
"P Used defective equipment"	"PDEFEQT"

APPENDIX 1
SAMPLES OF SAFETY DATA BASE CODING AND REPORTING FORMS

Boating Accident Reporting System (BARS)

ACCIDENT DESCRIPTORS - Select up to a maximum of three accident descriptors from the following list where needed. Leave unused columns blank.

01 Could not reach fire extinguisher/fire extinguisher not serviceable
02 Attempted to fight fire
03 Lack of extinguisher capability/extinguisher not adequate
04 Could not reach PFD/PFD not serviceable
05 Victim(s) trapped under boat
06 Put PFD on in water
07 Exposure, shock, hypothermia, etc.
08 Clung to boat or tried to cling to boat
09 Boat rolling or slippery and could not hang on
10 Could not right boat
11 Left boat/swam for shore
12 Injured upon entering water
13 Exhaustion/lack of swimming ability
14 Alcohol or drugs involved
15 Runaway boat (engine running without operator)
16 Boat found upright drifting
17 Boat found capsized
18 Lack of visual/electronic distress signals contributed
19 Ran out of fuel
20 Assisted others
21 Help was nearby
22 Coast Guard was directly involved
23 Boat went over dam or spillway
24 Boat found, body found, no witnessess
25 Boat hit by lightning or struck power cable
26 Medical complications contributed (heart attack, etc.)
27 White water canoeing/rafting/kayaking
28 Standing in boat starting engine
29 Improperly moored
30 Caught in heavy surf
31 Swimmer or diver involved
32 Lack of sound producing devices contributed
33 Lack of communications capability contributed
34 Lack of anchor contributed
35 Lack of bailing device contributed
36 Hit and run
37 Wake of other vessel contributed
38 Improper ventilation/failure to vent before starting
39 Improper navigational aid contributed (buoy off station/buoy unlighted)
40 Victim entangled in lines
41 Accident involved inner tubes or kites
42 Operating in congested area
43 Water skiing accident
44 Carbon monoxide
45 Contact with power lines
46 Improper use of PFD/PFD not fastened properly
95 Unable to determine if operator contributed to fault
96 Operator contributed to fault
97 Operator did not contribute to fault
98 Collision with commercial vessel
99 Information not available for other boat(s) involved in collision

APPENDIX 1
SAMPLES OF SAFETY DATA BASE CODING AND REPORTING FORMS

Railroad Accident/Incident Reporting Systems (RAIRS)

F. Sample Forms cont.

2c

DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION

RAIL EQUIPMENT ACCIDENT/INCIDENT REPORT

Joren South Railroad Company	JSRC	A7654
Amtrak	ATK	6789
Joren South Railroad Company	JSRC	A7654
N/A	0 1 / 0 1 / 7 7	12:35 P

1 Derailment 2 Rear end collision 3 Head on collision 4 Side collision 5 Rolling obstruction 6 Structure or track collision 7 Equipment overheating 8 Obstruction 9 Fire or explosion 10 Collision-Grade crossing 11 Other (specify) 12 Other (specify) | 0

HAZARDOUS MATERIALS (number of)

0	0	0	0

LOCATION

Cascern	Cooperville	25.2		DC

ENVIRONMENTAL CONDITIONS

-02 °F	1 Clear 2 Cloudy 3 Rain 4 Fog 5 Snow 6 Sleet	2	1 Clear 2 Cloudy 3 Rain 4 Fog 5 Snow 6 Sleet	1

OPERATIONAL DATA

(place a 0 in appropriate box) 1 Manual block 2 Interlocking 3 Cab signal 4 Automatic block 5 Traffic control 6 Auto. train control 7 Yard radio 8 Train radio 9 Radio 10 Auto. train control 11 Voice communication 12 Train order 13 Other (specify)

0 miles Operation	N/A		N/A

EQUIPMENT

N/A	1 Freight train 2 Passenger train 3 Work train 4 Other train 5 Freight car 6 Cut of cars 7 Locomotive 8 Light locomotive	6	1 Yes 2 No	0
ABC Siding	1	N/A	1 Main 2 Yard 3 Siding 4 Industry	3

XYZ111	N/A	Yes
N/A	N/A	N/A

0	0	0	0	0	5	0	1	0	0
0	0	0	0	0	1	0	0	0	0

PROPERTY DAMAGE

$ 1,200	$ 3,500

ACCIDENT/INCIDENT CAUSE CODE

702		N/A		N/A

CASUALTIES

0	0	0

CREW (no. of)				HOURS ON DUTY	
N/A	N/A	N/A	N/A	N/A	N/A

K. C. Jones, Superintendent of Safety	02/23/77

Siding switch thrown by unknown persons.

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TRAIN OPERATION - HUMAN FACTORS

BRAKES, USE OF

500	Automatic brake, improper use
501	Dynamic brake, improper use
502	Failure to properly secure engine(s) (railroad employee)
503	Failure to properly secure hand brake on car(s) (railroad employee)
504	Failure to apply sufficient number of hand brakes on car(s) (railroad employee)
505	Failure to apply hand brakes on car(s) (railroad employee)
506	Failure to properly secure engine(s) or car(s) (non-railroad employee)
507	Independent (engine) brake, improper use
508	Failure to control speed of car using hand brake (railroad employee)
509	Cause code not listed; enter code 509 in Item 35 and explain in Item 50

EMPLOYEE PHYSICAL CONDITION

510	Impairment of efficiency and judgment due to drugs or alcohol
511	Incapacitation due to death or illness
512	Employee restricted in work or motion
513	Employee falling asleep

FLAGGING, FIXED, HAND AND RADIO SIGNALS

517	Absence of fixed signal (Blue Signal)
518	Fixed signal improperly displayed (Blue Signal)
519	Fixed signal improperly displayed
520	Fixed signal, failure to comply
521	Flagging, improper or failure to flag
522	Flagging signal, failure to comply
523	Hand signal, failure to comply
524	Hand signal improper
525	Hand signal, failure to give/receive
526	Radio communication, failure to comply
527	Radio communication, improper
528	Radio communication, failure to give/receive
529	Cause code not listed; enter code 529 in Item 35 and explain in Item 50

APPENDIX 1
SAMPLES OF SAFETY DATA BASE CODING AND REPORTING FORMS

Safety Information Reporting and Analysis System (SIRAS)

DEPARTMENT OF TRANSPORTATION
URBAN MASS TRANSPORTATION ADMINISTRATION

RAPID RAIL TRANSIT TRAIN ACCIDENT REPORT

FORM APPROVED
OMB NO. 2132-0628
Expiration date [illegible] 30 95

REPORT NUMBER

[illegible]

HUMAN FACTORS

	29 TRAIN ATTENDED	30 NUMBER IN CREW			31 OPERATOR ACTIONS (enter up to 4)
a. STRIKING TRAIN (or only train)	___	___	___	___	_____
b. OTHER TRAIN (if applicable)	___	___	___	___	_____
	1—yes 2—no 3—unknown	motormen operators	conductors	other employees	1—none 2—normal brake 3—emergency brake 4—alerted passengers 5—[illegible] 6—[illegible] 7—[illegible] 8—other _____

Complete a column for each motorman operator, conductor, other employee involved in the accident. Use additional Page 3 if more than 3 employees are involved.

	EMPLOYEE INVOLVED				EMPLOYEE INVOLVED (continued)		
32. EMPLOYEE LOCATION 1—on striking train 2—on other train 3—not on train	___	___	___	35. YEARS OF SERVICE	___	___	___
33. EMPLOYEE JOB CODE 1—motorman, train operator 2—conductor 3—other personnel	___	___	___	36. WAS CHECK-IN PROCEDURE FOLLOWED AT START OF SHIFT? 1—yes 2—no 3—not applicable	___	___	___
34. JOB CODE FOR DUTIES PERFORMED AT TIME OF ACCIDENT 1—motorman, train operator 2—conductor 3—other personnel	___	___	___	37. HOURS OF DUTY SINCE START OF SHIFT	___	___	___
				38. AGE	___	___	___

APPENDIX 2

NOTES ON DRUG TESTING TECHNIQUES

- Urine is the fluid of choice for thin layer chromatography analyses because drug levels usually are higher in urine than in blood or serum; short-acting drugs, rapidly metabolized agents, and many of the narcotics and hallucinogens, appear only in the urine; and large volume specimens are readily available, improving the chances of detecting a compound. The normal composition of the urine varies considerably during a 24-hour period; most reference values are based on an analysis of the first urine voided in the morning. This specimen is preferred because it has more uniform volume and concentration, and its lower pH helps preserve the formed elements. Immediate refrigeration is essential unless preservatives can be used. The time of collection of the specimen should be noted on a test requisition form and on the label of the container. If a frozen specimen is required, the urine sample should be frozen immediately after collection and packed in dry ice for shipment to the laboratory. Typically, 50 ml of urine in a screw-cap bottle is required for a thin layer chromatography screen. A larger volume might be required for a confirmation, depending on the analytical method chosen.

- The requirements for a comprehensive drug screen using gas chromatography, liquid chromatography, and gas chromatography-mass spectrometry are samples of urine, serum, or gastric fluid. The most complete analysis is available when both serum and urine are submitted together. For these analyses, five ml of serum in plastic vial, 50 ml of urine in a screw-cap bottle, and 10-50 ml of gastric fluid in a screw-cap bottle are required. The blood sample should be treated in the following way: Venipuncture should be performed as with any other blood collection vehicle. The serum separator tube (SST), with its stopper in place, should then be allowed to clot for a minimum of thirty minutes and centrifuged within a maximum of sixty minutes after collection. A serum separator tube must not be centrifuged immediately after the draw. After the thirty minutes clotting time described above, the tube should be placed in a centrifuge and spun for fifteen minutes at an RPM of between 2200 and 2500. The stopper must not be removed from the tube at any time during collection, processing, or centrifugation.

When whole blood clots, if oxygen is present, the red blood cells rupture and release hemoglobin. This process is called hemolysis. To avoid this condition, the serum separator tube is used in such a manner that oxygen is excluded during the collection, spinning, and centrifugation processes, and hemoglobin is prevented from entering the serum. The presence of hemoglobin can change the drug levels. Also, as the blood clots, the fibrinogen, which is a globulin produced in the liver and present in blood plasma, is converted by the proteolytic enzyme thrombin to fibrin, which is a white insoluble fibrous protein. This process is called fibrinolysis. Thus, blood serum contains no hemoglobin, cells, or fibrinogen; the cells and fibrin have been separated by the spinning action. Again, proper control of the sample between collection and analysis is required to assure that the analysis goes with the proper individual.

- Thin layer chromatography (TLC) is a form of liquid chromatography. In thin layer chromatography (TLC), the stationary phase is a powdered adsorbent which is attached as a coherent film or layer to an impermeable plate or backing. The mixture to be separated is spotted onto one edge of the plate. The plate is then put into a chamber containing the solvent or mobile phase. The mobile phase moves up to adsorbent on the plate by capillary action, carrying along the components of the mixture. Because of the differences in the interactions of the components of the mixture with the solvents in the mobile phase, the components will be separated from each other. (Sometimes, the plate is turned ninety degrees, and the separation is allowed to occur in a second dimension.) After an appropriate time the plate is allowed to dry, and the components are identified by spraying the plate with developing chemicals which reveal the location of the components. The relative retention factor (Rf factor) is measured as the distance that the spot migrated from the starting spot relative to some internal standard Rf value.

- The immuno-chemical methods are characterized by their use of antibodies obtained from animals injected with drug-attached antigens or haptens. The basic principle of this procedure is based on the reaction between an antibody and an antigen, which is an antibody generator.

It is a chemical (hapten) which, when injected into an experimental animal, provokes an immune response in the animal's blood. To be effective, a hapten must have a large molecular weight, so it is essential to aggrandize the molecule by coupling the drug with a suitable protein such as bovine serum albumin. This coupling can be accomplished in one of several ways, depending on which active site of the drug the protein is coupled. Each will produce a slightly different hapten and a slightly different antibody. Thus, the specificity of the antibody is a function of the hapten synthesis.

Once a sensitive antibody (Ab) is generated, it is used by reacting it with an antigen (A) according to the following general equation:

A	+	Ab	---->	A.Ab
(Antigen)		(Antibody)		(Complex)

If one adds to this system another component that contains a labeled antigen (A1), it will compete with the unlabeled antigen (A) for the antibody and form some labeled antigen-antibody complex (A1.Ab). The labeled antigen (A1) will be distributed in this system--some in the free state (A1) and some in the bound state (A1.Ab). This distribution is a function of the unlabeled antigen (drug in the sample). Thus, by measuring the amount of labeled products, one may determine the amount of competing antigen (drug) in the sample.

- Chromatography is a physical method for separating or partitioning components in a mixture. In gas chromatography (GC), a carrier gas transports the vapors of the sample through a narrow column containing a stationary phase which combines with the components in the gas sample. Separation of components in the sample results from multiple forces--adsorption, solubility, chemical bonding, polarity, or molecular filtration--by which the stationary phase material tends to retain each of the components.

  As the sample components are selectively retarded by the stationary phase, they emerge from the column in the reverse order of their retention and pass through a detector which registers a signal corresponding to the amount of the component eluted at a particular time. The response of the detector is plotted in terms of

intensity versus time, producing a succession of peaks. Analysis of the area under each peak, after proper calibration, provides a quantitative indication of each component. Since the individual components of the sample are selectively retarded by the stationary phase, the time interval between sample introduction and the elution of the components from the column--the so-called retention time--can be used for component identification.

- High-pressure liquid chromatography (HPLC) is another form of liquid chromatography that is restricted to use of columns. Since both GC and HPLC are run in columns, the main difference is that one uses a gas as a mobile phase and the other uses a liquid. The gas used on GC (typically Helium or Nitrogen) is inert and has no affinity for the sample. The liquid used in HPLC always has some affinity for the sample (i.e., the sample will have some solubility in the mobile phase liquid), so it must be chosen carefully. In comparing the two techniques, the critical factors in GC are the stationary phase and the temperature (which determines the samples vapor pressure). In HPLC, both the stationary phase and the mobile phase are critical. The choice of the stationary phase is chosen to be "like" the sample. Since "like dissolves like," the result is that the sample is retained by the stationary phase and a separation is effected.

  The other differences between GC and HPLC can be related to the differences in the physical properties of gases and liquids. For example, a liquid is more viscous than a gas and thus requires (in part) higher pressure to force the viscous liquid through the packed bed. The diffusion coefficients of sample components in liquids are smaller than in gases, restricting mass transfer in the mobile phase in HPLC. This condition also leads to the use of very small particles in the stationary phase so the diffusion distances are decreased and the mixing is improved.

- Behavioral tests make use of relative objective changes in psychomotor performance which are directly but not uniquely associated with alcohol. The gaze nystagmus test makes use of the fact that alcohol intoxication reduces the ability of the eye to smoothly track a target moving in a horizontal plane; the walk and turn and the one leg stand test make use of the effects of alcohol on the vestibular system, which controls balance.

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