UMTA-MA-06-0152-84-3
DOT-TSC-UMTA-84-25

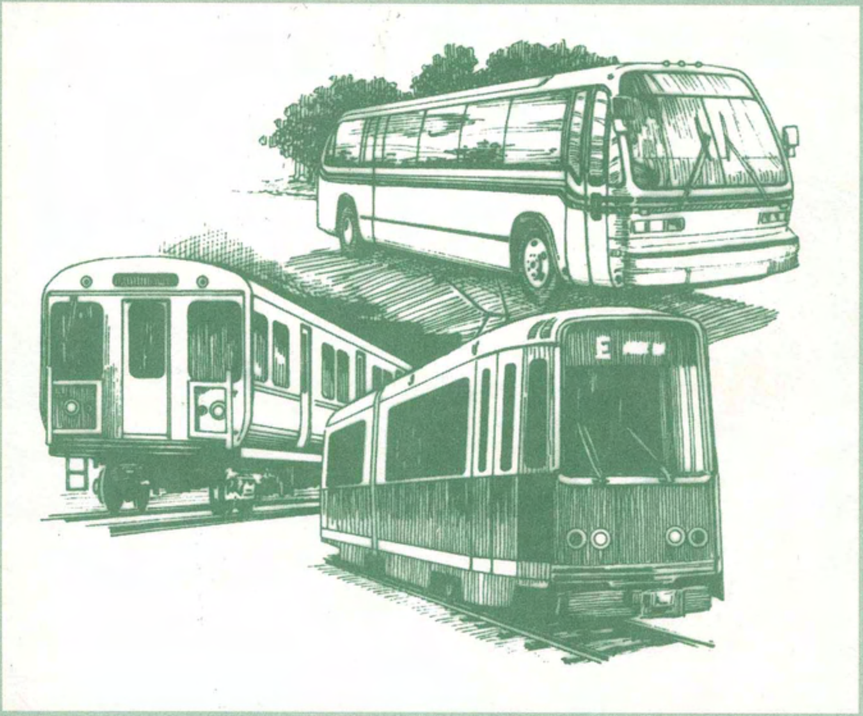
U. S. Department
of Transportation
Federal Transit Administration

Evacuation and Rescue of Elderly and Disabled Passengers from Paratransit Vans and Buses

Ketron, Inc.
58 Charles St.
Cambridge, MA 02141

October 1984
Final Report

Reprint
August 1995



FEDERAL TRANSIT ADMINISTRATION

REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
October 1984
Reprint
August 1995

3. REPORT TYPE AND DATES COVERED
Final Report
January 1983 • December 1983

4. TITLE AND SUBTITLE
Evacuation and Rescue of Elderly and Disabled Passengers from Paratransit Vans and Buses

5. FUNDING NUMBERS
DOT-VNTSC-UMTA-84-25

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER
DTRS-57-81-C-00144

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
Federal Transit Administration
Office of Technical Assistance
Washington, DC 20590

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
URT-6

11. SUPPLEMENTARY NOTES
•under contract to:
U.S. Department of Transportation
Research and Special Programs Administration
Volpe National Transportation Systems Center
Cambridge, MA 02142

12a. DISTRIBUTION/AVAILABILITY STATEMENT
This document is available to the public through the National Technical Information Service, Springfield, VA 22161

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The provision of efficient and safe methods for the effective evacuation and rescue of elderly and disabled passengers from such vehicles as standard and modified vans, body-on-chassis-small buses, and heavy-duty transit buses is necessary to ensure their safety during system use. Standard methods are not always useful for these patrons as a result of their physical and mental condition and their insufficient ability to manage self-evacuation. Effective methods and equipment are identified and developed as a function of transit use by the elderly and disabled, accident incidence rates for the various vehicles, a study of actual transit vehicle characteristics and their crashworthiness, and an analysis of emergency preparedness forces. Needed equipment is identified along with suggestions for familiarity and simulation training, the development of standard operating procedures, the debriefing of actual accident experiences and the sharing of this technology. An industry-wide Project Review Committee was established and utilized for the purpose of comment and input regarding the development of evacuation and rescue scenarios and alternative methods. Transit operators, state DOTs and transit equipment manufacturers were contacted and interviewed. A bibliography of 190 items is included.

14. SUBJECT TERMS
evacuation, rescue, elderly, handicapped, bus, van transit, paratransit, disabled, collision, safety, accident, fire, extrication, emergency causing incident, crashworthiness, emergency preparedness, rollover

15. NUMBER OF PAGES
190

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

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	1 kilometer (k) = 0.6 mile (mi)

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1 cup (c) 0.24 liter (l)	1 liter (l) = 0. 26 gallon (gal)
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1 quart (qt) 0.96 liter (l)	
1 gallon (gal) 3.8 liters (l)	
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TEMPERATURE (EXACT)	**TEMPERATURE** (EXACT)
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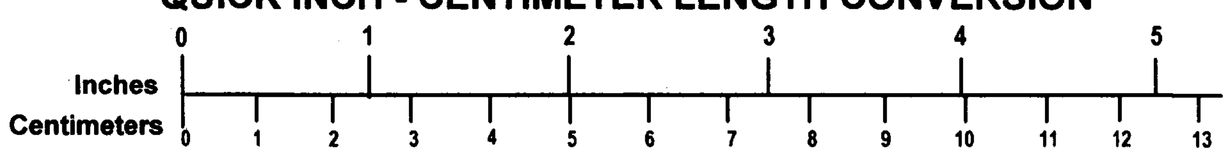

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Revised 1/23/95

PREFACE

This report was sponsored by the Urban Mass Transportation Administration's Office of Technical Assistance, Safety and Security Staff. Lloyd G. Murphy, Director of the Safety and Security Staff was instrumental in the initiation and overall guidance of this effort.

The contractual effort which resulted in this report also included consideration of evacuation and rescue of elderly and disabled passengers from vehicles and structures of underground portions of urban rail transit systems. The results of that work are not reported here but have been incorporated into the "Emergency Preparedness Guidelines for Rail Transit Systems" which are currently under review pending dissemination by the Urban Mass Transportation Administration's Office of Technical Assistance, Safety and Security Staff.

Special methods of evacuation and rescue are required to ensure the safety of elderly and disabled passengers on standard and modified vans, body-on-chassis small buses, and heavy-duty transit buses. The standard methods are often ineffective with elderly and disabled passengers because their physical and mental problems hinder them from cooperating with rescue forces or extricating themselves. This study determines the most effective methods of evacuation and rescue as a function of transit use by the elderly and disabled, accident incidence rates for various types of transit vehicles, transit vehicle characteristics and crashworthiness, and the state of emergency preparedness forces. Equipment needs are ascertained, and suggestions are made for providing familiarity and simulation training, for developing standard operating procedures, for debriefing actual accident victims, and for disseminating this newly developed technology. An industry-wide Project Review Committee has been formed and consulted to gather comments concerning the development of evacuation and rescue scenarios and alternative methods. Transit operators, state DOTS and transit equipment manufacturers have been contacted and interviewed. A bibliography of 190 items is included.

At the beginning of the project, important direction was provided by Roy Field, Arthur L. Flores, William T. Hathaway, Irving Litant, Stuart N. Palonen, Robert J. Pawlak, Donald E. Sussman, and Stephanie H. Markos from the U.S. Department of Transportation.

Stuart Palonen served capably as the Project Monitor until leaving the Center. Richard J. Porcaro took over as Interim Project Monitor and provided significant direction. Robert Pawlak subsequently brought this project to its successful completion.

Important contributions were made during the course of this project by our subcontractor, the University of Michigan, Transportation Research Institute, Ann Arbor, MI.

A special expression of gratitude is conveyed to George L. Cancro, Robert S. Carpenter, Richard Fasy, Farnham Folsom, Terrence J. Moakley, Thomas O'Brien, Albert Sergio, Robert Williams, and Carmella Strano, the members of the industry-wide Project Review Committee who contributed significant amounts of time and expert comment on the draft documents and at the Review Committee Meetings. Thanks also go to their respective employers for allowing their participation: The Port Authority Trans-Hudson Corporation of New York and New Jersey; the Arlington, Virginia, Fire Department; the Southeastern Pennsylvania Transportation Authority; the State of Maine and the Community Ambulance of Augusta, Maine; the Eastern Paralyzed Veterans Association of New York City; the Massachusetts Bay Transportation Authority; the Rescue Training institute of Ambler, Pennsylvania; the Pennsylvania Fire Training School of Bridgeport Pennsylvania; and Moss Rehabilitation Hospital, of Philadelphia, Pennsylvania.

During the conduct of the research a large number of transit operators, State Departments of Transportation, equipment manufacturers, police departments, newspapers, municipal libraries, and insurance agents (all listed in Appendix A) were contacted and requested to provide information. Their contributions are duly noted and appreciated.

Significant and interesting comments on the draft interim and final reports were provided by Abdo S. Ahmed, Roy Field, William T. Hathaway, Robert J. Pawlak, Richard J. Porcaro, Jeffery G. Mora, Patricia Cass and Stephanie H. Markos from the U.S. Department of Transportation.

Thanks go to my secretary, Virginia B. Orr, for her typing and graphic skills, and the other KETRON secretaries for their typing support, to Ms. Pat Afriat for her coordination of secretarial services, to Christine White for her fine artwork, and to Lawrence E. Decina for his help in developing the bibliography and acquiring source material.

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ABBREVIATIONS

APTA - American Public Transit Association

PARS - Fatal Accident Reporting System

FEMA - Federal Emergency Management Agency

FMVSS - Federal Motor Vehicle Safety Standard

GFC - Grumman Flxible Corporation

GMC - General Motors Corporation

HSRI - Highway Safety Research Institute

NASS - National Accident Sampling System

NCSS - National Crash Severity Study

NHTSA - National Highway Traffic Safety Administration

NTSB - National Transportation Safety Board

NTIS - National Technical Information Service

TRIS - Transportation Research Information Service

TSC - Transportation Systems Center

UMTA - Urban Mass Transportation Administration

UMTRIS - Urban Mass Transportation Research Information Service

US DOT - United States Department of Transportation.

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APTA - American Public Transit Association

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TSC - Transportation Systems Center

UMTA - Urban Mass Transportation Administration

UMTRIS - Urban Mass Transportation Research Information Service

US DOT - United States Department of Transportation.

EXECUTIVE SUMMARY

There is a need for developing safe and efficient methods of rescuing elderly and disabled passengers from transit vehicles. Existing procedures and available literature often do not adequately address the special needs of this group of passengers, the characteristics of the various types of vehicle they use, or the emergency response options that can be used to rescue them.

Elderly and disabled people are often a majority of the passengers on standard and modified paratransit vans and/or body-on-ohassis small buses. Their use of these vehicles is expected to increase because of special services being provided by transit operators.

Standard paratransit vans seem sufficiently crashworthy, although more inclined than automobiles to roll over in accidents. Modified vans, if properly constructed, are about as safe as standard vans. But poorly designed raised roofs, wheelchair lifts that block entrances and/or are not effectively counterbalanced, and other poorly designed or executed modifications have been shown to reduce the safety of some modified vans.

Body-on-chassis small buses, if properly designed and constructed, are sufficiently crashworthy (with one exception) but, like the vans, appear to be more inclined than automobiles to roll over in accidents.

Elderly and disabled people also use urban transit buses and intercity motor coaches but to a lesser degree than the vans and small buses previously mentioned, and their use of these vehicles is expected to remain constant. These bus types are the most crashworthy of all types previously mentioned.

The crashworthiness of these various transit vehicles was used to establish the kinds and degrees of crush that may occur in accidents. Scenarios for emergencies and accidents and their probability were determined from available data. Next, the kind of equipment and procedures that would be necessary to respond to these emergencies (such as extrication of trapped passengers) was determined.

Evaluation of methods and equipment currently available for rescue in such situations revealed a number of shortcomings in existing training, equipment, and operating procedures. Standard techniques for rescue from automobiles now serve as the basis for the rescue of elderly and disabled passengers from transit vehicles, yet these procedures are often insufficient. For example, elderly and disabled passengers may: 1) be unable to communicate; 2) have pre-existing conditions -that could affect the selection of the type of treatment for injury; 3) become entrapped or impaled by the aids that they use, such as wheelchairs; 4) become irrational; 5) be unable to contribute physically to the process of extrication; and 6) need to be immobilized before removal from the vehicle and transport to a hospital.

Options available to improve this state of affairs include:

- education of potential rescuers about the characteristics of these types of transit vehicles and the characteristics of elderly and disabled passengers;
- sharing of pertinent information by transit operators with rescue forces and involvement of operators in their training;
- increase in the realism of training exercises with actual vehicles and elderly and disabled people (or actors);
- development of methods of improvisation with present equipment;
- development of new rescue equipment;
- joint development of standard emergency procedures by transit operators and rescue forces; and
- documentation of accidents and incidents involving elderly and disabled people and dissemination of relevant information throughout the industry.

1. INTRODUCTION

To ensure the safety of passengers on paratransit vans and buses, efficient and safe methods of rescuing them are needed. Methods applicable to the general public, however, may not always be practicable in the rescue of elderly and disabled passengers because of their physical and mental conditions, and in many cases, because of their inability to escape by themselves. The identification, development, and implementation of effective methods for safely rescuing such passengers are necessary and increase in importance as transit and paratransit vehicles are made more accessible to them. This research program concerned the preparedness of transit operators and rescue forces for emergencies involving such passengers.

1.1 PROJECT GOAL AND OBJECTIVES

The purpose of this project has been formulated in response to concerns felt by both the transit community and the U.S. Department of Transportation over the ability of transit operators and rescue forces to rescue elderly and disabled passengers in emergencies. Specifically, it is to invent and to evaluate alternative methods that can be used to ensure the safe and quick rescue of elderly and disabled passengers from standard and modified vans, body-on-chassis small buses, heavy duty small buses, urban transit buses, and intercity buses.

The project has achieved the following objectives:

- establishment of an industry-wide committee responsible for reviewing and evaluating the rescue equipment, procedures, and techniques identified or developed under this project;
- review and evaluation of domestic and foreign literature on rescue from public vehicles;
- review of the emergency medical techniques and procedures currently employed by U.S. and foreign transit system operators for the rescue of passengers and employees during emergencies;

- identification of the most critical rescue problems likely to be encountered by elderly and disabled transit passengers and development of scenarios describing them; and
- development of alternative procedures and techniques for achieving safe and timely rescue in those scenarios for which existing methods do not appear to be feasible.

1.2 REVIEW COMMITTEE

A Project Review Committee was established to comment on and to add to the scenarios and the alternative methods, equipment, and techniques that were developed by this research program.

The committee members brought to their work a very broad array of qualifications and expertise. The qualifications of each potential member were fully reviewed and each person was extensively interviewed before the best candidates were approved for appointment to the committee by the Transportation Systems Center (TSC) Project Monitor. The committee members were:

- George L. Cancro
  Assistant Superintendent of Operations
  Acting Superintendent of Transportation
  Port Authority Trans-Hudson (PATH) Corp.
  New York and New Jersey

- Robert S. Carpenter
  Chief
  Arlington Fire Department
  Arlington, Virginia

- Richard Fasy
  Manager of System Safety
  Southeastern Pennsylvania Transportation
  Authority (SEPTA)
  Philadelphia, Pennsylvania

- Farnham Folsom
  Director, County Ambulance of Augusta
  Augusta, Maine

- Terence J. Moakley
  Barrier Free Design Director
  Eastern Paralyzed Veterans Association,
  New York, New York

- Thomas O'Brien
  Manager, Office for Special Needs
  Massachusetts Bay Transportation Authority (MBTA)
  Boston, Massachusetts

- Albert Sergio
  Executive Director
  Rescue Training Institute
  Ambler, Pennsylvania

- Carmella Strano
  Director of Transportation
  Evaluation and Training Center
  Moss Rehabilitation Hospital
  Philadelphia, Pennsylvania

- Robert Williams
  Senior Rescue Instructor
  Pennsylvania Fire Training School
  Bridgeport, Pennsylvania.

The Committee contributed to the study through general informal meetings with project team members and through formal reviews, with the TSC Project Monitor and the Project Team, of the interim report and the draft version of the final report. The Committee made substantive contributions to this final report.

1.3 LITERATURE REVIEW

Literature and reference materials were found by searching through various automated data bases. The libraries of the U.S. DOT/Transportation Systems Center, the Occupational Safety and Health Administration, the Veteran's Administration, the Transportation Research Board, the National Transportation Safety Board, various universities and medical schools, and various national associations, such as the National Association of Emergency Medical Technicians, the National Registry of Emergency Medical Technicians, and the National Fire Protection Association, were searched in order to find relevant documents. The ACT Foundation, a prominent national organization in the field of emergency medical services, was also contacted. From these sources of information and from contacts with transit personnel/ a large body of literature was located and reviewed. The relevant publications are listed in this final report as Section 5, the Bibliography.

1.4 CURRENT PRACTICE REVIEW

The project team contacted various transit operators in order to find out what procedures they have developed to rescue elderly and disabled passengers from vehicles in emergencies, and to learn of any actual accidents in which these procedures were used.

Limited information on preparedness and training in transit bus and paratransit vehicle systems was found. This reflects the common but incorrect assumption that there is no need for such documentation. There have been few catastrophic accidents, and for the most part, the systems enjoy very strong safety records.

The project team also consulted selected police departments, newspapers, and transportation consultants. The individuals and agencies that were contacted (and are listed in Appendix A) were:

- o transit operators;
- o state departments of transportation;
- o equipment manufacturers;
- o police departments;
- o newspapers and municipal libraries;
- o insurance agents; and
- o consultants.

The Illinois Paratransit Association provided local assistance by publishing a description of this research project in their May 1982 newsletter.

In addition, a number of automated accident files at the Transportation Research Institute of the University of Michigan were examined and used in the study. They were:

- the Fatal Accident Reporting System (PARS) of the National Highway Traffic Safety Administration (NHTSA)j
- data files from the states of Michigan, Pennsylvania, Texas, and Washington; and
- data from the second phase of the National Crash Severity Study (NCSS).

2. ORIENTATION: THE ELDERLY AND THE DISABLED

2.1 CHARACTERISTICS

The transportation characteristics of the elderly and the disabled have been extensively studied over the previous decade or so (43, 189, 190, et. al.). Much work has concerned a subgroup of this population referred to as the "transportation handicapped." Section I6(c) of the Urban Mass Transportation Act of 1964, as amended, defines a transportation-handicapped person as:

> "Any individual who, by reason of illness, injury, age, congenital malfunction, or other permanent or temporary incapacity or disability, is unable without special facilities or special planning or design to utilize mass transportation facilities as effectively as persons who are not so affected."

The transportation handicapped differ considerably among themselves in the severity and extent of their disabilities, the way in which other people view their physical and mental limitations, and their income, age, and mobility. Because of these differences, the transportation problems and needs of the transportation handicapped also differ widely. The likelihood of such a person using a conventional transit vehicle is inversely proportionate to the severity of his handicap. Often, however, studies of the transportation handicapped consider only chronic disabilities and neglect people in institutions. Estimates of the transportation-handicapped population, therefore, have limited applicability to the study of the overall elderly and disabled population using public transit. In reality, significant numbers of the elderly and disabled can be found on the various types of public transit vehicles, as will be shown in this section.

The term "elderly and disabled" includes any person who is elderly or disabled or both. This research concerns those who would find it difficult to escape from an accident involving a public transit vehicle without aid from transit personnel, rescue forces, or fellow passengers.

2.1.1 Elderly

The declining birthrate and increasing longevity have combined to produce an increasingly aged population in the United States. The elderly population, defined as including persons aged 65 years or over, is currently about 20 million persons, or 9 percent of the entire population. Of these, about one third are estimated also to be disabled in some manner.

2.1.2 Disabled

Definitive data concerning the size of the disabled population are not available, because disabilities are not recorded in the national census, and because many persons suffer from multiple disabilities. Most estimates are based upon National Health Surveys (NHS), conducted by the National Center for Health Statistics in concert with local studies and extrapolated to the overall population. The data are based upon perceived mobility limitations and therefore contain a subjective element.

According to the NHS data (43), approximately 6.5 million noninstitutionalized people have some mobility limitation due to a chronic condition. Of these, about 1.75 million are house-bound, 1.5 million use some form of special aid, and 0.50 million require assistance from another person. The incidence of wheelchair use is 2.10 per 1000 population, which suggests a total population of wheelchair users of between 400,000 and 500,000 persons.

Table 2-1 shows the incidence rates for the total U.S. population and the combined Standard Metropolitan Statistical Area (SMSA) populations within the various NHS mobility-limitation categories. For the institutionalized, the census data provide overall populations; all mobility limitations must be inferred. The total population of the chronically ill in institutions is more than 2 million persons, of whom nearly 1 million are in homes for the aged. By applying the same incidence rates for mobility impairment to the non-aged portion of the institutional population, the total institutional population with transportation disabilities has been estimated at about 1.25 million. Many of these people are in

TABLE 2-1. INCIDENCE OF MOBILITY LIMITATIONS DUE TO CHRONIC CONDITIONS BY AGE AND MOBILITY LIMITATION CATEGORY: U.S. AND METROPOLITAN POPULATION (NONINSTITUTIONAL)

(Number Mobility Limited/1000 Population)

Age	Use Transit with Difficulty: Has Trouble	Use Transit with Difficulty: Uses Other Aids	Cannot Use Transit: Uses Other Aids	Cannot Use Transit: Needs Help	Cannot Use Transit: Uses Wheelchair	Cannot Use Transit: Confined To House
U. S. Population						
Under 18	1.13	0.12	0.06	0.68	0.42	0.57
18 to 64	11 .60	1.65	0.96	1.52	1.44	5.96
65 &. Over	57.77	22.03	15.71	17.37	11.54	51.55
All Age Groups Combined	12.78	3.15	2.11	2.80	2.10	8.70
Metropolitan Population (All SMSAS)						
Under 18	0.98	0.12	0.07	0.69	0.42	0.56
18 to 64	10.32	1.55	0.90	1.44	1.36	5.52
65 & Over	49.56	20.32	14.42	15.97	10.65	53.24
All Age Groups Combined	11.05	2.85	1.90	2.56	1.93	8.42

SOURCE: ADAPTED FROM REFERENCE NO. 43.

institutions (homes and schools for the mentally or physically disabled, homes for dependent and neglected children, homes for unwed mothers, etc.) that allow movement by public transit.

According to the NHS data, the overall incidence rates of acute mobility limitations are 2.78 per 1000 persons and 3.31 per 1000 for the age group of 18 and over. An incidence rate for the elderly only was not obtained. Overall, the acutely disabled population is estimated to be approximately 600,000 persons.

2.1.3 Medical Conditions and Mobility

Many disabilities do not impose significant limitations upon the use of transit but may well cause difficulty in escape or rescue from traffic accidents. For instance, the U.S. has about 2 million blind persons and several hundred thousand deaf persons, many of whom use transit regularly. Table 2-2 is taken from a study of the Chicago metropolitan area and illustrates this point by comparing various mobility states associated with a range of musculoskeletal, systemic, and sensory-degraded conditions. Each of these has many implications

TABLE 2-2. MEDICAL CONDITION BY MOBILITY LIMITATION

Medical Condition	Mobility Limitation				
	Home-bound (%)	Wheelchair (%)	Use Aids (%)	Some Difficulty (%)	No Limitation (%)
Musculoskeletal:	5	13	19	28	36
Arthritis	4	5	13	34	44
Back or Spine	7	14	19	29	32
Missing Limbs	5	10	55	20	10
Paralysis	8	53	24	8	8
Other	7	10	33	16	35
Cardiovascular	10	3	11	33	43
Respiratory	5	3	11	32	49
Nervous System	13	35	37	10	6
Multiple Sclerosis	20	37	37	6	0
Cerebral Palsy	6	33	36	14	11
Perceptual	a	1	17	40	34
Visual	9	1	19	41	30
Hearing	0	0	4	35	61
Mental Disorders	0	0	4	12	84

SOURCE: REFERENCE 189

for the state of a passenger during a traffic accident. Passengers with cardiovascular and respiratory conditions and any limitations arising therefrom will be especially sensitive to the temperature and toxicity of the atmosphere and the degree of anxiety expressed by fellow passengers.

Table 2-3 shows the effects of the passengers' medical conditions on their ability to perform various tasks required for the use of transportation. The effects of these mobility limitations in public transportation are also shown in Table 2-4, the data of which derive from a national sample survey of the transportation handicapped by the Urban Mass Transportation Administration of the U.S. Department of Transportation (190). For example, 64.9 percent of the transportation handicapped experienced difficulty going up or down stairs or inclines. Approximately 60 percent found it difficult to stoop, kneel or crouch. Some of the transportation handicapped experience both types of mobility problems. One can infer that many suffer from some combination of the eight identified mobility problems.

TABLE 2-3. FUNCTIONAL PERFORMANCE BY MOBILITY LIMITATION

Difficulty in Performing Task	Mobility Limitation: Homebound (%)	Wheelchair (%)	Use Aids (%)	Some Difficulty (%)	No Limitation (%)
Walking:					
Extreme	44	82	18	1	0
Great	42	11	37	11	1
Some	6	4	27	52	14
Little	8	3	18	36	85
Dynamic Movement:					
Extreme	42	42	17	2	0
Great	33	47	34	17	1
Some	11	7	30	41	12
Little	14	4	19	40	87
Vehicle Environment:					
Extreme	45	36	21	3	1
Great	39	57	50	28	5
Some	8	7	16	46	24
Little	8	0	13	23	70
Manipulative Ability:					
Extreme	7	5	3	0	0
Great	33	32	23	10	1
Some	38	48	45	30	10
Little	22	15	29	60	89
Perceptual Variables:					
Extreme	4	2	1	0	0
Great	8	1	7	3	1
Some	25	9	25	27	9
Little	63	88	67	70	90

SOURCE: REFERENCE 189.

TABLE 2-4. INCIDENCE OF GENERAL MOBILITY PROBLEMS AMONG TRANSPORTATION HANDICAPPED PEOPLE

Mobility Problems	Transportation Handicapped With Problem (%)
Difficulty going up or down stairs/inclines	64.9
Difficulty stooping/kneeling/crouching	60.6
Difficulty walking/going more than one block	56.9
Difficulty waiting/standing	56.2
Difficulty lifting or carrying weights up to 10 lbs.	47.3
Difficulty moving in crowds	41.4
Difficulty sitting down or getting up	40.5
Difficulty reaching/handling or grasping	33.5

NOTE: Percents add to more than 100% because of multiple general mobility problems among transportation handicapped people.

SOURCE: REFERENCE 190.

Passengers with musculoskeletal disorders may be susceptible to post-accident injury because of such factors as bone embrittlement. The sedentary way of life imposed by some physical handicaps, especially among wheelchair users, may also lead to extremes of body weight or unusual weight distribution, which may further complicate rescue.

The deaf and blind are frequent users of vans and especially of public buses. The deaf may be difficult to recognize but might need special help during an emergency, since they would not hear announcements or instructions. Seeing-eye dogs are used by only 3 percent of the whole visually-impaired population. Although these dogs are permitted on all public transit, it is not possible to tell whether the same small portion of the blind use them there.

2.2 USE OF TRANSIT

The use of transit obviously depends upon two factors, the accessibility of the transit system and the desire and need of the transportation handicapped to travel. The first is very mode-specific and will be discussed under each mode. The second is affected by a variety of socio-economic factors as well as by mobility limitations.

Availability of mass transit has a negligible effect on the frequency of trips by the transportation handicapped, according to the national survey (190). Overall, they take fewer trips than the non-handicapped population. For instance, transportation handicapped people 16 years and over in mass transit areas travel at the rate of 29.1 trips (by all modes) per person per month versus 54.8 trips (by all modes) per person per month among non-handicapped people of the same age group. Elderly transportation-handicapped persons and those with severe dysfunctions have even lower trip rates. Among the elderly transportation handicapped, 96 percent take trips, but their average number of monthly trips (by all modes) is lower than the rate for all the transportation handicapped (20.4 versus 29.5).

Few of the transportation handicapped take work trips (Tables 2-5 and 2-6). However, among those who do work, work trips are taken

TABLE 2-5. TYPES OF TRIPS TAKEN IN AN AVERAGE MONTH

(Base: Transportation Handicapped People in Each Group)

Trip Types	IN TOTAL URBAN AREAS	IN MASS TRANSIT AREAS	
	% of Transportation Handicapped People Taking Trips	% of Transportation Handicapped People (16 yrs. +) Taking Trips	% of Non-Transportation Handicapped People (16 yrs. +) Taking Trips
Shopping/Personal	76	77	94
Leisure/Recreation	69	68	87
Medical/Therapy	69	70	31
Work	14	14	55
School	8	5	15
Across all trip types	98	97	99

NOTE: Percenta add to more than 100% because of multiple trips taken.

SOURCE: REFERENCE 190.

TABLE 2-6. MONTHLY TRIP RATES BY TYPE OF TRIP TAKEN

(Base: Total Trips Taken By Each Group)

Trip Types	IN TOTAL URBAN AREAS		IN MASS TRANSIT AREAS			
	Total Transportation Handicapped Trips		Transportation Handicapped People (16 yrs. and older)		Non-Transportation Handicapped People (16 yrs. and older)	
	Trips Taken (%)	Avg. No. of Trips* Per Month	Trips Taken	Avg. No. of Trips* Per Month	Trips Taken	Avg. No. of Trips* Per Month
Shopping/Personal	34	12.9	36	13.2	29	16.6
Leisure/Recreation	28	11.5	28	11.9	23	14.4
Medical/Therapy	11	4.8	12	4.9	2	3.9
Work	18	36.3	19	37.8	39	39.1
School	9	31.5	5	26.4	7	25.1

•Average number of trips per month are based on those who take the trip type.

SOURCE: REFERENCE 190.

at about the same rate as those of the non-handioapped. Because of their relatively high age, few of the transportation handicapped take trips to school.

Like the transportation handicapped as a whole, the elderly transportation handicapped travel primarily for shopping and personal business, leisure and recreation, and medical reasons. As might be expected, only a very small proportion of elderly transportation handicapped persons take work or school trips.

2.2.1 Van and Small Bus Usage

There are many kinds of operators of standard and modified vans and body-on-chassis small buses, such as special agencies or organizations providing services to their clientele, coordinating agencies providing overall specialized transportation services, private operators providing non-emergency ambulance service, and public transit authorities providing demand-responsive or community-oriented transportation services. In an emergency, the identity of the operating agency will be an immediate clue to the nature of the passengers. A van operated by a senior center or an area agency on aging obviously carries elderly persons. A vehicle serving a sheltered workshop probably has passengers with a wide range of systemic dysfunctions.

The type of vehicle may suggest an upper limit to the number of persons on board. A modified van has at most 12 to 15 ambulatory persons, but only 7 to 11 passengers if wheelchair capability has been added. Similarly, a body-on-chassis small bus usually can seat 20 to 25 ambulatory persons. However, if all the positions on the vehicle are for wheelchair users, then the only ambulatory passenger is the driver. The greatest variations in passenger characteristics occur among body-on-chassis small buses used by public transportation authorities. These small buses, defined in Section 4, are used primarily for services to the elderly and disabled although some are used in general services in rural areas and small cities.

The Southeastern Michigan Transportation Authority (SEMTA), which is the largest operator of small bus services in the United States provides a good example of the use of such vehicles. It estimates that 2-3 percent of all its trips are provided to wheelchair users. Disabled people are about 15 percent of SEMTA's patronage and wheelchair users are approximately 15 percent of this group. Since there are about 200,000 riders per month and 215 small buses operating 6 days a week, there is about 1 wheelchair user per bus per day and 7 disabled persons per bus per day. But because most service is demand-responsive, the number of daily trips for each vehicle cannot be determined. If each vehicle makes one tour per day, then every vehicle, on the average, carries one wheelchair user. If each makes two tours per day, half the tours have a wheelchair user aboard. Unless the vehicles are used in a service for the non-frail elderly only, the probability of a wheelchair user being aboard ranges from 0.33 to 1.00. In systems that are specifically for the disabled, the probability of a wheelchair user being on board is very close to 1.0. For example, data from Project Mobility in Minneapolis-St. Paul, Minnesota, demonstrated that wheelchair user trips are approximately 40 percent of all trips. Wheelchair user ridership is about 10 trips per day per vehicle. Therefore, if each vehicle makes two tours per day, five wheelchair users will simultaneously be on each vehicle.

2.2.2 Bus Usage

Of the various modes of public transportation, the bus is relied on most frequently by the transportation handicapped (190), being used by 22 percent of all of them (Table 2-7). Further, usage of the bus is slightly higher among those aged 16 or over in mass transit areas (29 percent) than among the non-handicapped aged 16 or over in mass transit areas (25 percent). Also, the transportation handicapped who use the bus rely on it heavily, using it for 41 percent of all their trips. For 233,000 of the transportation handicapped, the bus is the only means of transportation. The monthly trip rate for the transportation handicapped using buses is 12.5 (Table 2-8).

TABLE 2-7. MODES USED IN AN AVERAGE MONTH

(Base: Total Respondents in Each Group)

Node	IN TOTAL URBAN AREAS		IN MASS TRANSIT AREAS	
	Total Transportation Handicapped People		Tranaportation Handicapped People (16 yra. and Older)	Non-Transportation Handicapped People (16 yrs. and Older)
	*People Using	No. of People (000)	% People Using	*People Using
Car	Si	6,140		
As passenger*	66	4,920	62	41
As driver	32	2.371	29	67
Bus	22	1,612	29	25
Malking	14	1,042	16	16
Taxi	13	972	14	5
Rail Transit**	2	164	3	7
Aiioclatlon Van	1	84	1	-
Personally Owned Van	1	79	1	1
Other (e.g., School Bui)	7	496	$	5
NUMBER OF PEOPLE (000)	7,440		4,716	92,403

• **Percenta add to more than the net of car usage became some people use the car both as a passenger and a driver.**

•* **Defined In the study as a Rapid Rail System serving an urban area which utilised either a subway or an elevated-type construction with high level platforms.**

SOURCE: REFERENCE 190.

TABLE 2-8. MONTHLY TRIP RATES OF TRANSPORTATION HANDICAPPED PEOPLE BY MODE

Mode	*Trips Taken	Average No. of Trips Per Month Among Users of Mode
Car		
As passenger	34	15.0
As driver	38	34.9
Bus	9	12.5
Walking	7	14.9
Taxi	3	7.1
Rail Transit*	2	21.3
Personally Owned Van	1	25.3
Association van	1	20.2
Other Nodes (e.g., School Bus)	5	19.5
TOTAL	100	

* Defined in the study as a Rapid Rail System serving an urban area which utilizes either a subway or an elevated-type construction with high level platforms.

SOURCE: REFERENCE 190.

The number of the elderly and disabled traveling by bus varies considerably. Those dependent upon mass transit have always been a large proportion of all transit riders. The elderly may be 40 percent of all transit riders. The number of elderly passengers, however, is significantly lower during peak hours, when most people are traveling to or from work, and higher during off-peak hours. Consequently, although bus occupancy is lower during the non-peak period, the number of elderly aboard may be much higher. Except for certain special express bus commuter services, it is probable that there are elderly passengers aboard every bus trip.

Wheelchair users are 0.2 percent of the general population, but the proportion using mass transit is not known. Obviously, those transit systems with buses that are inaccessible to wheelchair users have zero ridership, and no major metropolitan area has yet established a fully accessible bus transit system. However, in Seattle, which has made a commitment to overall environmental as well as transportation accessibility, the rate of wheelchair users' ridership is near that of their population incidence, and there are similar rates in some smaller cities where a high level of accesibility is provided. Even at the highest of these ridership levels, a wheelchair passenger is still relatively uncommon: approximately one rider per accessible bus per day. Since the average bus makes many trips, perhaps as many as 30 during one day, the chance of a wheelchair passenger being on any one trip is approximately 1 in 30. The exception to this is modified full-size buses operated by institutions to carry large groups of the disabled. These may carry as many as 10 to 16 wheelchair passengers. Although few in number, these vehicles are used in many major metropolitan areas and pose significant problems for escape and rescue in the event of an emergency.

2.3 INCIDENCE OF TRANSIT ACCIDENTS INVOLVING THE ELDERLY AND THE DISABLED

Knowing the probability of elderly and disabled passengers being on board a transit vehicle that is involved in an accident would help to determine the amount of specialized equipment that should be made available to rescue teams. Some information that bears on this problem, derived from the published literature, was included in Section 2.2; and more data are recorded in appropriate parts of Sections 3 and 4.

These published data, however, are not comprehensive enough to draw clear inferences. Consequently, a search through computerized accident data bases was made by the project team to find statistics pertaining to elderly and disabled passengers in transit vehicles. Since no single source of accident data was totally suitable, a number of accident files were examined and used to compile incidence values. They were the Fatal Accident Reporting System (PARS) of the National Highway Traffic Safety Administration, files from the States of Michigan, Pennsylvania, Texas, and Washington, and data from the second phase of the National Crash Severity Study (NCSS). Only these highway vehicle accident files were cost-effectively available, and only the PARS, Michigan and Pennsylvania data bases proved useful.

The probability of an elderly person being on board a highway transit vehicle at the time of an accident can be estimated from the accident data by examining the age of each occupant whose age, injury, etc., were recorded by the investigating officer, and of whom a record is included in the computerized data files. The total number of occupants is the number listed as being in the vehicle at the time of the accident, in those jurisdictions that give such information. Because the number and characteristics of occupants are frequently under-reported, especially in the case of uninjured occupants, the probability of the presence of an elderly occupant, when computed from the accident data, may be too low.

Disabled passengers are not specified in any of the accident data sets examined. Instead, the presence of children under five years of age was used as a surrogate for disabled passengers.

The results for FARS, Michigan, and Pennsylvania are given in Tables 2-9 through 2-11. Probabilities are given for the presence of at least one occupant 65 years or over, and 70 years or over. Note that the figures vary greatly among the three data sets, that of Michigan being the lowest. (This is particularly interesting since Michigan has the largest fleet of small buses in operation in the country.) These differences probably reflect local differences in documentation policies and practices. The high figures from the FARS data may result from higher occupant injury rates in fatal accidents, and consequently more complete occupant documentation. Still, one must be careful in applying the FARS statistics, since this data set records only fatal accidents, and investigating officers do not uniformly document accidents involving large vehicles with multiple occupants. The lack of uniformity of definitions of vehicle types also suggests that one must exercise caution in using these probability values.

Because of the possibility of under-reporting, which would lead to bias in the accident files, the 1977 National Personal Transportation Survey was used to obtain national estimates of the ages of bus passengers. Passenger-miles were used as the measure of exposure for estimating the probability of a passenger in a given age range being on board any bus at any time (including the time of an accident). It is not possible to differentiate between intercity and transit bus use, but school buses have been noted and excluded. The results are given in Table 2-12. The vehicle-miles are weighted by sample expansion factors to give national estimates of bus travel. The actual number of trips in each age category of the survey is also shown to give an indication of the size of the sample upon which the national estimates are based. The percentage of the total passenger-miles accrued by each group of interest is also given.

Computation of the probability that at least one passenger of a particular age group would be on board at the time of an accident would require knowledge of the distribution of the number of passengers by vehicle-mile, information that is not available.

TABLE 2-9. PROBABILITY OF AT LEAST ONE OCCUPANT OF GIVEN AGE GROUP BEING IN THE INVOLVED HIGHWAY TRANSIT VEHICLE

FARS 1975-1980

	School Bus	Cross Country Bus	Transit Bus	Other Bus	Unknown Bus	Van as School Bus	Van as Other Bus	TOTAL
Total Highway Transit Vehicles in Fatal Accidents	786	220	795	91	109	32	23	2,056
Vehicles With at Least One Occupant of:								
Age>.65	29	51	58	9	13	2	4	166
Prob.	0.037	0.232	0.073	0.099	0.119	0.063	0.174	0.081
Age>70	14	39	31	4	7	0	2	97
Prob.	0.018	0.177	0.039	0.044	0.064	0.000	0.087	0.047
Age 0-4	1	16	9	1	5	1	4	37
Prob.	0.001	0.073	0.011	0.011	0.046	0.031	0.174	0.018
Age 0-4 &>65	0	12	2	0	2	0	2	18
Prob. -	0.000	0.055	0.003	0.000	0.018	0.000	0.087	0.009

NOTE: Probability = Number of vehicles with occupants/Number of vehicles.

TABLE 2-10. PROBABILITY OF AT LEAST ONE OCCUPANT OF GIVEN AGE GROUP BEING IN THE INVOLVED HIGHWAY TRANSIT VEHICLE

MICHIGAN 1981

	School Bus	Other Bus	Total
Total Highway Transit Vehicles in Accidents	1,427	1,365	2,792
Vehicles With At Least One Occupant of:			
Age >_ 65	28	32	60
Prob.	0.020	0.023	0.021
Age > 70	10	13	23
Prob.	0.007	0.010	0.008
Age 0-4	2	3	5
Prob.	0.001	0.002	0.002
Age > 65 & 0-4	0	0	0
Prob.	0.000	0.000	0.000

Probability = Number of vehicles with occupant of given age group/Number of vehicles.

2-11. PROBABILITY OF AT LEAST ONE OCCUPANT OF GIVEN AGE GROUP BEING IN THE INVOLVED HIGHWAY TRANSIT VEHICLE

PENNSYLVANIA 1979

	Intercity Bus	Transit Bus	Total
Total Highway Transit Vehiclel in Accidents	97	633	730
Total Occupants	720	2,056	2,776
Vehicles With At Least One Occupant of:			
Age > 65	19	49	68
Prob.	0.196	0.077	0.093
Age > 70	11	35	46
Prob.	0.113	0.055	0.063
Age 0-4	6	18	24
Prob.	0.062	0.028	0.033
Age > 65 & 0-4	4	7	11
Prob.	0.041	0.011	0.015
Number of Vehicles With At Least One Occupant Requiring Extrication	1	8	9
Prob.	0.010	0.013	0.012

TABLE 2-12. 1977 NATIONAL PERSONAL TRANSPORTATION SURVEY: TRANSIT AND INTERCITY BUS RIDERS

Age	Actual Number (Unweighted)	Weighted Passenger Miles ($x10^6$)	Proportion of Travel (%)
0-4	31	156.218	0.5112
5-9	142	1042.195	
10-14	328	275.651	
15-19	440	6341 .583	
20-24	215	3404.381	
25-29	187	2334.479	
30-34	133	1917.129	
35-39	126	1338.063	
40-44	85	1600.164	
45-49	71	885.460	
50-54	100	1629.408	
55-59	129	1501.318	
60-64	91	2050.447	
65-69	110	1495.109	4.89
70-74	72	1656.172	5.42
75-79	32	311.727	1 .02
≥80	19	148.609	0.486
TOTAL	2,311	30558.1	
≥ 65	233	3611.6	11 .8
≥ 70	123	2116.5	6.93

Nevertheless, crude but useful estimates can be obtained by making a simple assumption. If it is assumed that a given number, n, of passengers are in a bus at the time of an accident, the probability that at least one passenger of age group i is aboard is

$$P = 1 - (1-Pi)^n$$

where p_i is the probability that an individual passenger is of age group i. Using the proportions given in Table 2-2 for P_i and an assumed load of 20 passengers, the probabilities of at least one elderly passenger being on board are, for those aged 65 or over, P = 0.919, for those aged 70 or over, P = 0.762, for those 0-4 years, P = 0.097, and for those 0-4 and 65 or over, P = 0.928. One can also ask how many patrons must be on board for the expectation of an elderly or young (surrogate disabled) passenger to be at least 0.5. Then $(1-Pi)^n = 0.5$. For those aged 65 or over and 0-4 years, $p_i = 0.123$, and n = 5.3 passengers.

The probabilities of elderly passengers being aboard obtained from the accident data are much lower than those obtained by the above approximations. It is not likely that under-reporting in the accident data would result in such a large discrepancy unless occupancy rates are very low. In fact, a check of the Pennsylvania data indicated that 45 percent of the intercity buses and 42 percent of the transit buses were reported to have only one occupant, presumably the driver, at the time of the accident, and this information probably accounts for the better part of the discrepancy.

3. PARATRANSIT VANS

3.1 INTRODUCTION

Paratransit vans carry a much greater proportion of elderly and disabled passengers than do full size transit buses, body-on-chassis small buses, and railcars. As mentioned in the preceding section, one can expect up to 40 percent of urban bus passengers to be elderly and 1 in 30 buses to be carrying a wheelchair user. In contrast, all of the passengers in a paratransit van may be elderly or disabled. The only able-bodied occupant of a van that has been in a collision or other accident may be the driver. Even if the driver is uninjured or only slightly injured, he/she may not be able to single-handedly evacuate elderly and disabled passengers from the vehicle. Help from trained rescuers, the police, or emergency medical service personnel will probably be required for most accidents. If the vehicle catches fire, the passengers and the driver may have to rely on the immediate help of nearby motorists and other good Samaritans before professional rescue personnel arrive.

Thus, a serious van accident poses difficult problems of rescue. The operators of paratransit vans must extend their driver training programs to include rescue methods and practices. Such programs, which should include simulations, are necessary to realize the goal of providing the safest paratransit service to all passengers.

This section lays the foundation for accomplishing that goal. Recommendations are based on a review of the literature on the subject, of current practices, and of case studies of accidents.

3.1.1 Use of Paratransit Vehicles

Although some transit authorities and systems provide paratransit service to commuters by subscription, the likelihood of an elderly or disabled person being on board such a vehicle is slight because of a common lack of wheelchair lifts and other aids to access. In contrast, some paratransit vans are occupied only by elderly and disabled persons, particularly those vans used by:

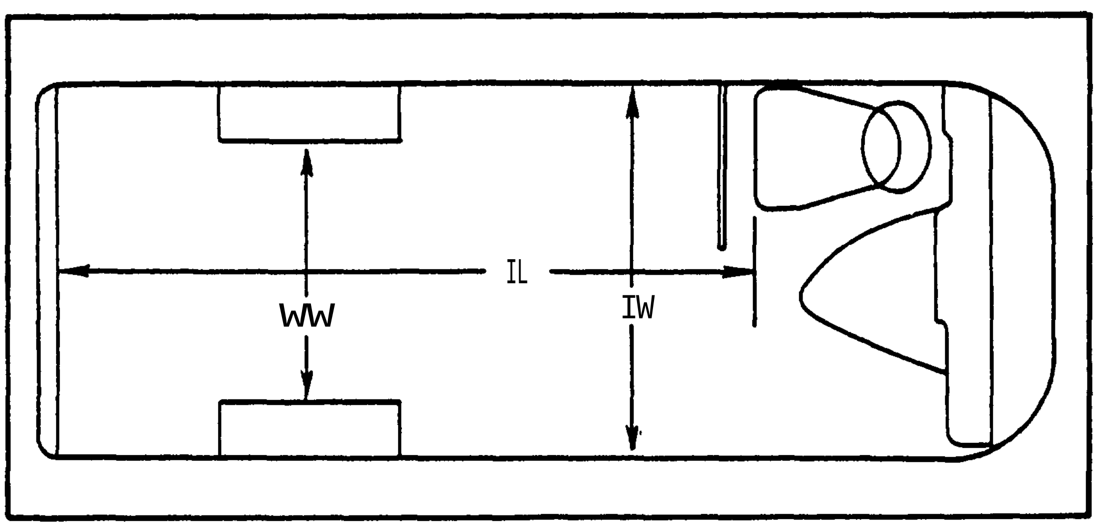
- o nutrition centers;
- o sheltered workshops;
- o therapy centers;
- o doctor's offices and hospitals;
- o schools or learning centers;
- o shopping centers; or
- o vocational rehabilitation centers.

The problems of rescue can be complicated by the practice of combining the transportation services provided to the elderly and disabled. This combination can result in a variety of types of passenger, such as wheelchair users, retarded, senile, blind and/or deaf persons in one vehicle. Rescue personnel must be aware of this possibility and must know how to handle such a situation.

3.1.2 Paratransit Vehicle Characteristics

Because vans have become common on the nation's highways, emergency-response personnel may feel they are already familiar with them. However, when used for paratransit, vans are often modified to seat up to 15 individuals, often have lifts and tiedown devices for the disabled, and often have raised roofs. The specific dimensions and features of paratransit vans can serve to demonstrate how closely the passengers are seated inside and can begin to suggest some of the problems of extrication that may be encountered when such a vehicle has been involved in an accident.

Dimensions. Figure 3-1 and Table 3-1 show the interior dimensions of the standard vans that are often used for paratransit service. The headroom, about 53 inches, prevents one from standing erect. Figure 3-2 illustrates the typical seating arrangements of



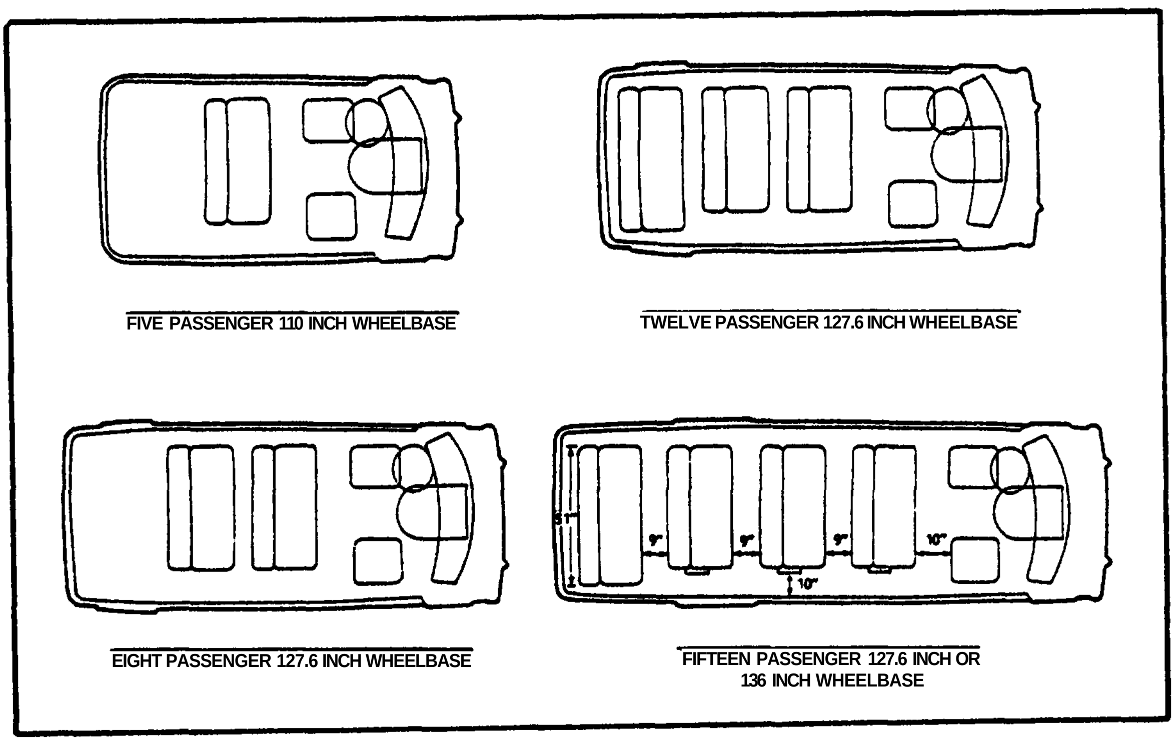
Source: Reference 31

FIGURE 3-1. INTERIOR DIMENSIONS FOR STANDARD VANS

TABLE 3-1. INTERIOR DIMENSIONS FOR STANDARD VANS

Model	CHEVROLET & GMC			DODGE			FORD		
	G20	G20	G30	B200	B300	B300	E150	E250	E350
WHEELBASE WB (ins.)	110	125	125	109.6	127.6	127.6	124	138	138
INTERIOR LENGTH - BACK OF FRONT SEAT TO REAR DOOR AT SHOULDER HEI6CT IL (ins)	94.2	118.2	118.2	92.9	110.9	136.9	91.2	111.2	131.2
INTERIOR WIDTH AT SHOULDER HEIGHT IW (ins)	70.8	70.8	70.8	69.0	69.0	69.0	70.6	70.6	70.6
WIDTH BETWEEN WHEEL-HOUSING WW (ins)	53.5	53.5	53.5	50.0	50.0	50.0	48.0	48.0	48.0
MAXIMUM INTERIOR HEIGHT FLOOR TO ROOF IH (ins)	53.7	53.8	53.8	53.2	53.2	53.2	51.6	51.6	51.6

Source: Reference 31•



Source: Reference 31

FIGURE 3-2. SEATING ARRANGEMENTS FOR STANDARD VANS

vans of three different wheelbases. The narrow width of the aisle along the side of the vehicle and the short distance between the seats, about 10 inches, may hinder escape and rescue. The rear wheelhousing, by protruding into the aisle, further reduces freedom of movement. The full-width bench seat found in the rear of many vehicles partially blocks the rear door.

In order to provide additional room and to permit access to wheelchair users, many paratransit vans have been modified by increasing headroom, widening the body and/or by adding a lift. These modifications are made by companies other than the original equipment manufacturers. Several of them are listed in Appendix A, Table A-3.

Raised Roof. The most common modification is the addition of a raised roof. Some states require such roofs to be capable of supporting the weight of a fully loaded, overturned vehicle. Some raised roofs, however, are simply unreinforced fiberglass caps that can immediately be separated from the vehicle in a collision or rollover. Such low-quality roofs can also reduce the structural integrity of the vehicle so that in an accident, the van may be partially crushed. (Subsection 3.2.3 reviews an accident that resulted in severe buckling.) Rollover accidents of vehicles with such roofs can also easily allow passengers to be ejected, causing serious or fatal injuries. Unfortunately, since many paratransit operators lack adequate funding, they often buy unreinforced roofs because they are less expensive.

Vehicle Widening. The Wide One Corporation now offers an increase in the width of a standard B-300 Dodge MaxiVan by 14 inches. The vehicle is cut in half along its centerline, the frame and body are widened, and the axles are extended. This type of modification should add to the stability of the vehicle and increase the interior space, thereby incidentally facilitating escape or rescue work should there be an accident.

Lifts and Ramps. Lifts or ramps are often installed in paratransit vans as an aid to wheelchair users and others who have difficulty negotiating the step into the van. Figure 3-3 shows one

Source: Collins Industries, Inc.

FIGURE 3-3. REAR MOUNTED WHEELCHAIR RAMP example of a ramp in the rear of a modified van. In its stored position, this ramp could block a significant portion of the rear exit in an accident if the rear of the passenger compartment is crushed.

Figure 3-4 shows a powered lift installed in a modified van and being operated by a wheelchair user. Figure 3-5 shows a lift in its stored position in a van. This typical lift fully blocks the side door while stored and may become inoperative in an accident. Rescue personnel would have to use the rear or cab doors or to cut through the side of the van to gain access. In contrast, another type of side-mounted lift (Figure 3-6) folds in half when stored, thus allowing some access by rescue personnel.

It is possible for a lift or ramp to be forced over and onto passengers during an accident. The weight of such devices can also reduce the stability of vans, thereby increasing the probability of rollover (not uncommon in accidents), and the possibility of serious injury or death.

Doors. It is important to note that the rear doors of many paratransit vans cannot be opened from inside.

Windows. The windows of most standard and modified vans are not designed for emergency access. Many are sealed, some slide horizontally to allow only a partial opening, and still others may open outwards to only a limited extent.

Fuel. Because all vans necessarily carry fuel, there is always a danger of fire or explosion.

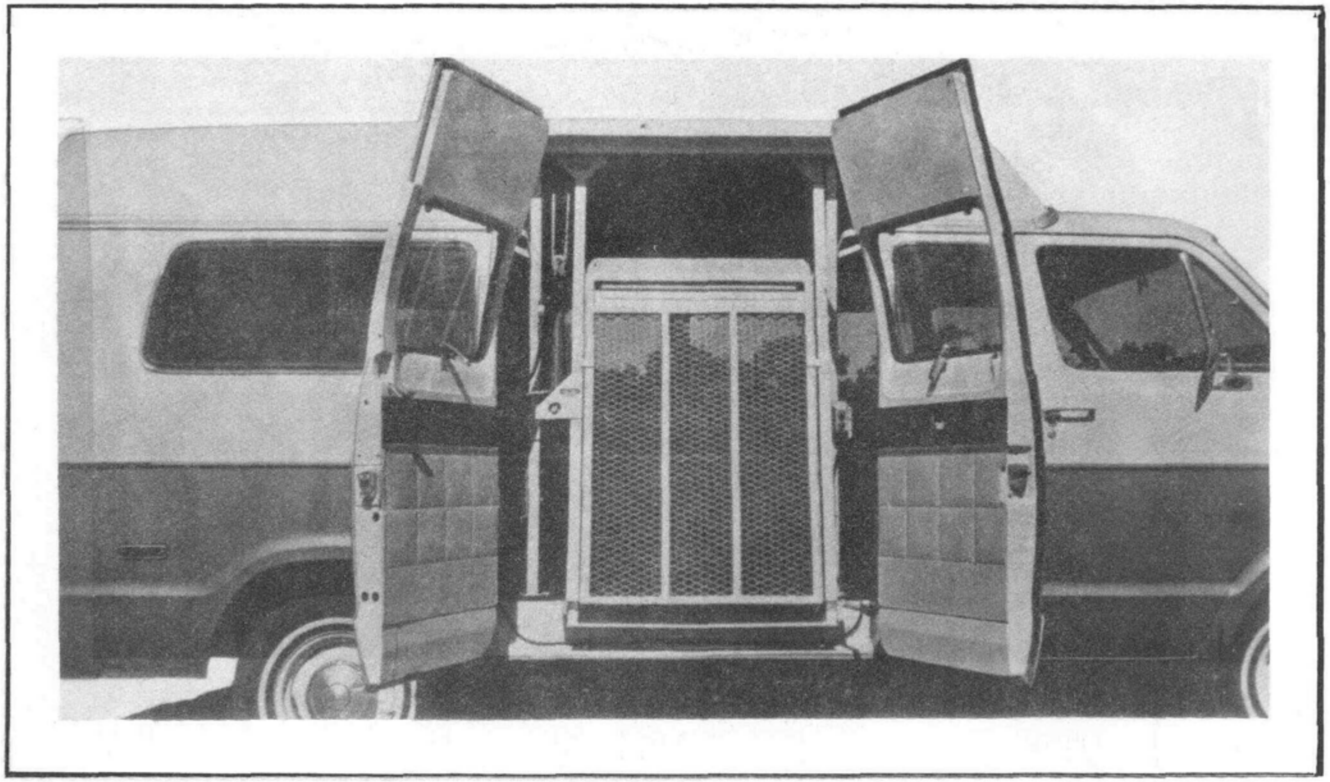
3.2 PARATRANSIT VAN ACCIDENTS

This subsection:

- o identifies the types of accidents in which a paratransit van may be expected to be involved;
- o determine the probability of occurrence of each type of accident; and

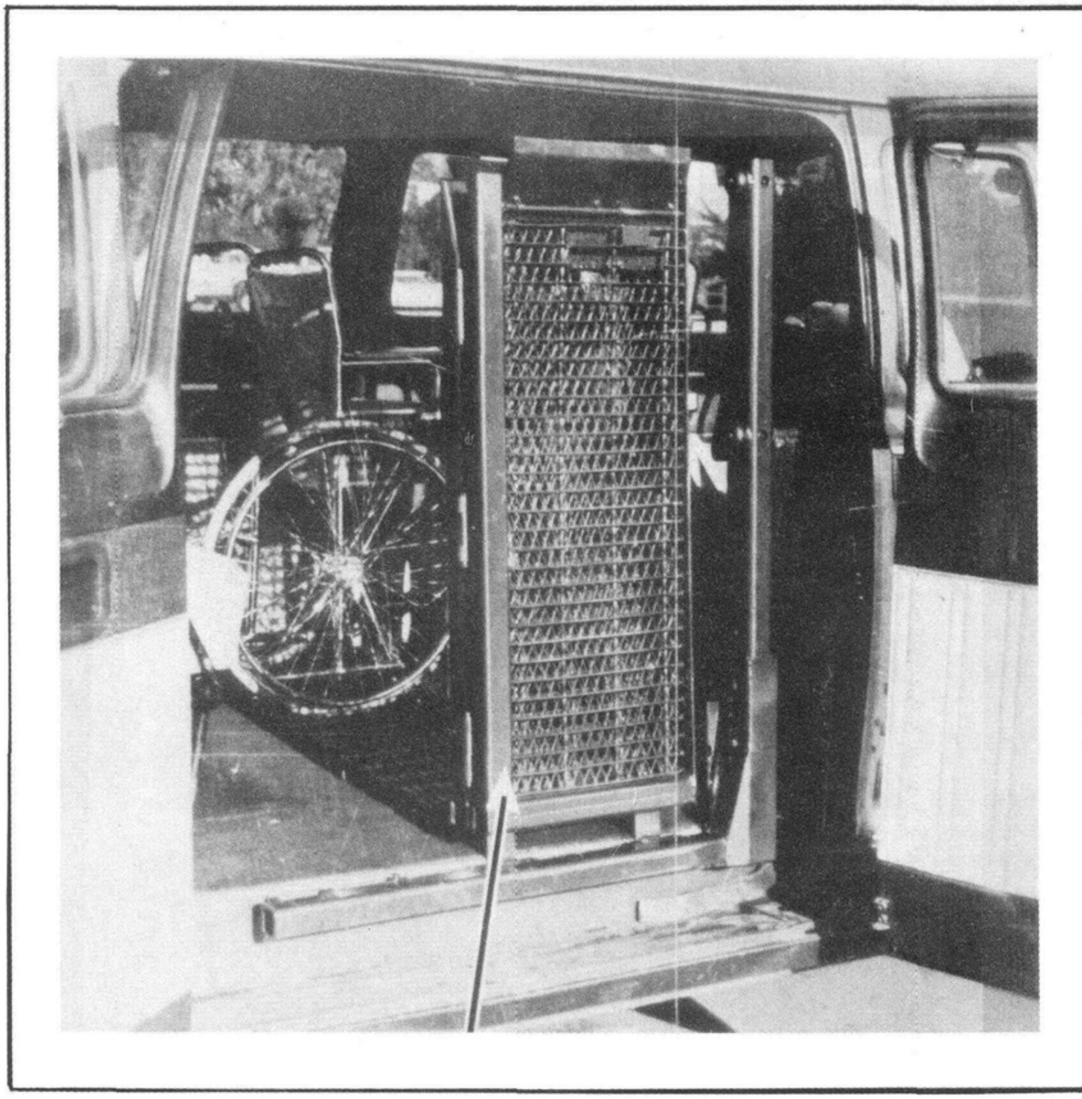
Source: The Braun Corporation.

FIGURE 3-4. POWERED WHEELCHAIR LIFT INSTALLED IN MODIFIED VAN



Source: The Braun Corporation.

FIGURE 3-5. POWERED WHEELCHAIR LIFT IN ITS STORED POSITION ON A MODIFIED VAN



Source: The Crow River Corporation

FIGURE 3-6. FOLD IN HALF WHEELCHAIR LIFT IN STORAGE POSITION

- discusses several actual paratransit van accidents involving the elderly and disabled.

3.2.1 Types of Accidents

There are five basic types of emergencies that may befall paratransit vans. They are:

- driver incapacitation;
- collision;
- rollover;
- fire; and
- complete or partial immersion in water.

The following is a list of possible accident combinations:

- driver incapacitation to collision;
- driver incapacitation to rollover;
- driver incapacitation to water immersion;
- driver incapacitation to collision to rollover;
- driver incapacitation to collision to water immersion;
- driver incapacitation to rollover to water immersion;
- driver incapacitation to rollover to fire;
- collision to rollover;
- collision to water immersion;
- collision to fire;
- collision to rollover to water immersion;
- collision to rollover to fire;
- rollover to water immersion;
- rollover to fire;
- fire to collision; and
- fire to rollover.

Incapacitation of the driver, for whatever reason, could lead to any of these accidents. Even if the driver becomes incapacitated while the van is stopped, an emergency could develop if, for example:

- the passengers are retarded to the point of not being capable of caring for themselves and seeking help;
- passengers, such as wheelchair users, are so disabled that they cannot leave the van to seek help; and/or
- the senility of the passengers prevents them from seeking help.

Of all the accidents, those involving fire and water immersion require the quickest action. If a van's driver first detects smoke, he/she may have time to evacuate all occupants before the van is engulfed in flames. The driver may have to singularly carry passengers out of the van because there probably would not be sufficient time to use a wheelchair lift or ramp. Passengers must always be evacuated <u>before</u> any attempt is made to fight a fire, even if an extinguisher is on board.

Complete or partial immersion in water would probably leave few, if any, survivors. Each of the occupants might be dazed by the initial plunge. With a lift-equipped van, the right side door in most cases would prohibit escape, and a full-width rear seat, in any van so equipped, would obstruct the rear door. This would leave only the two cab doors as possible exits, and the driver-side door would not permit quick escape because of the seat and the steering wheel. Immersion accidents are quite rare, but when they occur, few drivers or passengers escape.

3.2.2 Probabilities of Various Types of Van Accidents

Each type of accident may demand specific techniques and equipment for effective rescue. Knowing the frequency of each of these types of accident might allow rescue teams to make economical decisions on special training and the purchase of equipment. The available automated data bases were used to find the probability of each type of accident.

Although the sources of accident information, which were named in Section 2.3, are very extensive, they were not able to answer the exact questions posed. For example, one sub-category of accident is a collision leading to fire, but the sources include those accidents that involved both a collision and a fire without indicating the order of the two events. Also, none of the sources differentiates between complete and partial immersion in water. There were no cases of immersion of vans used as buses in any source that includes such a code, that is, PARS, Washington, and Pennsylvania. Only PARS lists driver incapacitation in the form "died before accident." Even here, however, there were so few such cases (5 out of a total of 63,467 vehicle accidents) that it is doubtful that any involved vans. In Table 3-2, the category "No. Resulting in Driver Incapacitation" may, in fact, include drivers who died before the accident.

Table 3-2 summarizes the PARS van data for the period 1975-1980. The number of fatal van accidents for the six year period appears to be unrealistically low, however. The data indicate that only 18 fatal accidents of vans operating as buses occurred during the period. Of these, 72.2 percent were caused by collisions, and only 23.1 percent of the collisions resulted in the driver becoming incapacitated. None of the accidents involved a fire, a combination of rollover and fire, a combination of collision and fire, a combination of collision, rollover and fire, or water immersion. Table 3-2 also shows that 17 of the 18 (94.4 percent) fatal accidents began with a collision. Of these 17, 5 (29.4 percent) resulted in incapacitation of the driver. Five of the 18 (27.8 percent) total accidents began with or included a rollover. It was not until 1978 that PARS introduced rollover as a separate variable.

The Texas records for 1981 (Table 3-3), do not differentiate among vans being used for transit, private, and recreational use. They do distinguish rural from urban settings. Ninety-one percent of all van accidents in rural areas and 99 percent in urban areas involved collisions. Since many social service agencies in rural areas use vans to transport their clients, the ratio of collision to rollover, 10:1, is particularly interesting.

TABLE 3-2. PARS 1975-1980 VANS: NUMBER OF VEHICLES (ACCIDENTS) AND PROBABILITY OF INVOLVEMENT IN EACH TYPE OF ACCIDENT

Accident Type				Vans as School Buses				Vans as Other Buses			
Colli- sion	Roll- over	Fire	Hater Immer sion/ Sub- mersion	No. of Vehicles (Acci- dents)	Proba- bility of In- volve- ment	No. Result- ing In Driver Incapa- citation	Proba- bility of Driver Incapa- citation	No. of Vehicles (Acci- dents)	Proba- bility of In- volve- ment	No. Result- ing In Driver Incapa- citation	Proba- bility of Driver Incapa- citation
		●		0	0	0	0	0	0	0	0
	●			2	0.091	1	0.500	1	0.056	0	0
	●	●		0	0	0	0	0	0	0	0
●				17	0.773	9	0.529	13	0.722	3	0.231
●		●		1	0.045	1	1.00	0	0	0	0
●	●			2	0.091	1	0.500	4	0.222	2	0.500
●	●	●		0	0	0	0	0	0	0	0
			●	0	0	0	0	0	0	0	0
Tbtal Vehicles (Accidents)				22	1.00	12	0.545	18	1.00	5	0.278
All Accidents Involving:											
●				20	0.909	10	0.500	17	0.944	5	0.294
	●			4	0.182	2	0.500	5	0.278	2	0.400
		●		1	0.045	1	1.00	0	0	0	0
			●	0	0	0	0	0	0	0	0

TABLE 3-3. TEXAS 1981 SMALL VANS: NUMBER OF VEHICLES (ACCIDENTS) AND PROBABILITY OF INVOLVEMENT IN EACH TYPE OF ACCIDENT.

Accident Type		Small Vans* Rural				Small Vans* Urban**			
Colli-sion	Roll-over	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-ment	No. Result-ing In Driver Inrapa-citation	Proba-bility of Driver Incapa-citation	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-ment	No. Result-ing In Driver Incapa-citation	Proba-bility of Driver Incapa-citation
●		3,677	0.910	161	0.044	17,986	0.990	234	0.013
	●	364	0.090	33	0.091	175	0.010	12	0.069
Total Vehicles (Accidents)		4,041	1.00	194	0.048	18,161	1.00	246	0.014

* Small vans in this data base include private and recreational vehicles.

** Urban as used here includes all accidents that occurred in a community with a population of over 5,000. Otherwise, the accident was classed as rural.

In rural areas 4.4 percent of the drivers became incapacitated as a result of a collision, but more than twice as many (9.1 percent) were incapacitated by a rollover.

Michigan records for 1981 and Pennsylvania records for 1979 do not specify vans as a vehicle category.

The number of occupant fatalities and the sum of fatalities and "A" (incapacitating) injuries taken from PARS are shown in Table 3-4. For vans used as (non-school) buses, 65 out of 110 occupants (59 percent) incurred fatal or "A" injuries. This implies an average of 2.8 per vehicle.

3.2.3 Van Accident Case Studies

Several accidents involving paratransit vans carrying elderly people are described and discussed below. Some of the information comes from National Transportation Safety Board (NTSB) reports, which are well documented.

Paratransit Van/Farm Vehicle Collision. On September 12, 1979, a 1976 standard Dodge paratransit van occupied by 14 elderly persons was traveling on U.S. Route 6/50 near Delta, Utah. About 6:25 A.M., before dawn, it overtook and collided with a poorly-lighted, slow-moving farm vehicle. The van was lifted up on its left wheels, traveled off the right side of the road, and struck a concrete bridge parapet that was approximately 4 1/2 feet beyond the edge of the pavement. Eight of the van's occupants were killed and the remaining six were injured; the operator of the farm vehicle was not injured. Figure 3-7 shows a simulation of the accident using vehicles similar to those originally involved. Figure 3-8 presents the van's seating chart with occupants' ages and injuries and the amount of penetration by the bridge parapet into the passenger compartment of the paratransit van.

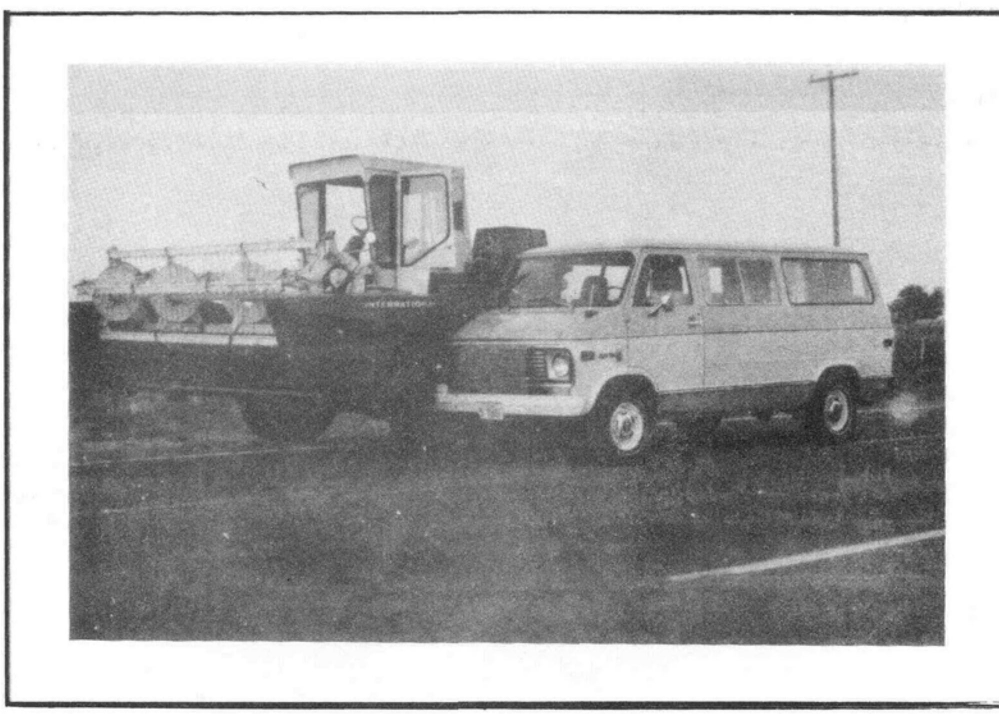
Figure 3-9 shows the front left of the van. The damage to the roof, left side, roof supports, and seatbacks was caused by the parapet when it penetrated the van along the left side windows from

TABLE 3-4. PARS 1975-1980 VAN OCCUPANCY AND INJURY

Vehicle Type	Number of Vehicles	Number of Occupants	Number of Fatalities	Number of Fatalities and "A" Injuries
Vans Used as (non-school) Buses	23	110*	14	51
All Vans	9,661	18,062** 18,932*	4,943	9,274
Total	9,716	18,062** 19,156*	4,972	9,355

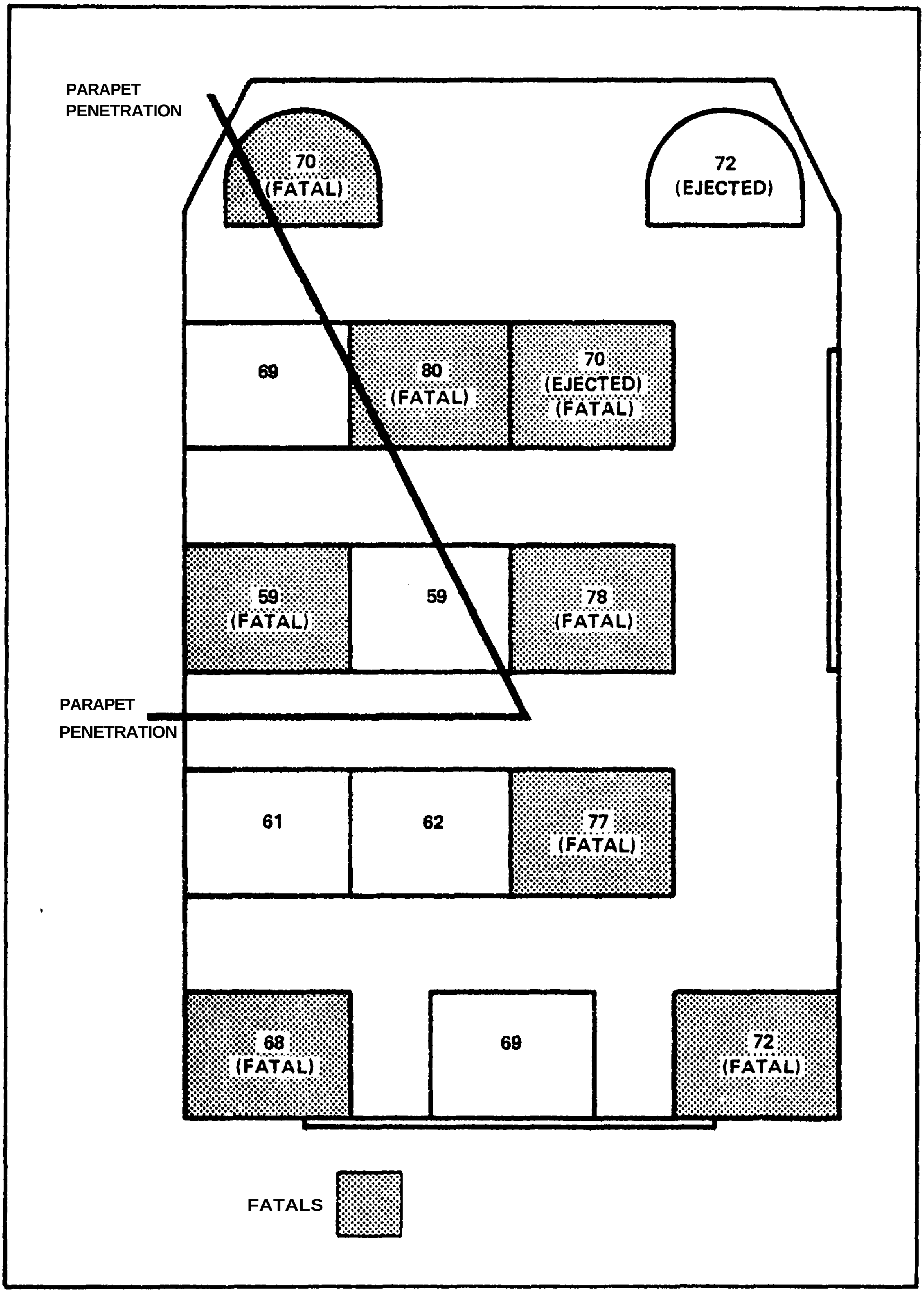
*The number of occupants statistic is missing data on 0.1? of the vans.

**Occupants with recorded documentation on each.



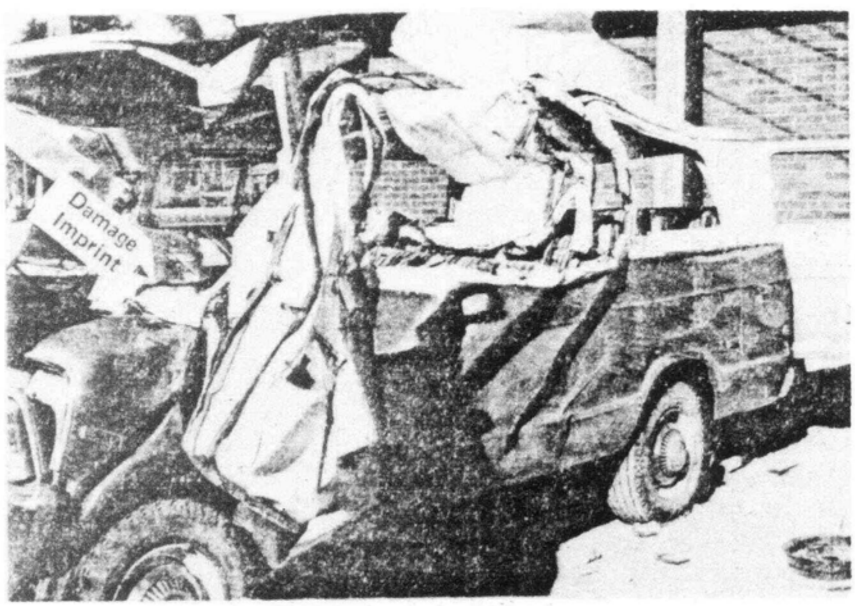
Source: Reference 107

FIGURE 3-7. IMPACT SIMULATION OF DELTA, UTAH, ACCIDENT USING SIMILAR VEHICLES



Source: Reference 107

FIGURE 3-8. DELTA, UTAH, VAN SEATING CHART



Note damage imprint from bridge parapet at top of left front fender and at top of left side instrument panel. Note buckling of side panel to rear tire area.

Source: Reference 107

FIGURE 3-9. LEFT FRONT VIEW OF DELTA, UTAH, VAN the left front corner to the middle of the second bench seat. The van came to rest on its left side with its front end on top of the bridge wing wall.

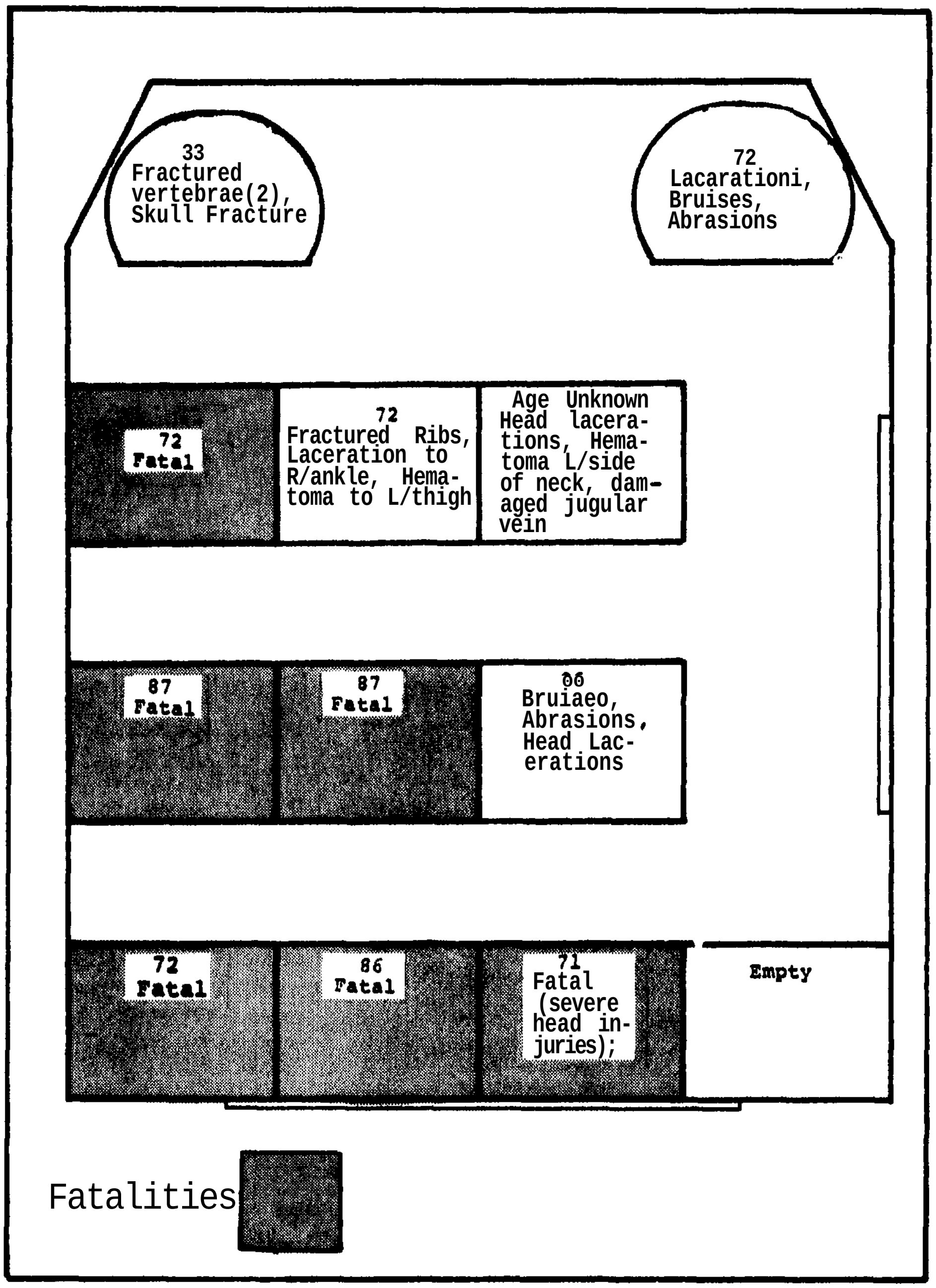
All of the occupants had to be extricated from the vehicle except the passenger in the right front seat and the passenger on the far right of the first bench seat. (See Figure 3-8.) Both of these passengers were ejected into an irrigation canal. The 72-year-old passenger sustained a shoulder injury but managed to swim to and crawl up the embankment. The other's body was found several hundred feet downstream. An autopsy was not performed.

Paratransit Van/Pick-up Truck Collision. On February 23, 1978, at 4:20 P.M., a standard 1978 Chevrolet paratransit van carrying 12 elderly passengers was struck on the left front and left side by a 1951 Chevrolet pick-up truck traveling in the opposite direction on U.S. 395 near Susanville, California. The van was owned by a council on aging and was being used to transport the passengers to the state fair. The impact caused the van to lift up, roll over, and come to rest on its top.

Figure 3-10 is the seating chart of the occupants with their ages and injuries. After impact, the van rolled clockwise along its longitudinal centerline. The 72-year-old passenger in the middle of the first bench seat was pinned inside the van and was one of the last to be extricated. The 86-year-old passenger on the second bench seat was also pinned in the wreckage and had to be extricated.

Figure 3-11 shows the van in its final resting position. Being upside down made gaining access to the victims extremely difficult, as did the crushing of the roof and the distortion of the body.

Modified Paratransit Van Collision. On July 21, 1978, a modified 1976 Dodge Maxivan was being operated as a paratransit vehicle for elderly people in Howard County, Maryland, when it overtook a State Highway Department line-painting operation. The van collided first with the right rear of a trailer carrying a large lighted traffic control arrow, then with the right rear of the truck that was pulling the trailer, then with the rear of a pick-up truck



Source: California Highway Patrol.

FIGURE 3-10. PARATRANSIT VAN SEATING CHART SHOWING OCCUPANT AGES AND INJURIES: SUSANVILLE, CALIFORNIA, ACCIDENT

Source: California Highway Patrol.

FIGURE 3-11. SUSANVILLE, CALIFORNIA, ACCIDENT; VAN IN FINAL RESTING POSITION AT ACCIDENT SITE carrying a large lighted traffic control arrow, causing it to leave the roadway, and finally with a bridge parapet (Figure 3-12).

Despite the four collisions, the van remained nearly intact. Figure 3-12 shows the front of the van crushed considerably, but the raised roof stayed in position and the wheelchair lift at the side doors remained operable (Figure 3-13). Figure 4-14 shows emergency first aid being provided to one of the six persons (aged 68, 74, 80+, 84, and 89) on board. It appears from Figure 3-14 that one of the passenger bench seats partially failed as a result of the collisions. Evacuation of the passengers was facilitated by using the side doors and by lowering the wheelchair lift.

Multipurpose Van Safety (Reference 110). Because of the increasing popularity of multipurpose vans and concern for how their interiors are being furnished, the National Transportation Safety Board (NTSB) investigated 18 low-to-moderate-speed accidents involving such vehicles. They studied crashworthiness, immediate causes of injuries, occupant restraints, postcrash fires, and ease of escape.

Injuries to 64 occupants are summarized in Table 3-5 and damage to the vans in Table 3-6. The following points in the NTSB report should be noted:

- 5 of the accidents involved rollovers;
- 11 occupants were ejected in the rollover accidents (four through the windshield);
- 17 occupants from the accidents were ejected;
- 3 of the 17 ejected were killed;
- 23 doors (mostly front doors), of the 114 (of 19 vans) were jammed and could not be opened without tools;
- the volume of passenger compartments was reduced (as shown in Table 3-7); and
- 10 of 19 vans did not retain their windshields on impact.

Source: Maryland State Police.

FIGURE 3-12. PARATRANSIT VAN IN FINAL RESTING POSITION AFTER MULTIPLE VEHICLE COLLISIONS: HOWARD COUNTY, MARYLAND

Source: Maryland State Police.

FIGURE 3-13. PARATRANSIT VAN AGAINST BRIDGE PARAPET; HOWARD COUNTY, MARYLAND

Source: Maryland State Police,

FIGURE 3-14. SENIOR CITIZEN VICTIMS OF PARATRANSIT VAN ACCIDENT: HOWARD COUNTY, MARYLAND

TABLE 3-5. KINDS OF INJURIES FOUND IN THE NTSB STUDY OF MULTIPLE VAN ACCIDENTS

ABBREVIATED INJURY SCALE	NUMBER OF OCCUPANTS
0. No Injury	2
1. Minor	38
2. Moderate	5
3. Severe (not life threatening)	4
4. Serious (life-threatening survival probable)	5
5. Critical (survival uncertain)	1
6. Fatal (within 24 hours)	8
9. Unknown	1
TOTAL	64

Source: Reference 110.

TABLE 3-6. DOOR RETENTION AND POSTCRASH CONDITION: NTSB STUDY OF MUTIPURPOSE VANS

VAN	DOOR POSITION	DAMAGE
1963 Chevrolet	Left Front	Upper hinge sprung and partially separated from "A" Pillar, door latch abraded, opened at impact.
	Right Front	Hinges sprung and partially separated from "A" pillar, buckled outward, door jammed.
1965 Chevrolet (1/2 roll)	Left Front	Hinges bent, latch released, opened at impact and driver ejected.
	Right Front	Jammed shut; roof crushed downward 12-inches causing "A" pillar distortion and jamming of door. Right rear door opened at impact; latch released; hinges damaged.
1966 Ford	Right Front	Jammed, latch damaged.
	Left Rear	Torn off in crash. (Prior damage to left rear corner.)
1967 Ford	Left Front	Not damaged, opened at impact;
	Right Side Front and Rear and both Rear Doors	Latch released, doors opened at impact.
	Right Side Rear	Pin on top hinge sheared.
1969 Ford	Left Front	Latch damaged;
	Right Front and Two Right Side Doors Jammed	Two rear doors opened at impact.
1969 Dodge	Left and Right Front	Jammed and had to be forcibly opened by rescuers - both doors had male latch shear failures. Hinges on right side (forward door was forced through.
1970 Ford	Left Front	Moved rearward 1 inch at impact, jammed shut.

Source: Reference 110.

TABLE 3-6. DOOR RETRENTION AND POSTCRASH CONDITION: NTSB STUDY OF MULTIPURPOSE VANS (Continued)

VAN	DOOR POSITION	DAMAGE
1973 Chevrolet	Right Front	Jammed shut; both rear doors paneled over - no exit.
1974 Ford	Left Front Right Front	Sprung. Jammed (forced into hinges of right side (forward door)).
1974 Ford	Right Rear Left Rear	Latch damaged, jammed shut. Hinges damaged, jammed shut. Impact in area caused mechanisms to be punched in.
1975 Dodge	Left and Right Front	Jammed due to "A" pillar displacement.
1977 Chevrolet	Right Front	Jammed shut.
1977 GMC	Left Front	Intrusion 8 to 10 inches, severe crushing of left front of vehicle and door during head-on crash.
1977 Dodge (rollover)	Right Front	Latch released and opened at impact, left front damaged at top rail "A" Pillar forced downward in rollover.
1977 Dodge	Left Front	Jammed shut, both rear doors locked.
1977 Dodge	Right Front	Jammed shut, 3-inch intrusion.
1977 Dodge	Left and Right Rear	Both jammed shut, 4-inch intrusion from direct crush.
1977 Ford		No damage to any doors.
1977 Ford	Left Front	Opened at impact, latch released, left "A" Pillar shifted releasing door and door, left and right rear - both jammed.

Source: Reference 110.

TABLE 3-7. REDUCTIONS IN PASSENGER COMPARTMENT VOLUME OF MULTI-PURPOSE VANS IN NTSB STUDY OF ACCIDENTS

ESTIMATED PERCENT REDUCTION	NUMBER OF VANS
0	6
1	3
2	2
4	2
5	2
10	4
AVERAGE PERCENT CRUSH = 3.4%	

Source: Reference 110.

3.2.4 Jamming of Van Doors During Collisions and Degree of Crushing

The NTSB study revealed that doors frequently jam in van accidents. This poses a problem for rescuers. Table 3-8 suggests the extent of the problem. The data come from the National Crash Severity Study (NCSS) between April 1, 1978 and March 31, 1979. The data are weighted. Unweighted numbers of vehicles are shown in parentheses. The vans in the NCSS data were standard small vans, and probably few, if any, were modified for use as paratransit vans.

Table 3-9 shows, in a different form, NCSS Phase 2 data for the crushing of vans in accidents. The degree of crush for each vehicle (for which crush data are available) was specified by a horizontal profile made up of 2, 4, or 6 individual crush measurements. The greatest of the crush measurement for each vehicle was assigned to that vehicle. The measurments for all vehicles were then averaged to give the mean maximum amount of crush shown in the table.

3.2.5 Modifying Factors

There are several modifying factors that can contribute to the complexity of an accident. They include:

- The time of day of the accident
- The day of the week
- The location of the accident
- The potential for secondary injuries.

If the accident occurs in an urban area, it is highly probable that it will be noticed immediately and that rescue and emergency medical personnel will be able to reach the scene quickly. In contrast, a rural setting may mean that precious time is lost before a passerby notices the accident (especially if the van is off the road or immersed in water) and before rescue personnel can arrive on the scene. Similarly, time of day and day of the week can affect the response time.

TABLE 3-8. VAN AND CAR DOORS JAMMED CLOSED (WEIGHTED DATA FROM THE NCSS PROGRAM, PHASE 2)

ACCIDENT TYPE	CARS N*	CARS %	VANS N*	VANS %
Rollovers				
Jammed**	262 (82)	66.8	85 (20)	67.5
Not Jammed	130 (43)	33.2	41 (8)	32.5
Total	392 (125)	100.0	126 (28)	100.0
Non-Rollovers				
Jammed**	2800 (902)	31.9	229 (49)	50.3
Not Jammed	5982 (1183)	68.1	226 (118)	49.7
Total	8782 (2085)	100.0	455 (118)	100.0

* The numbers of vehicles shown are the numbers after weighting by the inverse of the sampling fraction. The unweighted actual numbers of observations are shown in parentheses.

** At least one door in the vehicle jammed closed. Unweighted numbers are given in parentheses.

TABLE 3-9. CRUSH OF VANS AND CARS (WEIGHTED DATA FROM THE NCSS PROGRAM, PHASE 2)

Accident Type		Mean Maximum Crush			
Collision	Rollover	CARS		Vans	
		N**	CRUSH (in.)	N*	Crush (in.)
	o	187 (43)	7.4	27 (6)	5.6
o		8444 (1989)	16.9	391 (110)	12.5
o	o	67 (36)	22.7	80 (15)	13.6

*The numbers of vehicles shown are the numbers after weighting by the inverse of the sampling fraction. The unweighted actual numbers of observations are shown in parentheses.

**The numbers of vehicles shown are the numbers after weighting by the inverse of the sampling fraction. The unweighted actual numbers of observations are shown in parentheses.

In any highway accident, there is always a possibility of additional injury to victims and of injury to the rescue forces, other motorists, witnesses, and spectators. These injuries may be caused by:

- a fire or explosion after the accident;
- other vehicles colliding with the wreckage, rescue equipment, rescue personnel, or victims; or
- ineffective or improper use of equipment and extrication methods.

All three of these threats can be mitigated by trained and alert personnel.

3.3 COMPONENTS OF EFFECTIVE RESCUE

Literature on the escape and rescue of elderly and disabled passengers from paratransit vans is extremely scarce, and little has been written on escape and rescue from vans in general. Nevertheless, some discussion of this matter is embedded in general discussions of escape and rescue from highway vehicles. In this subsection, information on escape and rescue derives from the existing literature and from project team experiences.

This discussion is structured around what Grant (6?) refers to as "the system of vehicle rescue operations." The system comprises the following ten activities:

- preparation;
- response;
- assessment;
- hazard control;
- support operations;
- gaining access;
- emergency care;
- disentanglement;

- removal and transfer; and
- debriefing and documentation.

3.3.1 Preparation

Preparation for rescue requires both equipment and personnel.

Equipment. One often hears from rescue personnel that "If we only had more and better equipment, we could be so much more effective." This may be true, but most emergency response units do not have the equipment listed in Table 3-10 and still succeed in their areas of specialization. This is because each of them is totally familiar with the equipment it has and consequently can make effective use of it.

Much of the equipment that is used to extricate victims from automobile accidents can also be used with paratransit vans. However, other equipment that is necessary for gaining access to vans is not in the inventory of all rescue forces. For example, rescue forces will need powered hydraulic tools to cut through wheelchair lifts, and/or ramps, which commonly block side or rear doors. Such tools are expensive and require training for those who will use them. Inexpert use of them can be dangerous. Among rescue forces, stories circulate of cases where misuse of the tools resulted in accidental injury to entrapped victims.

If the van is carrying wheelchair users, one may reasonably assume that the secured chairs have suffered some deformation during the accident (particularly if the chairs are positioned sideways) and that some passengers may be entangled. Because wheelchair users form close bonds with their chairs, extrication by means of the destruction of a chair should be carried out only when absolutely necessary.

Rollover accidents are considerably more common with vans than automobiles. Stabilization equipment will frequently be needed to prevent movement of the wreckage while the passengers are being rescued.

TABLE 3-10. LIST OF EMERGENCY RESCUE EQUIPMENT

HAND TOOL KIT

Aircraft snips
Cold chisel set
Claw hammer
Machinist hammer
Short-handled sledgehammer (2 1/2 pound)
Linoleum knife
Battery pliers
Channel-locking pliers
Diagonal-cutting pliers
Needle-nosed pliers
Slip-joint pliers
Vise-grip pliers
Punch set
Rubber mallet
Regular frame hacksaw
Low-profile frame hacksaw
Carpenter's handsaw
Small treesaw
Wiresaw
Adjustable wrench (assorted sizes)
Open-end wrench (assorted sizes)
Pipe wrench (assorted sizes)
Socket wrench (3/8-inch drive, 3/8-inch to 3/4-inch capacity)

ADDITIONAL HAND TOOLS

Crash ax
Flat-head ax
Pick-head ax
Rescue-type ax (such as the pry ax)
Combination rescue tools
Impact bar
Bolt cutter (36-inch)
Pry bar
Sledgehammer
Wrenching bar
Can opener
Dent puller
Door-lock opener

ELECTRICALLY-POWERED TOOLS

Chain saw
Rescue-type circular saw
Wood-cutting-type circular saw
Electric drill
Reciprocating-type power hacksaw
Power shears
Electric impact tool

GASOLINE-POWERED TOOLS

Disc saw kit

HYDRAULICALLY-POWERED TOOLS

4-ton, 10-ton, or 20-ton capacity hydraulic rescue tool kit
Hurst rescue tool

AIR-POWERED TOOL

Air cutting-gun kit

CHEMICALLY-POWERED TOOLS

Oxy-acetylene cutting torch kit

TRAFFIC HAZARD-CONTROL EQUIPMENT

Safety flares
Warning flags
Traffic-control flashlight

FIRE SUPPRESSION AND PREVENTION EQUIPMENT

Pressurized water extinguisher
Carbon dioxide extinguisher
Dry-chemical extinguisher
High-expansion foam generator
Light Water and dry-chemical system

Source: Reference 67.

TABLE 3-10. LIST OF EMERGENCY RESCUE EQUIPMENT (Continued)

HAZARD DETECTION EQUIPMENT

Combustible gas detector kit
Carbon monoxide detection kit
Oxygen analyzer

ELECTRIC HAZARD-CONTROL EQUIPMENT

Lineman's gloves and protectors
Lineman's hot stick
100 feet of weighted synthetic rope
Insulated wire cutters

DANGEROUS-MATERIALS LEAK KIT

Nonsparking hammer
Hardwood and rubber cone-shaped plugs

VEHICLES STABILIZATION EQUIPMENT

Hardwood cribbing
Hardwood wedges
Air bag set

SUBMERGED VEHICLE KIT

Scuba gear
Compressed air tank with a long hose

POWER-GENERATING AND POWER-DISTRIBUTING EQUIPMENT

Portable electric generator
Power cord and reel
Power distribution box

LIGHTING EQUIPMENT

Portable floodlights
Battery-operated handlights

COMPRESSED AIR SUPPLY SYSTEM

High-pressure compressor
Manifold air storage system
Spare air cylinders

RESCUER PROTECTION EQUIPMENT

Safety Helmet
Safety goggles
Gloves
Turnout coat
Boots
Self-contained, demand-regulator breathing apparatus
Spare compressed air cylinders
Pull body acid suit

VICTIM PROTECTION EQUIPMENT

Aluminized rescue blankets
Asbestos blankets
Salvage covers
Smoke ejector and extension tube

WARNING AND SIGNALING DEVICES

Traffic-guidecones
Safety vests
High-intensity, battery-operated flashing lights

LIFE-SUPPORT KIT

Hand-held, bag-mask ventilating unit
Combination airway and resuscitation tubes
Self-contained suction unit
Oropharyngeal airways (assorted sizes)
Multitraumadressings
Self-adhering bandages
Triangular bandages
Gauze pads (4 x 4 inches)
Two towels
Adhesive tape
Occlusive dressings (aluminum foil or plastic wrap)

Source: Reference 67.

TABLE 3-10. LIST OF EMERGENCY RESCUE EQUIPMENT (continued).

LIFE-SUPPORT KIT (Cont'd.)

Commercially made tourniquets
Cervical collars (extrication-type)
Sphygmomanometer (dial-type)
Stethoscope
Flashlight
Bandage scissors
Notebook and pen

ADDITIONAL EMERGENCY CARE EQUIPMUNT

Positive-pressure oxygen resuscitator
Aspirator (hand, battery, or gasoline-operated)
Straps (9-foot web-type)
Blankets
Disposable obstetrics kit
First-aid kit (modular)
Inflatable splints
Vacuum splints
Traction splints
Wire splints
Short-board splints
Cardboard splints

PATIENT-TRANSFER EQUIPMENT

Short spine-board with straps
Full backboard
Combination rescue board
Scoop-style stretcher

PATIENT-TRANSFER EQUIPMENT (Cont'd.)

D-ring stretcher
Basket stretcher
Reeves stretcher
1-inch rope sling
Hill-assist device
Disaster pouch

LIFTING AND PULLING EQUIPMENT

Cable or chain come-alongs
Chain and hook sets
Rope and cable slings
Number one grade manila rope (1/2-inch, 5/8-inch, and 3/4-inch)
3/4-inch two-shreave blocks
3/4-inch three-shreave blocks
1/2-inch and 3/4-inch snatch blocks
Hydraulic lifting jacks (various capacities)
Ratchet lifting jack

MISCELLANEOUS EQUIPMENT

Step-to-straight-type ladder
Gasoline storage cans
Mobile radio transceiver
Portable radio transceiver

Source: Reference 67.

Because some elderly and disabled passengers may have difficulty communicating or indicating injuries, rescuers may find it prudent to immobilize and secure, as a precaution, some who may later be found to be uninjured. This will consequently require significantly more equipment than is normally carried by rescue forces.

Improvisation can also increase effectiveness. For example, if an accident causes several back injuries, and the rescuers do not possess more than one or two backboards, they may use the plywood sheets found between the stacked hoses on a fire truck.

Personnel. Rescue personnel must be properly led, properly trained, and quick-thinking. This is particularly important for paratransit van accidents because the rescue personnel may find a particular kind of handicap or mechanical contrivance for the first time in such cases.

Progressive fire companies, rescue forces, and emergency medical units across the country long ago noted the need for hands-on simulation training exercises for rescue and regularly conduct such training sessions. Worn-out cars are used as "accident" vehicles. Trainees remove the doors, roof, or windows, for example, to provide medical personnel with access to the "victims" and to facilitate extrication afterward. These simulations have proved extremely beneficial. Unfortunately, it is not at all common for the same units to enact simulations using paratransit vans and actual or mock elderly and disabled persons as victims. Consequently, when they arrive on the scene of a paratransit van accident, they attempt to use techniques more appropriate to automobile accidents.

Many of the operators who provide transportation to elderly and disabled clients regularly schedule sensitivity and safety training sessions with their drivers, dispatchers and call takers. However, it is not yet a common practice to involve firemen, rescue forces, and emergency medical personnel in such programs. Rescue units should engage in simulations using actors or real elderly or disabled passengers and a typical paratransit van.

Role of the Operating Agency. The agency operators of paratransit vans should help rescue forces before an accident. They can do this by providing the rescue and emergency medical forces in their area with the following information:

- o agency name and address;
- o name and telephone number of an offical of the agency;
- o name and telephone number of a back-up official;
- o description of vehicles in fleet, including their passenger capacity and the usual number transported;
- o the characteristics of the passengers generally carried; and
- o any other information that might be useful.

Each agency might also develop a one page summary of the pertinent characteristics of each passenger. It might contain:

- o name and address;
- o date of birth;
- o description (eye color, height, weight, hair color, etc.);
- o person to notify in case of emergency (and telephone number);
- o medical condition;
- o unusual characteristics (senility, retardation, deafness, missing limbs, etc.); and
- o names and telephone numbers of physicians, doctors, therapists, etc.

These client-specific summary sheets could be bound in plastic and given to the driver. The system has a precedent in the procedures used with truck cargos: rescue personnel at the site of a truck accident are instructed always to look for the manifest to see if the cargo is flammable, explosive, toxic, corrosive, and so on.

This proposal was heavily debated by the Review Committee and did not receive general approval. Reasons for opposition were mainly logistical problems, such as the difficulty of assigning information sheets to vehicles when elderly and disabled clients are carried to their destinations by one van and returned by another, and the difficulty of matching sheets with passengers who are unconscious. The Committee generally recommended that passengers be encouraged to bear medic-alert identification. The Research Team acknowledges the merit of the Committee's arguments but suggests that the former proposal be tried by paratransit operators and be evaluated. Many transportation systems have automated management information systems, which could automatically print out the client information daily, thereby eliminating the need to file and claim laminated sheets.

Another way that agency operators can help rescue forces is to equip all paratransit vans with two-way radios and permanently post instructions on their use. In the event of an accident or emergency, the driver or a passenger could call for help. Rescue personnel might also use them to speak directly with the agency about a victim.

3-3.2 Response

When the police department, fire department, rescue squad, or ambulance company learns of an accident involving a van, it should attempt to ascertain whether the van is a paratransit vehicle. If it is, the rescuers should assume that elderly or handicapped passengers are aboard and that a larger-than-usual team of personnel and ambulances should be sent. Elderly and disabled passengers should not be expected to free themselves or even to cooperate with the rescuers.

3.3.3 Assessment

When arriving at the scene of a paratransit van accident, rescue personnel should resist the impulse to take immediate action. They must assess the situation and consider their capabilities. If necessary, they must request additional resources such as more rescuers, emergency medical technicans, crowd control officers, and firemen, as well as more backboards or ambulances.

Once the officer in charge has completed the assessment and has requested whatever further assistance is necessary, he/she should appoint certain squad members to control hazards, others to maintain support operations, and still others to find victims. Some victims may already have been removed from the wreckage by passersby or may have wandered away from the scene.

All victims, if able to reply, should be asked about their disabilities or illnesses, their new injuries, and the characteristics of other passengers who may be unconscious. Because elderly and disabled passengers frequently use paratransit vans, they are, if of sound mind, a strong source of information on the other persons with whom they regularly ride. The van's driver, if conscious, should know the exact number of passengers on board. If the passengers are clients of a social service agency, the system operator can very quickly provide case histories over the van's two-way radio if there is one.

3.3.4 Hazard Control

"Hazard control" simply means preventing death or injury from traffic-related hazards, which may be handled by police officers, and non-traffic hazards, such as downed wires, fire, hazardous cargo, unstable vehicles, and debris, which must be dealt with by rescue personnel. Rescue personnel should be wary of entering any van that may look unstable. Vans tend to roll over in accidents because the weight of lift- or ramp-equipped vehicles is often poorly distributed.

3.3.5 Support Operations

Additional equipment and personnel may be required for any of the following reasons:

- a fire may break out or re-ignite;
- darkness may hinder rescue and emergency medical treatment;

- o crowds may be difficult to control; or
- o bystanders may try to steal victims' belongings.

The reader may want to pursue these matters further in Grant (67).

3.3.6 Gaining Access

Training in the gaining of access to damaged paratransit vans is necessary if the rescuers are to be proficient. The rescue crew does not, as mentioned earlier, need exotic equipment in order to gain access. A fire axe or a sledgehammer, for example, can be used to cut or break through a sheet metal roof or wall.

As was shown in the preceding section, wheelchair lifts, full-width rear bench seats, and the structural members of paratransit vans can obstruct access to accident victims. The structurally unsound fiberglass or plastic raised roofs, however, can actually ease access, because they are easily cut open.

3.3.7 Emergency Care

While rescuers are gaining access to the victims, an emergency medical technician should try to determine the extent of the victims' injuries. Important as it is to extricate victims and to transport them to hospitals, it may first be necessary:

- o to engage in life-support activities;
- o to evaluate each victim's situation in order to aid further extrication procedures;
- o to protect all victims during extrication; and
- o to wrap or secure each victim.

The first two points are so important that they demand the delay of extrication until the victims are medically stable. In some cases, extrication may have to be concurrent with medical treatment to minimize danger to both victims and rescuers from spilled fuel or other hazards.

Basic emergency care needed by elderly and disabled passengers is not unlike that provided to other accident victims, but the determination of their injuries is much more difficult. For example, if a non-elderly or disabled person has suffered a fracture, he/she will complain of pain to the emergency medical technician, but a paraplegic may have a fracture and not be aware of it. The emergency medical technician may have to assume that the victims have suffered more serious injuries than their complaints indicate.

A very useful flowchart for applying emergency treatment, taken from Grant (67), is reproduced as Figure 3-15.

3.3.8 Disentanglement

Once the emergency medical technician has gained access to the victims, and begun emergency treatment to stabilize their conditions, he/she must decide how best to disentangle the passengers. The decision should be made jointly by the technician already within the van and the rescue officer in charge.

With automobile accidents, disentanglement may involve:

- cutting seat belts;
- removing seats;
- displacing pedals;
- cutting the steering wheel;
- displacing the steering column;
- removing victims from the windshield; and/or
- removing victims from impaling objects.

With paratransit van accidents, any or all of the above may be necessary as well as disentanglement of passengers from:

- torso-restraint devices;
- wheelchairs;
- a wheelchair lift;

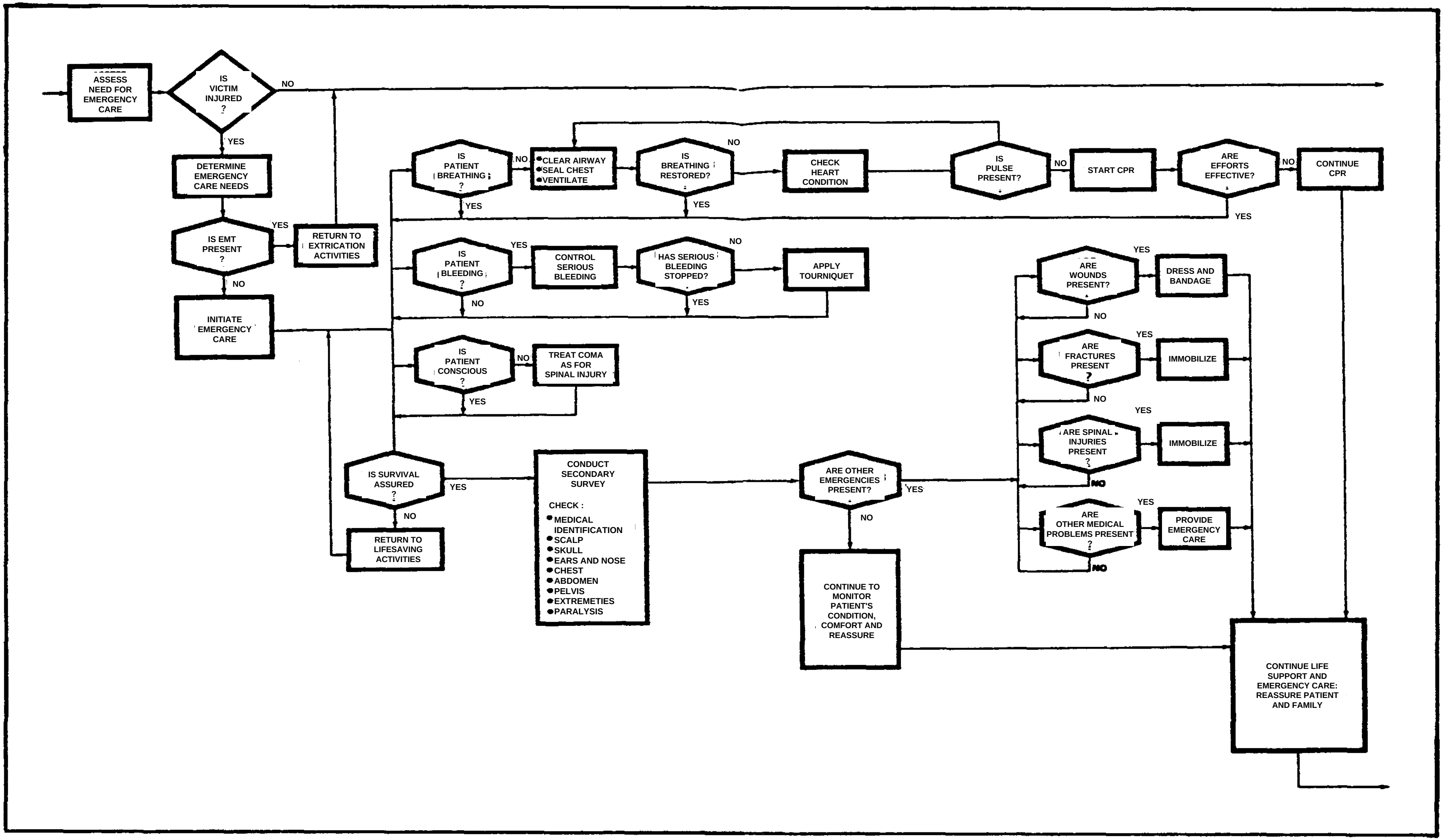


FIGURE 3-15. EMERGENCY CARE FLOWCHART

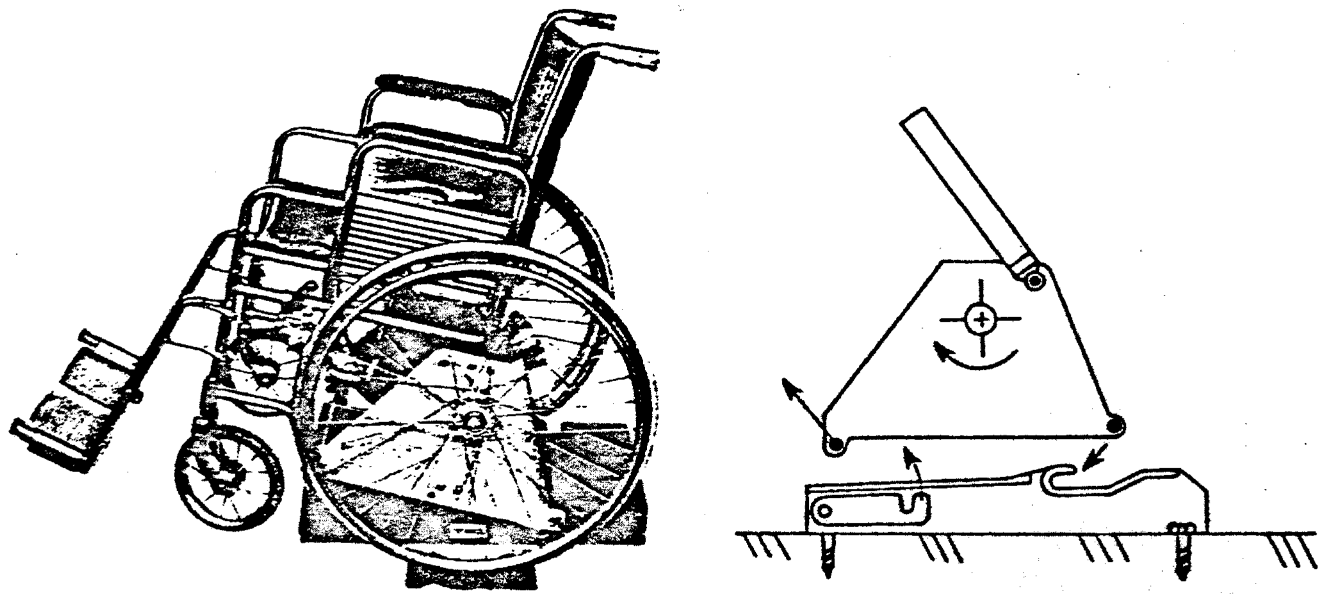
- wheelchair ramp;
- crutches or walkers; and/or
- prostheses.

Torso-restraint devices can be removed by a seat belt cutter, but there may be difficulty in getting at a portion of the device that can be cut without endangering the passenger.

Wheelchair users are generally quite agile. In a paratransit van, however, the wheelchair itself can entangle its user. Indeed, Schneider (147) has concluded that most people who use their wheelchair as a vehicle seat are at high risk of injury in an accident. All wheelchairs in a paratransit van should be secured to prevent movement during normal driving and to reduce, if possible, the initial effects of a crash. Unfortunately, Schneider has concluded from extensive testing of various devices now used to secure wheelchairs and their occupants in paratransit vans that they violate basic principles of crashworthiness design, so that the user might be at a greater risk of injury with the system than without. Many of these devices have been designed not for protection during impact, but rather for stability during normal vehicle operation.

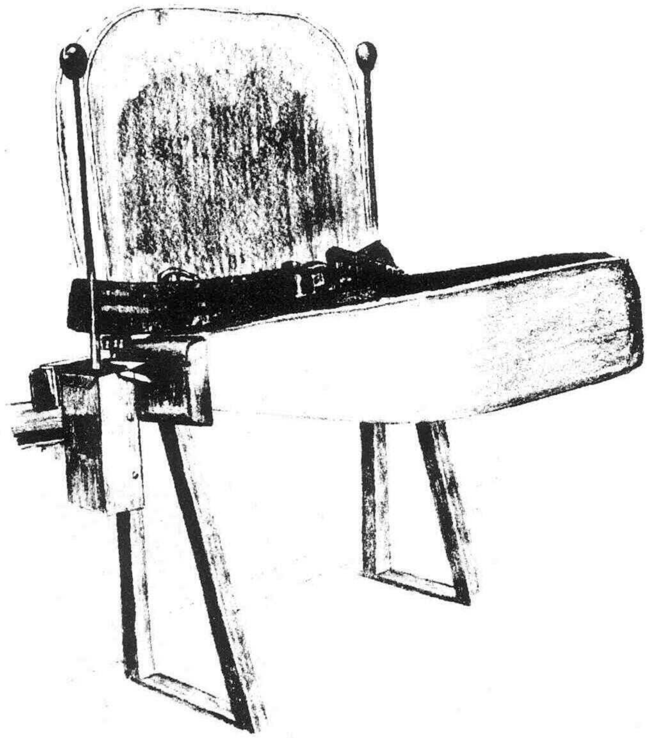
Even those tie-down devices found to be very effective in proper use can be dangerous when used improperly. For example, if two air cargo straps are attached to the rear of a wheelchair at tubing joints such as the seat-frame/rear-post junction, the wheelchair can undergo significant frontal impact with little or no damage. However, if the straps are attached to the center of the wheelchair crossbars, as is more convenient, the chair will collapse. Rescue personnel can begin to gain familiarity with various types of tie-downs by examining Figures 3-16, 3-17 and 3-18. They must learn through training how best to disentangle passengers from their wheelchairs.

Electric wheelchairs pose special problems because of their greater weight and because of the danger from the acid of their batteries. Wheelchair lifts and ramps are very sturdy because of their function, and consequently are difficult for rescuers to cut,

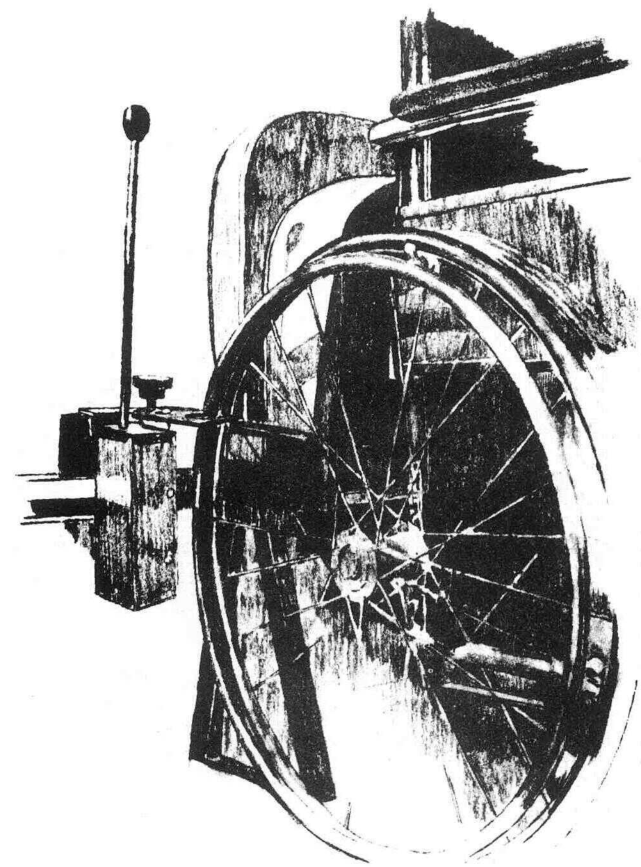


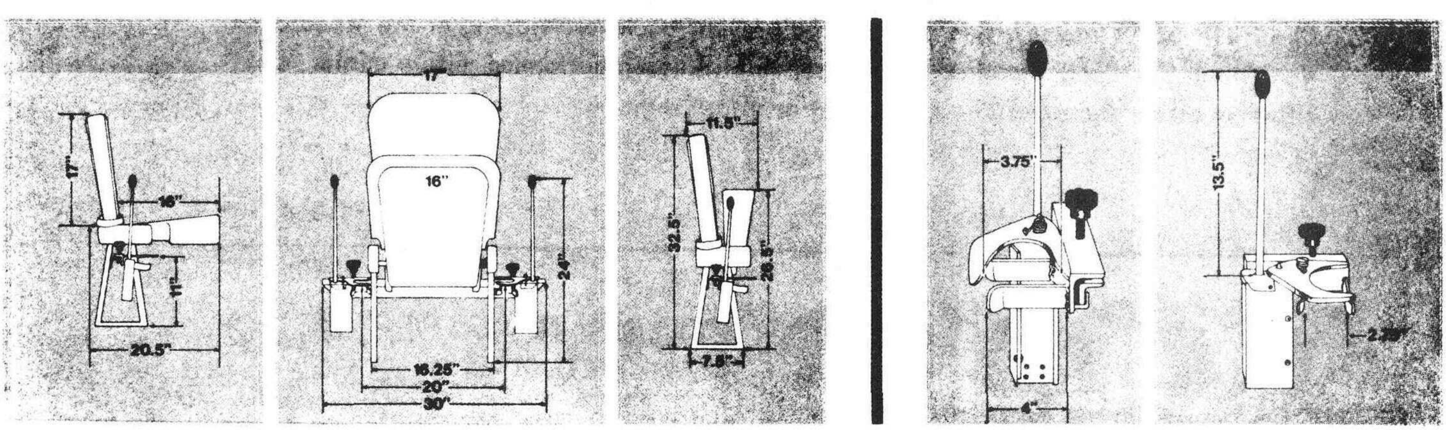
Source: Reference 147.

FIGURE 3-16. SECUREMENT SYSTEM USING TRIANGULAR PLATES AND STEEL BARS ATTACHED TO WHEELCHAIR



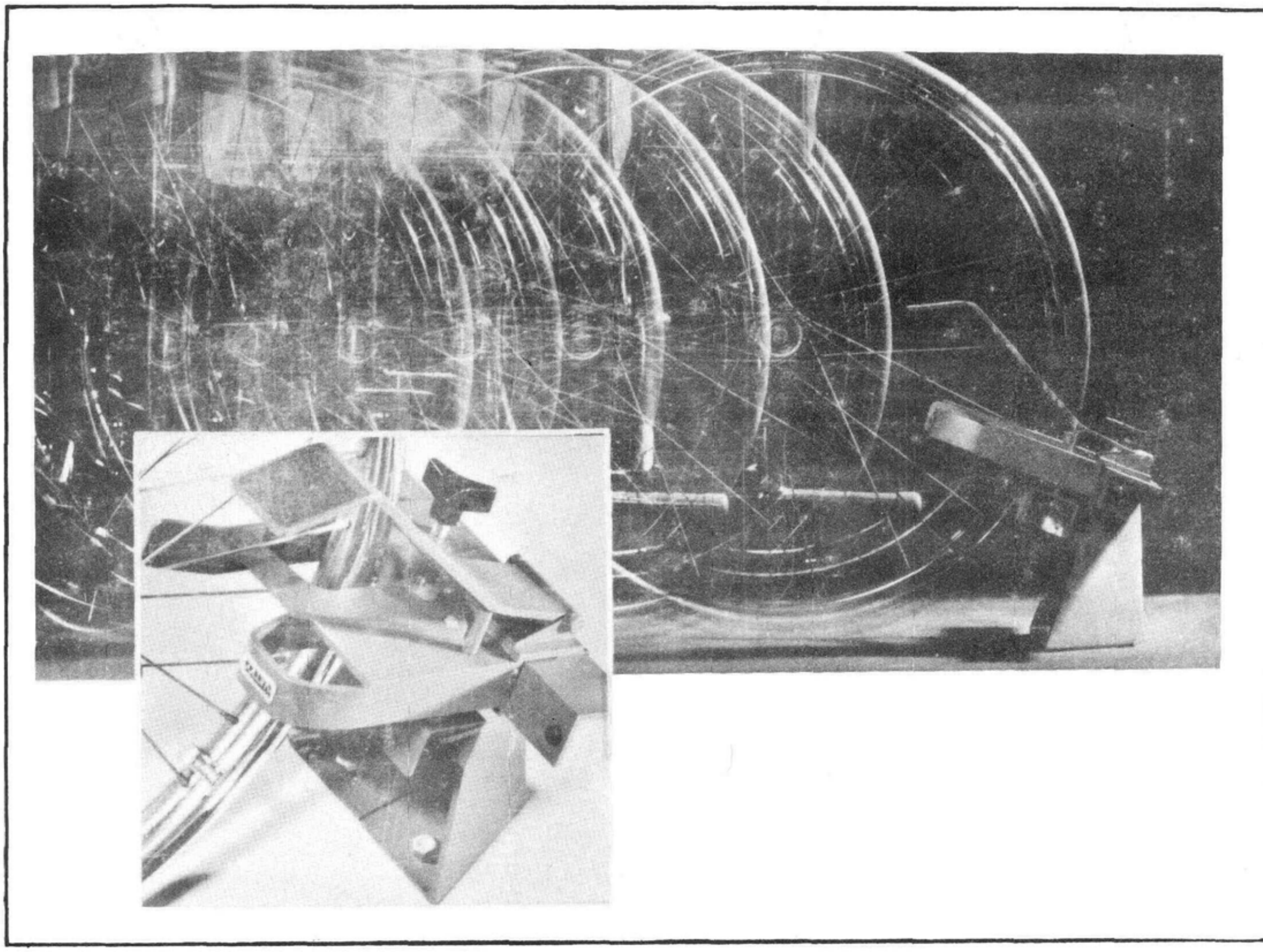
This seat holds both wheels of a wheelchair during transport. Seat folds down for additional seating.





Source: Collins Industries, Inc.

FIGURE 3-17. FLIP SEAT WHEELCHAIR LOCKING DEVICE



Source: Collins Industries, Inc.

FIGURE 3-18. WHEELCHAIR LOCKING DEVICE

bend, or otherwise disentangle. Hydraulically-powered lifts may be moved with relative ease after their hoses are cut. All fluids from machinery must be carefully disposed of in order to prevent fire, difficult footing problems caused by the slipperiness of the fluids, and contamination of the passengers' open wounds.

Some passengers who appear to have distorted or severed limbs may be suffering from nothing worse than detached prostheses. Artificial limbs can be easily removed to facilitate extrication.

3.3.9 Removal and Transfer

The obvious exits from the van are:

- route taken by the emergency medical technician to gain access to the victims;
- cab doors;
- windshield;
- windows along the body sides;
- side door; and
- rear door.

In a severe accident, most of these access routes may be blocked or inoperable. The creation of holes suitable for evacuation may affect the disentanglement of passengers, and care must be taken to protect the passengers during removal.

Injured passengers must be wrapped and secured for removal, that is, their wounds must be dressed and bandaged, their fractures splinted, and, if the victims seem to have spinal injuries or are para- or quadriplegic, their entire bodies must be rigidly fixed to reduce the possibility of further damage.

Removal through windows may be only a last resort because of their relatively small openings, their height above ground, and the interference of seat backs. The side door, if a lift does not obstruct it, or the rear door, if not excessively crushed, would probably be the easiest exits.

Transfer, though it may be as easy as just moving a few steps to an ambulance, can also be very complex. For example, if the paratransit van has rolled down a hill, plunged into a drainage ditch, dropped off a cliff, or plunged into a lake, stream, or river, transfer may require the use of rope and tackle, a basket stretcher, and/or a hill-assist harness.

3-3.10 Debriefing

All rescue personnel should be debriefed after completing each job. The debriefing should help to find:

- o what standard rescue techniques could not be used because of the special characteristics of the elderly and disabled victims and of the van;
- o what new techniques were improvised;
- o what special equipment might have been useful if it had been available; and
- o what kinds of training might increase the prepardness of rescue personnel.

NTSB has done a creditable job in debriefing those involved in the selected paratransit van accidents it has investigated. Some local forces, e.g., those in California and Montgomery County, Pennsylvania, conduct debriefings. It would be highly beneficial if all local forces adopted this practice and circulated the results for review.

4. BUSES

4.1 INTRODUCTION: CHARACTERISTICS OF BUSES

There are three kinds of buses: body-on-chassis and other small buses used in paratransit, heavy-duty transit buses designed for long life and low maintenance in regular fixed-route transit service, and motor coaches designed for intercity service. The characteristics of each of the three kinds, the difficulties to which each may give rise during rescue operations, and existing and proposed methods for the rescue of elderly and disabled passengers from buses are considered in this section.

There have been two design changes made on some buses that may hinder search and rescue. These are: use of the full rear height of many body-on-chassis small buses for active wheelchair lifts, which eliminate or greatly restrict entry and exit, and the elimination of emergency doors in favor of push-out windows. The installation of emergency doors appears to be somewhat controversial because of the potential for misuse or abuse by vandals and the mentally retarded, but the alternative, push-out windows, severely limits use by the elderly and disabled. Unless the windows are kept lubricated and in proper adjustment, the release forces can be high, and they are not easily releasable from the outside. One change for the better is the development of "softer" interiors to reduce minor injuries.

4.1.1 Body-on-Chassis and Other Small Buses

The need for a small transit vehicle larger than standard and modified vans has given rise to the small bus. These buses are usually built upon the mass-produced chassis of trucks, motor homes, or school buses. The small bus manufacturer is really only a body builder and assembler. These vehicle have front-mounted gasoline engines (or in some cases, diesel engines), rear-drive axles on wheelbases of 130-170 inches, and gross vehicle weight ratings of up to 12,000 Ib. They are often used in services for the elderly and disabled.

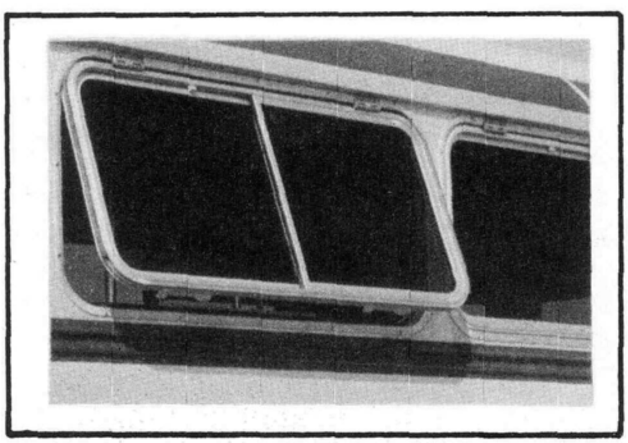
The small bus manufacturing business is very dynamic and oontains many companies. Among them are several manufacturers of heavy-duty small buses of monocoque construction. These are often diesel-powered and in many ways are small versions of the large heavy-duty urban transit buses. (This latter olass of bus is discussed in subsection 4.1.2.) Most small buses, in contrast, are of body-on-ohassis construction. There are, thus, several kinds of small buses that rescue personnel may have to deal with.

The following paragraphs describe the basic characteristics of body-on-chassis small buses and discuss their interior configurations.

Chassis. Body-on-chassis small buses are built upon commercial chassis that may originally have been intended for motor-home, school-buses, or commercial use. The basic running gear is retained with springs and brakes upgraded to the final vehicle manufacturer's plated gross vehicle weight. Often, extra fuel capacity is called for and is generally met with the chassis supplier's optional equipment. Because body-on-chassis small buses have significant requirements for heating and cooling systems and for electrical systems, considerable under-the-hood modifications are necessary. Some can be supplied with the chassis, but most are made by the vehicle manufacturer. These modifications include extra battery capacity, hose runs for heaters and air conditioners, wiring harnesses, and wheelchair lift controls and associated electro-hydraulic systems.

Body. Body construction of body-on-chassis small buses varies greatly. The most usual form consists of a steel under-floor and framing with steel, aluminum, or plastic paneling. Major variations include all-aluminum frames and paneling, and wooden floors with molded plastic and/or fiberglass side and roof panels. The most common flooring is 1/2" to 3/4" plywood, but solid and foam-filled sandwich floors up to 2" thick are also used.

The windows may be vertically sliding (school-bus type) or horizontally sliding. Other windows are not meant to be opened. Sometimes, push-out windows are installed to meet Federal Motor Vehicle Safety Standards. Figure 4-1 shows an opened push-out



Source: Blue Bird/Micro Bird.

FIGURE 4-1. EMERGENCY PUSH-OUT WINDOW ON BODY-ON-CHASSIS SMALL BUS IN PARTIALLY OPEN POSITION window. Some buses may be equipped with rear emergency doors, and others may have roof hatches. The roof hatches may be for ventilation and/or may be specifically designed for escape.

Passenger doors come in a great variety of forms, depending on their location and the degree of modification of the basic vehicle. Three different sorts of door for the same body-on-chassis small bus are shown in Figure 4-2. Other common types include a manually operated extended cab door, similar to those used in modified vans, and dual-leaf folding doors operated manually or electrically. For vehicles equipped with a lift for handicapped passengers, a separate entryway is often provided, either directly behind the passenger door or at the rear right of the bus. If an active lift is installed, the opening is generally obstructed from the inside by the lift platform, as shown in Figure 4-3. The door must, therefore, be opened from the outside before the platform can be lowered and the entryway used. The clear height of such doorways varies from 50" to 70" and depends on the extent to which the bus has been structurally modified and on the characteristics of the lift. Also, depending upon the specific lift installation, the width of the clear opening varies but typically is about 50".

Interior. The interior width of body-on-chassis small buses varies from 80" to 92", and often the interior space cannot be used as effectively as in a heavy duty transit bus because of the obtrusion of the wheelhousings and doorways into the relatively small passenger compartment. Figure 4-4 shows possible internal layouts of a typical smaller vehicle. The three illustrated configurations are as follows:

A. Mixed capacity, accommodating four wheelchairs and five ambulatory passengers (or seven if tip-up seat positions are used).

B. Mixed capacity, with accommodations for two wheelchairs and nine ambulatory passengers (or eleven when the tip-up seats at the wheelchair positions are included.

C. All ambulatory with forward-facing seats and shopping parcel accommodations. Fourteen forward-facing seats are shown and

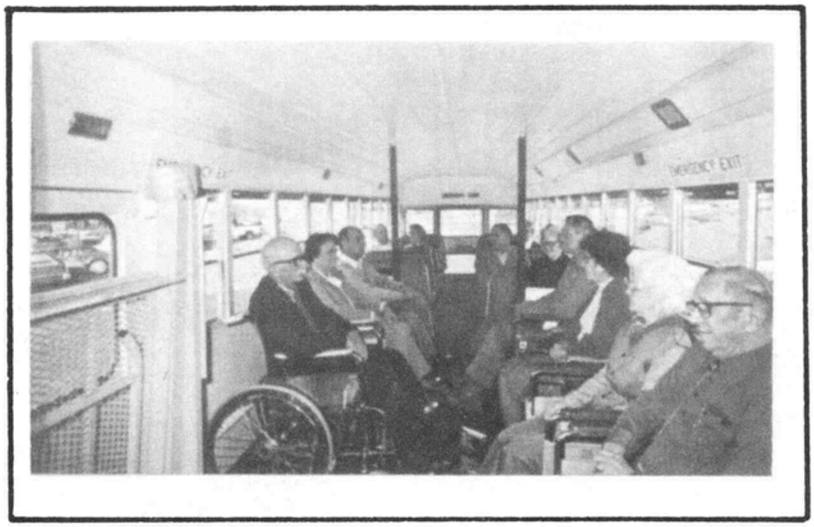
BI-FOLD SIDE DOOR

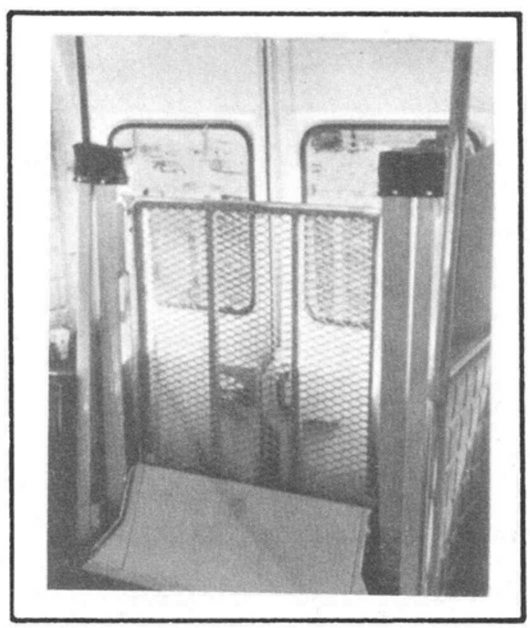
CURVED SIDE DOOR

Source: Champion Commercial Vehicle Division.

EXTENDED CAB FRONT DOOR

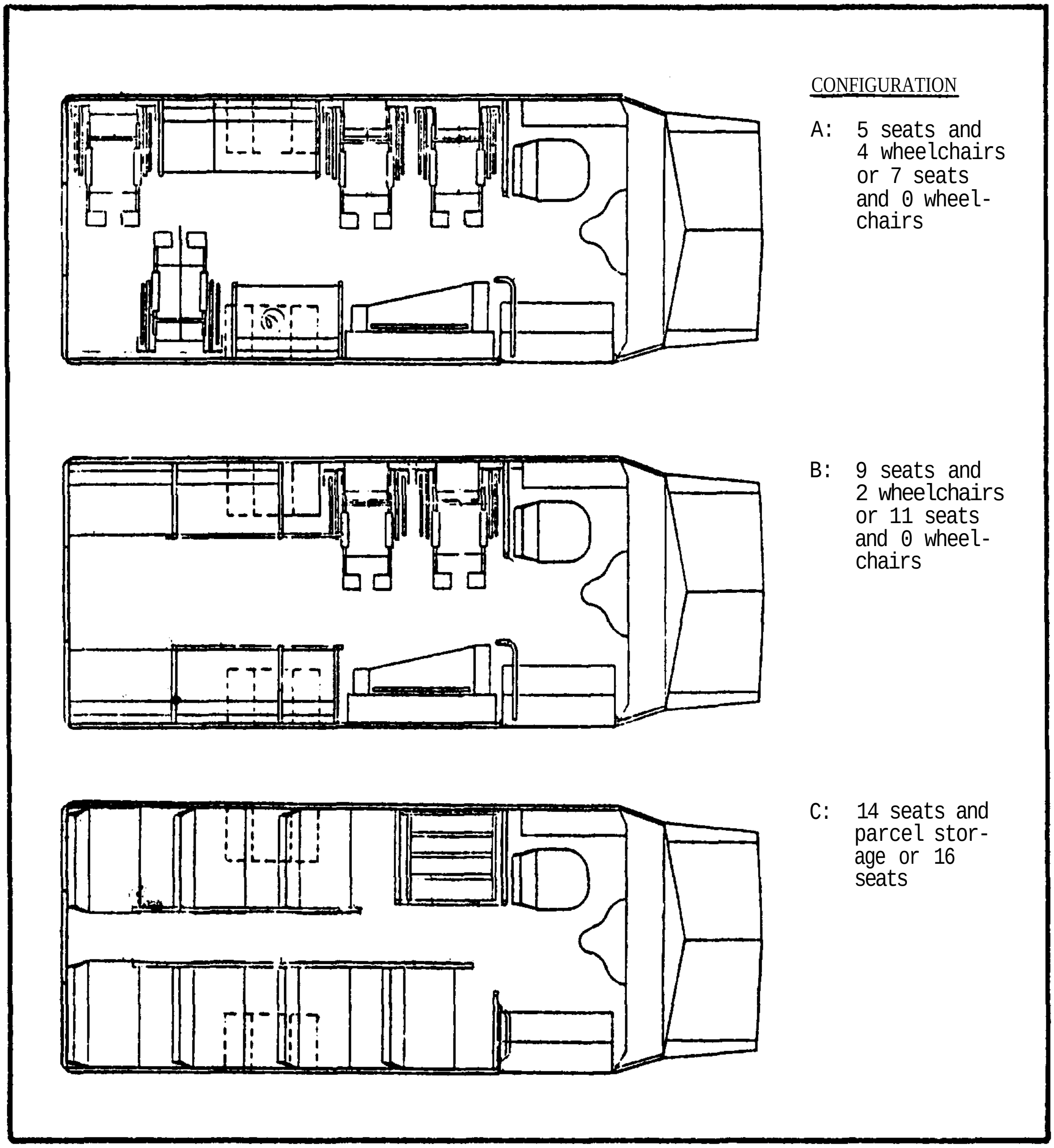
FIGURE 4-2. TYPICAL BODY-ON-CHASSIS SMALL BUS DOOR CONFIGURATIONS





Source: Wayne Corporation.

FIGURE 4-3. TYPICAL BLOCKAGE OF AN ENTRYWAY BY A LIFT REQUIRES AN ADDITIONAL ENTRYWAY



Source: Greater New Haven Transit District, and Coach & Equipment Corporation.

FIGURE 4-4. EFFECT OF ACCOMMODATION REQUIREMENTS ON A SMALL BUS INTERIOR LAYOUT two more could be included instead of the parcel storage structure.

These diagrams illustrate some of the general features of the interior of the body-on-ohassis small bus. First, the aisle widths tend to be narrower than in full-size, heavy-duty transit buses. Second, wheelchair orientation is generally across the vehicle rather than fore-and-aft. This results in some obstruction of the aisle when the wheelchair stations are close to the driver. Third, wheelchair users must board and alight one at a time. Fourth, the buses must often be fitted with perimeter seats to allow wheelchair passage, although conventional transverse seats are preferable for ambulatory passengers when ease of entry or exit from the seat is not a primary consideration.

Wheelchair Restraints. Like modified vans, body-on-chassis small buses should be fitted with devices for securing wheelchairs. The two most common devices for securing wheelchairs are tie-downs, one using some arrangement of straps, and the other using wheelchair rim pins. The former are generally floor-mounted and attached to the wheel-chair frame. The latter may be floor-mounted but are more often wall-mounted. They consist of sliding pins that go through the spokes and secure the chair by restraining the rim and tire between the pin and the fixture. A variant of this is a rotating clamp over the tire and rim. These arrangements are sufficiently flexible to accommodate a variety of chair sizes. The effectiveness with which these devices might restrain the wheelchair and its occupant in a crash is variable. Furthermore, they all have manually-operated release mechanisms that are difficult for the wheelchair user to reach. Some wheelchair users might be unable to free themselves. Several tie-down devices are shown in Figures 3-16, 3-17 and 3-18.

4.1.2 Urban Transit Buses

This group contains large heavy-duty vehicles up to 40 feet in length with passenger capacities of up to 53 persons. They are primarily used for urban transit and have the entry door ahead of the front wheels and the rear door, if there is one, ahead of the rear wheels. A rear-mounted diesel engine drives the vehicle, which has full air suspension and braking systems. Because of these features, these buses are much more expensive than the light-duty small buses previously discussed, but they are much more rugged and have a much greater operational life expectancy.

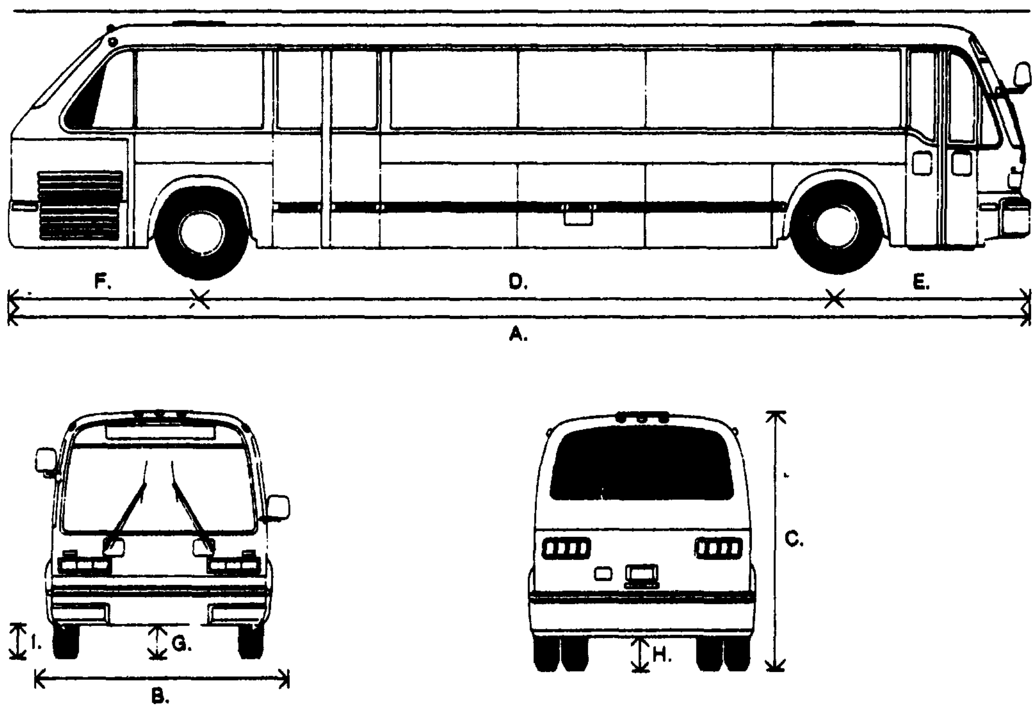
One of the most common of these buses is the GM RTS (Figure 4-5). Many others are used as well. One special form is the articulated urban transit bus, illustrated in Figure 4-6.

Even the smallest of these buses are not normally employed in special services for the elderly and disabled. Transit buses built with UMTA funds and ordered since May 1977 have been required to incorporate a "kneeling" device to lower the height of the first step. Those ordered between July 1978 and July 1981 were required to be equipped with wheelchair lifts. Since the latter date, this has been an option governed by local, state, or other mandates. Each of these features must be interlocked with the brake system to immobilize the bus when it is used. The rear doors, likewise, are interlooked with the brakes when open.

Chassis & Body. The body framing of some of the smaller of these buses is often welded to the chassis to produce a unitized construction. Many of the larger vehicles are also of unitary or monocoque construction and are produced by a variety of manufacturing techniques. For instance, the General Motors Corporation (GMC) "New Look" buses are riveted aluminum monocques with steel reinforcing at load points. The Grumman Flxible Corporation's Model 870 series uses interlocked aluminum extrusions and sandwich panels. GMC's RTS-2 and 4 series uses stainless steel welded modules with reinforced plastic side panels, and Neoplan uses a welded square-section tube space-frame with welded stressed skin steel paneling.

Interior. The typical urban transit vehicle has an external width of 96 to 102 inches, depending upon operator needs and legal requirements. Interior widths vary correspondingly from about 90 to 96 inches.

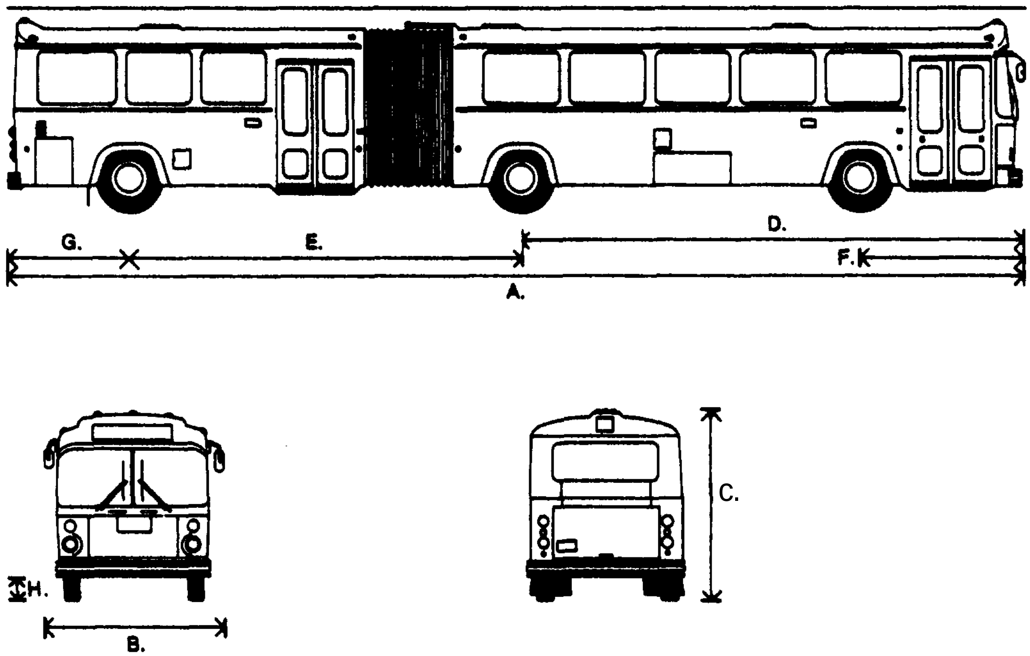
Seating arrangements vary with the intended use of the vehicle. By far the most common arrangement is to have inward-facing longitudinal seats over the wheelhousings with forward facing



Item	Dimension (Feet)	(Meters)
A. Overall Length	40.0	12.2
B. Overall Width (Including mirrors)	10.5	3.2
C. Overall Height (Including antenna)	9.5	2.9
0. Wheelbase Length	24.9	7.6
E. Front Overhang	7.85	2.3
F. Rear Overhang	7.5	2.2
Q. Front Bumper Distance to Ground	1.4	0.4
H. Rear Bumper Distance to Ground	1.3	0.4
I. First Step Distance to Ground	1.3	0.4
Turning Radii	**Dimension (Feet)**	**(Meters)**
Maximum Left Front Body Comer	54.5	16.5
Minimum Right Rear Wheel	32.0	9.7
Gross Vehicle Weight	**Dimensions (Pounds)**	**(Kilograms)**
Front Axle	12,500	5,681.8
Rear Axle	22,500	10,227.3
Total	35,000	15,909.1
Seating Capacity	47	

Source: Southeastern Michigan Transportation Authority,

FIGURE 4-5. GM RTS HEAVY DUTY TRANSIT BUS



Item	Dimension (Feet)	(Meters)
A. Overall Length	59.64	18.2
B. Overall Width (Including mirrors)	10.5	3.2
C. Overall Height	10.3	3.2
0. Wheelbase Length—Drive Axle to Front	18.5	5.7
E. Wheelbase Length—Rear to Drive Axle	24.0	7.3
F. Front Overhang	8.7	2.7
Q. Rear Overhang	8.6	2.6
H. First Step Distance to Ground	1.25	0.4
Turning Radii	**Dimension (Feet)**	**(Meters)**
Maximum Left Front Body Comer	43.35	13.0
Minimum Right Rear Wheel	23.54	7.9
Gross Vehicle Weight	**Dimensions (Pounds)**	**(Kilograms)**
Total	55,000	24,795
Seating Capacity	67	

Source: Southeastern Michigan Transportation Authority.

FIGURE 4-6. TYPICAL ARTICULATED HEAVY DUTY TRANSIT BUS transverse seats in the rest of the vehicle. These are generally four abreast (2x2 with a Central aisle) but sometimes are 2 x 1 to allow more room for standees. For express and commmuter services, an all forward-facing seat arrangement is often used. This is created by raising the floor on which the seats are mounted to reduce the size of the wheelhousing. Thus, a step up from the aisle is necessary. Generally, these buses do not have a rear exit door. It is the normal policy of transit operators not to allow standees on these services, but occasional violations of this policy do occur in practice.

The use of longitudinal seats throughout the vehicle to form a perimeter seating arrangement is not widespread and is largely confined to smaller vehicles used in downtown services. Use of such seating in front of the rear door has, however, been a feature of some larger buses on crowded urban routes.

The seats vary greatly in quality. The most common type, the low back seat, generally has some form of built-in handgrip. Passenger assistance is also provided through vertical stanchions, overhead rails, and stairway rails.

There has been a positive development in the improved structural integrity of cantilevered seats in the Advanced Design Bus (ADB). Conventional seats mounted on floor tracks and body side-rails have been found to pull out in crash testing.

Windows usually slide horizontally and can be pushed out for emergency egress. The original ADB specifications did not include sliding windows because the buses were air conditioned. Consequently, roof hatches were provided for emergency ventilation and as possible additional evacuation routes. Older buses often have an emergency exit on the left side of the bus near the rear. (Refer to Figure 4-17, Section 4.2.3.) It is also worth noting that on the ADB buses, mechanical equipment occupies the full height of the rear of the bus. Hence, there is no rear window or emergency exit.

Elderly and Disabled Accommodations. In a special effort to serve the elderly and disabled, operators receiving UMTA funds are required to designate specific seating areas for them.

These are generally the longitudinal seats over the front wheel-housing, because of their proximity to the entry way and the driver and because of their ease of access and egress.

If wheelchair accommodations are provided, they may be at either the front or the middle, depending upon which doorway has the lift. On the GMC RTS-2 and 4 buses, either one or two wheel-chair stations are provided opposite the rear door. The most forward of these often requires the passenger to travel backwards. Most other accessible transit buses have a lift positioned in the front door and wheelohair stations provided to the immediate rear of the longitudinal seat over the wheelhousing.

4.1.3 Intercity Motor Coaches

This third group includes those vehicles that are primarily used at high speeds in intercity service. They are typically about 40 feet in length and about 8 feet in width. They carry 43 to 53 seated persons with few, if any, physical aids such as lifts for the disabled. Because these vehicles provide inexpensive transportation for trips of up to 200 miles, (compared to air or train travel) they often carry elderly people, as will be shown later in this section. Wheelchair users, however, seldom ride on these vehicles. Intercity motor coaches are relatively expensive and are designed to have long lives. They often remain in service 15 years or more.

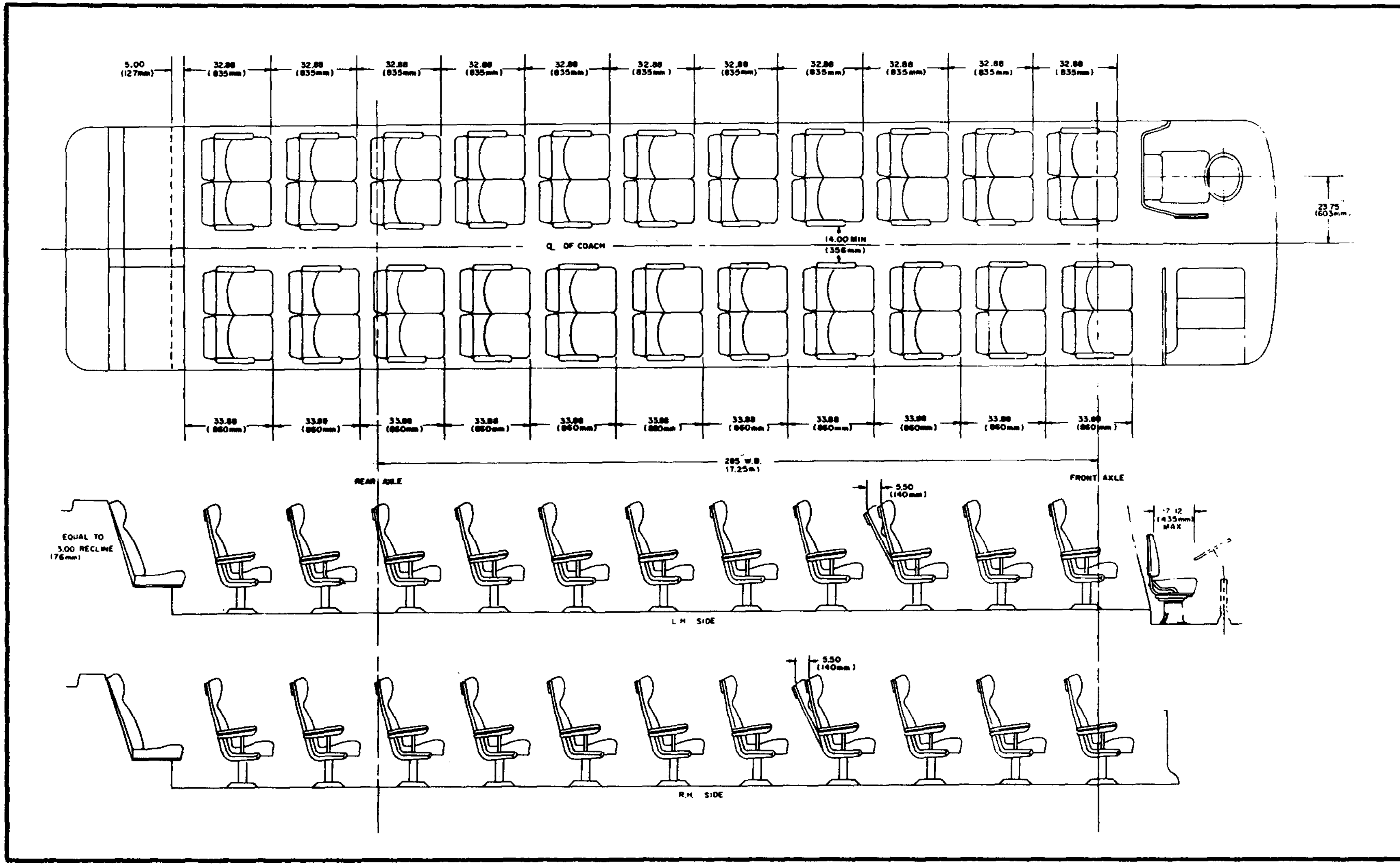
Chassis and Body. These vehicles generally have a welded single-piece frame and monocoque body. The exterior center roof and the side-wall panels immediately below the passenger windows are usually made of high-tensile, treated aluminium. Fluted stainless steel paneling is often used below the passenger floor-line on both sides and at the front and rear. The roof and sidewalls are insulated with fiberglass and an asbestos blanket. Double floor construction is used over the axles. In lieu of a rear window, there is usually a large, one-piece, colored, reinforced fiber-glass panel. These buses also contain three full-width under-floor baggage compartments between the front and rear axles.

Interior. The interiors are much more plush than those found in small buses and urban transit buses. A sample floor plan is shown in Figure 4-7.

Special Characteristics. Intercity motor coaches have a number of safety features that can be of use to emergency forces in the rescue of passengers. Each of them is discussed here.

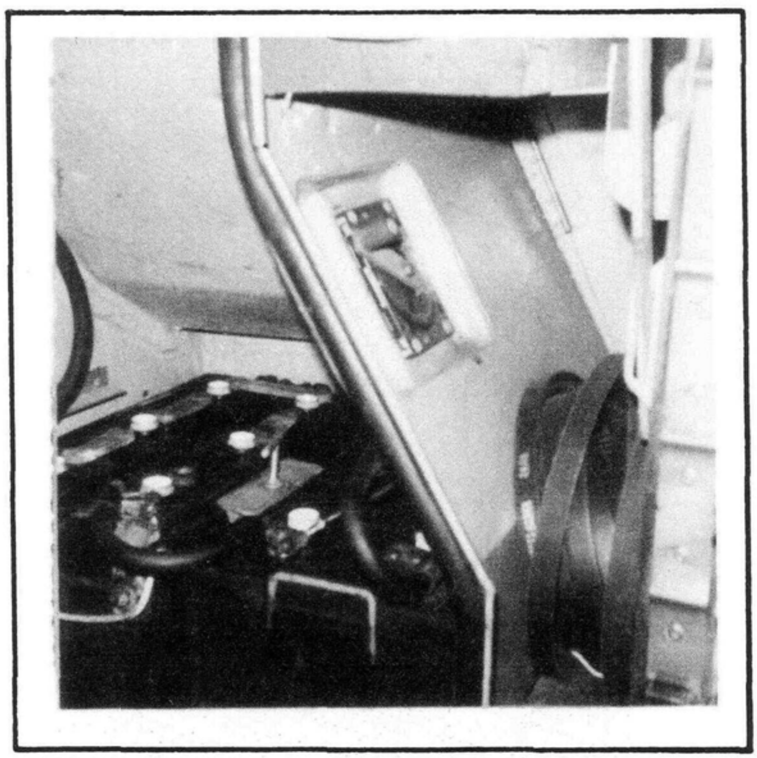
Accidents involving these buses are considerably rarer than those involving automobiles. Emergency forces, consequently, do not acquire much on-the-job training that might aid them in future accidents. Nevertheless, the design of these buses should facilitate emergency response. The MCI Intercity Motor Coach may serve as an example. As shown in Figure 4-8, an emergency cutoff switch for the battery is located in an easily opened compartment on the side adjacent to the front door. If the vehicle has been involved in an accident and the engine is still operating, emergency forces can shut it down by using the switch or by cutting the cables. If the compartment is inaccessible as a result of the accident, the engine can be shut down by a switch on the left wall within the engine compartment, as shown in Figure 4-9. If this compartment also is inaccessible, the engine can be shut down by a switch on the dashboard at the operator's position. This assumes easy access to the interior, but as one can see in Figure 4-10, the door does not have a handle. If one looks closely at this figure, however, one can see that there is a mechanical device on the front of the bus, directly below the "I" in MCI, for operating the door.

There are three escape routes from the vehicle in addition to the main door. They are: the side windows, each of which is hinged as shown in Figure 4-11; the windshields, which are removable when the rubber inserts are pulled out; and two emergency escape hatches in the roof. A closed hatch and a partially open one are shown in Figure 4-12. The hatches are actuated by a simple pull-push quick release mechanism and can easily accommodate someone standing 6 feet tall and weighing 240 pounds, as can be attested to by the author who easily negotiated one of these hatches.



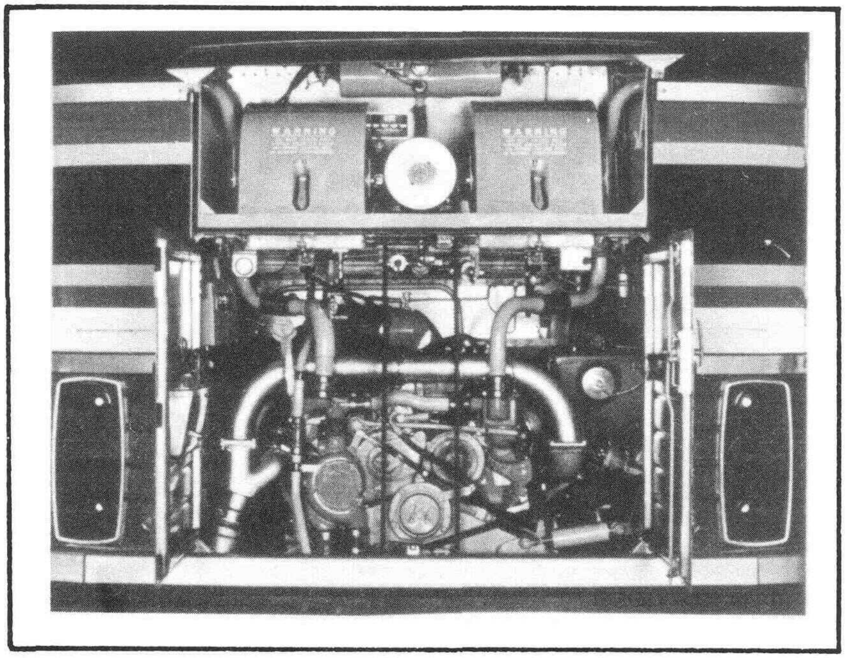
Source: Motor Coach Industries, Inc.

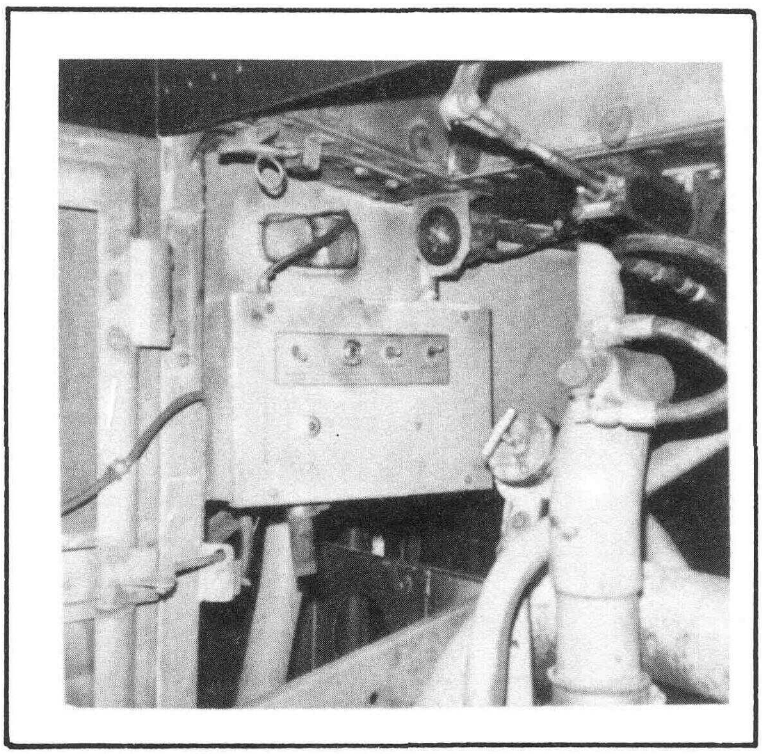
FIGURE 4-7. TYPICAL PASSENGER SEATING ARRANGEMENT: INTERCITY MOTOR COACH BUS



Source: John N. Balog.

FIGURE 4-8. EMERGENCY BATTERY CUT-OFF SWITCH ON MCI INTERCITY BUS



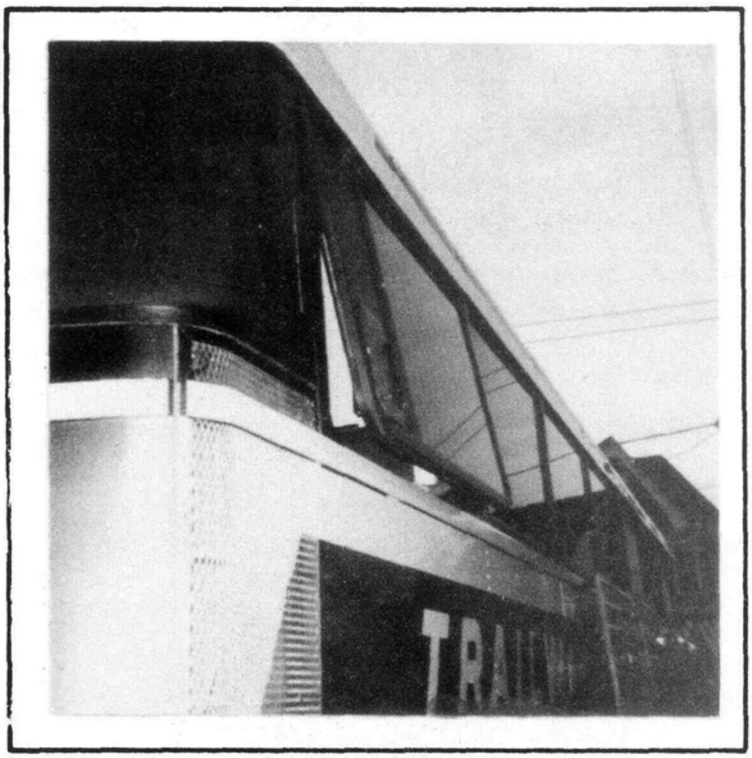


Source: Motor Coach Industries, Inc., and John N. Balog

FIGURE 4-9. ENGINE CUT-OFF SWITCH IN ENGINE COMPARTMENT ON MCI INTERCITY BUS

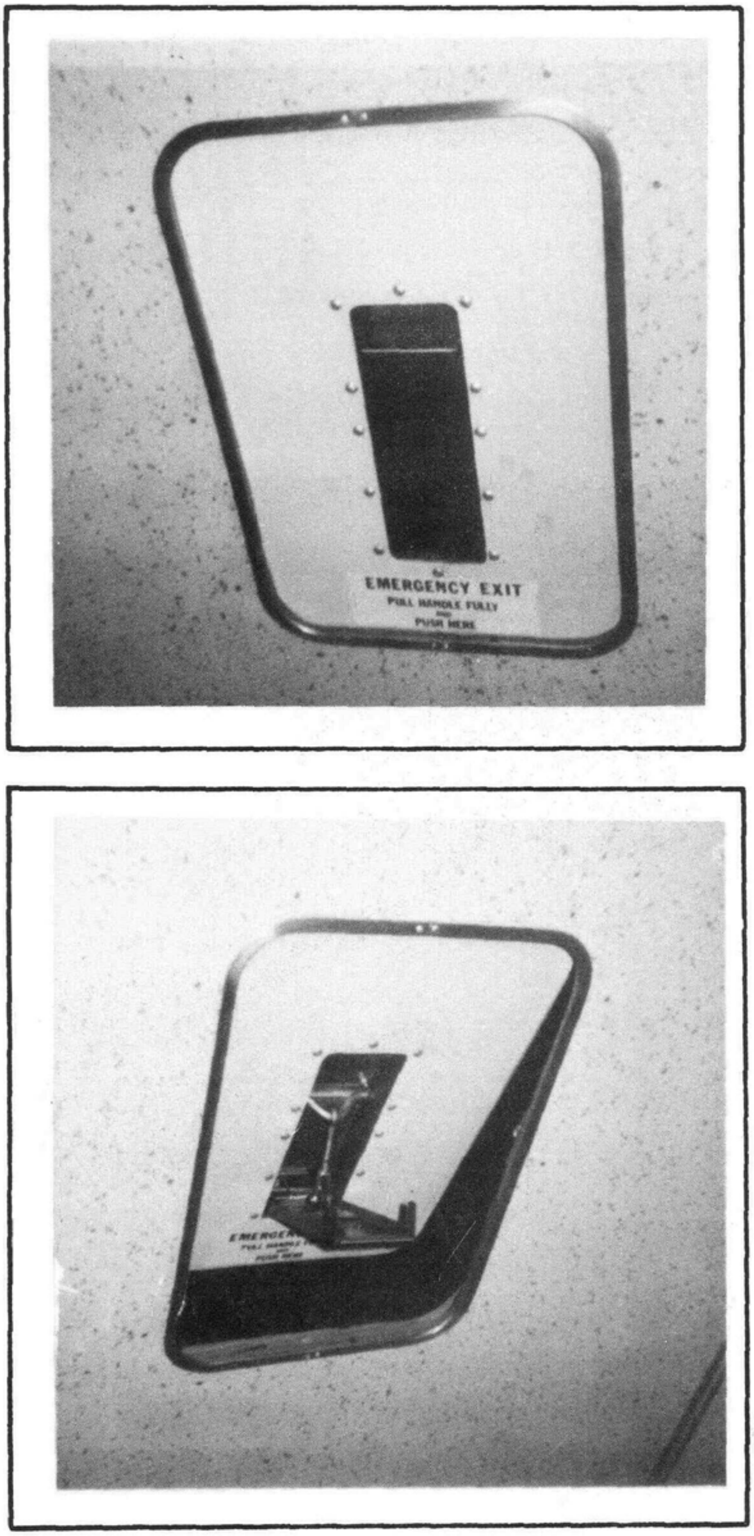
Source: Motor Coach Industries, Inc.

FIGURE 4-10. OUTSIDE DEVICE FOR OPENING DOOR LOCATED UNDER THE "I" IN MCI



Source: John N. Balog.

FIGURE 4-11. HINGED EMERGENCY ESCAPE WINDOW ON MCI INTERCITY BUS



Source: John N. Balog.

FIGURE 4-12. CLOSED AND OPEN EMERGENCY HATCHES IN ROOF OF MCI INTERCITY BUS

]4.2 REVIEW OF CURRENT PRACTICES FOR EVACUATION AND RESCUE

As the discussion above has implied, standard automobile practices are far from adequate for satisfying the unusual demands of bus accidents. Consequently, the approach in this subsection is tot

- o identify the types of accident in which a bus may be involved and the specific problems they may pose for rescuers)
- o determine the probability of occurrence of each of the accidents; and
- o discuss several actual bus accidents.

4.2.1 Types of Accidents and Emergencies

Buses are subject to the same kinds of accidents that were identified in Subsection 3.2.1, which include, either singularly or in combination:

- o collision;
- o rollover;
- o fire; and
- o complete or partial immersion in water.

Danger may arise also if the bus stalls or the driver becomes incapacitated. Each of these emergencies is considered.

Collision. Front-end collisions of body-on-chassis small buses have occurred at relatively high speeds. These have included impacts with cars traveling in the opposite direction, with trees, and with highway trucks. Drivers have been injured, but the front-end mass (engine, suspension, and structure) has generally reduced damage to the passenger compartment. The front door, although damaged, has sometimes continued to work.

Collisions involving transit buses do not generally require emergency evacuation, still, transit buses frequently suffer sufficient damage to make the front door unusable and to incapacitate the driver. Because elderly and disabled passengers are likely to be seated in the front of most kinds of transit buses, they will often be injured, especially in the area of the front wheel-well seats.

The causes of injuries to wheelchair users are various and depend upon the interior arrangements of the vehicles and the practices of the operators. Many small buses have sideways or diagonally facing seats which are especially likely to damage the wheelchair and to injure its occupant in front or rear collisions. This danger can be greatly reduced by the use of a 3-point diagonal-plus-lap belt combination to restrain passengers, but the internal construction of many existing small buses would make it difficult to install such a system. Wheelchairs in transit buses are often oriented fore and aft, but operators differ greatly in their methods of securing chairs and passengers. Some chairs, particularly powered ones, do not fit into standard securement devices and may be transported unrestrained. Some operators insist on the use of supplementary seat belts to secure the passenger, but others have discarded them as time-consuming and unnecessary. Some wheelchair users have refused to use tie-downs because they fear entrapment. In body-on-chassis and transit buses, there are a number of rear-facing installations, which do not provide head support and consequently pose a greater risk of backlash injuries.

Vehicle Rollover. A rollover may be complete, with the vehicle ending up on its roof, or partial, with the vehicle ending up on its side. The latter form of rollover seems to happen more frequently among transit buses than among small buses. The former is likely to result in more severe injuries. If a transit bus is resting on its roof, it is possible for all doors to function and the window exits, once they are released, to fall open under the force of gravity. If a transit bus is resting on its right side, all the normal doors will be blocked, and only emergency exits (windows and roof hatches) will be available. The side windows will be about 8 feet above ground level, thus necessitating the use of a ladder by rescuers. Many windows are not marked as exits or releasable from the outside. The size of the openings on transit buses varies with the models. The smallest opening may be that of the lozenge-shaped windows of the "New Look" buses, which are approximately 25 inches high and 67 or 87 inches long. Entry with a stretcher would have to be by way of the windshield. With body-on-chassis small buses, it is probable that the only exits will be openable or broken windows.

The driver may be injured in a rollover. The driver's seat in most modern buses is equipped with a lap seatbelt, but one cannot assume the driver has used it. A bus tipping over to the right could throw the driver into the stepwell.

The designated seats for elderly and disabled passengers happen to be those that provide the fewest handholds. Because these seats face inward, their users may have less warning of an impending accident. Therefore, they are more vulnerable to injury than users of the transverse seats, where handholds are generally available. The same dangers are to be found among similar seats over the rear wheelhousings, which are generally used by regular passengers, and the longitudinal tip-up seats provided at wheelchair stations.

The wheelchair user, if he/she remains in the chair, may hang sideways or upside down until released. This in itself could result in the restraint system putting undue strain upon the anatomy and inflicting an injury. Because these conditions have not been simulated in crash testing, it is not certain that all restraint systems currently used would prevent the chair from moving under the crash-induced and gravitational forces imposed on it. Nor is it certain that all restraint systems currently used would function properly. The most commonly used mechanical restraints on transit buses are single wheelclamps, which in a rollover would be required to carry the full weight of passenger and chair. It is quite conceivable that under those circumstances, the mechanism might release the chair and occupant. Alternatively, it might jam.

Obviously, the preservation of the chair must be only a secondary consideration compared to the safety of the occupant. But since these devices represent a considerable investment ($600 to $8,000), are often tailored to a particular user's needs, and hence become in the mind of the user an extension of himself, salvaging them with minimum damage, whenever possible, becomes a worthy objective.

The electric battery powerpacks for powered wheelchairs are often trunnion mounted and are therefore free to swing about an are.. The physical performance and mechanical and electrical integrity of such a system as it is rolled into an inverted position are not yet known. The chief designer of a wheelchair manufacturer suggested, in telephone conversations, that battery leakage can be expected (sealed batteries cannot be used because the charging process is discontinuous) and that there is a possibility that the battery pack, when fully inverted, could become unhinged and free to fall.

On-Board Fire. Fires in front-engine, body-on-chassis small buses most commonly start under the hood or in the dashboard, and have a variety of causes, including gasoline, oil, and fluid leaks in the engine compartment, electrical short circuits in the battery boxes, overheated brakes or burst tires igniting reinforced plastic wheelhousings, and fires set by vandals in foam upholstery. Some operators have equipped their buses with underhood fire extinguisher systems, but information on their performance and cost-effectiveness is generally unavailable. Since such fires can occur in the vicinity of the main entryway, this should not be the only emergency exit. However, some large operators have objected to the use of a rear-door emergency exit (as provided in school buses), because they know of cases where mentally retarded persons have opened such doors while the vehicles were in motion.

The worst case would be an electrical fire that immobilized the wheelchair lift. If the fire is not contained or is producing toxic fumes inside the vehicle, the manual operation of the lift might take too long, and it may be necessary to evacuate passengers without their chairs. The decision to do so would be influenced by the degree of danger posed by the fire, the location of the lift (rear installation would usually be well away from the source of the fire) and the weights of the clients and their chairs. If the vehicle is not equipped with a rear or side emergency exit, the ambulatory passengers would have to exit towards the fire, unless they use the window exits.

In transit buses and intercity motor coaches, *7Q%* of all fires have developed in the rear of the bus and outside the passenger compartment. The remoteness of some of these locations has often allowed fires to grow before they were detected. This has been particularly true of wheelwell and engine compartment fires, which account for about 40% of fires. Despite such fires, evacuations have generally been carried out with few injuries.

Although the buses are constructed basically of metal, they contain large amounts of materials capable of supporting combustion and producing smoke and fumes. These include wooden floors with rubberized coverings, foam insulation and upholstery, plastic glazing and illumination panels, fiberglass reinforced polyester resin body panels and components, and plastic coated trim panels and wiring harnesses.

The designated seating areas for the ambulatory elderly and disabled on transit buses are usually the longitudinal seats over the front wheelhousing, adjacent to the front door and driver's station. Evacuation, therefore, should not be very difficult, even for wheelchair passengers, if there is a front-door lift. The aisle width between the longitudinal seats is sufficient to allow a chair to pass. Even if the lift is not working, it should be possible to evacuate wheelohair passengers by carrying them out.

Rear-door lifts are less favorable for quick evacuation. They are close to likely fire sources. (In the RTS series of buses, the rear door is immediately ahead of the rear wheelwell.) The aisle width, and possibly the front door width as well, will not allow a passenger to be wheeled out the front. Therefore, if the rear door or lift cannot be used, there is no alternative but to carry the passenger forward and out. An open rear door has been shown to contribute to the spreading of an internal fire by allowing heated air to vent through the top while cool air enters over the steps. Use of the rear door for lift operation could therefore accelerate the spread of a fire.

Water Immersion. When a bus is immersed in water, the problems of evacuation are especially great, particularly for elderly and disabled passengers. Small boats and/or chairs and slings may be required. Wheelchairs and such other locomotion aids as canes and walkers may get in the way and cannot be saved. Plenty of help will be needed to rescue the elderly and disabled.

If the bus becomes partly immersed on its side, and if the water is fairly deep, elderly and disabled passengers, whether injured or not in the initial accident, may drown unless fellow passengers aid them immediately and continuously until rescue forces arrive.

In the event of total submersion, it will be every person for him/herself. It is unlikely that any elderly or disabled passenger will survive.

Stalled Bus. A bus stalled on the road for any reason is a hazard. The most dangerous place to stall is on a railroad crossing. Buses have occasionally stalled there when their brake interlock systems have been activated on rough crossings by jouncing of the front suspension on buses equipped with a kneeling device, or by jarring of the rear doors when these are driver-controlled. There is usually an override mechanism to allow the brakes to be released, but this requires some deliberate action by the driver. Depending upon circumstances and the amount of activity on the railroad, it may be prudent to evacuate all passengers before attempting to move the bus. The passengers must be positioned well clear of the crossing to avoid injuries from debris should the bus be struck before it can be moved.

Driver Incapacitation. Drivers have been totally or partially incapacitated for a number of reasons, including seizures, heart attacks, being struck by objects such as rocks, wheels or tires coming through the windshield, or by an accident itself. Depending upon the severity of the situation, the vehicle may be brought safely to rest by a quick-acting passenger, or it may be involved in a collision, rollover, fire, water immersion, or combination thereof. Apart from vigorous health checks and insistance on safety precautions such as not driving in the passing lane of divided highways, there is little that can be done to avoid such catastrophes. The "dead man's pedal" used in railroad locomotives cannot be used in the busy traffic of the highway. Any reduction in the driver's capabilities could adversely affect evacuation or rescue efforts before the arrival of a proper rescue force. Inoapacitation of the driver can also delay communication of news of an accident and lengthen response time.

4.2.2 Probabilities of Various Types of Bus Accidents

Each of the types of accident can require different procedures and equipment for effective rescue. Knowledge of the frequency of each of these accidents should allow rescue forces to make cost-effective decisions on special training and the purchase of extra equipment.

Although the data bases include a significant amount of useful information, they do not allow quantification of answers to the questions posed. For example, one identified type of accident is a collision leading to a fire. The data do not distinguish this from a fire leading to a collision. No order is indicated. Also, none of the data bases differentiates between complete and partial immersion in water. In the period under consideration, not one case of immersion of a bus was found in any data set that included such a code, that is, FARS, Washington, or Pennsylvania. None of the data bases includes driver incapacitation as the initial cause of an accident, except for a "died before accident" code in FARS. However, there were so few of these (5 out of 63,467 vehicles in the total 1980 data base) that it is doubtful that any involved buses. Because a bus driver incapacitated by injury in an accident would be unable to aid in or supervise the rescue of passengers, drivers who received fatal or "A" (incapacitation) injuries are included in the data reported in this subsection. These, therefore, include anyone who may have died before the accident.

The FARS bus data for the period 1975-1980 are summarized in Table 4-1. The data base differentiates among school, cross country, transit, other, and unknown buses. All are reported, since the summation over the six-year period for any one type of bus is quite small.

The Michigan commercial bus data for 1981 are presented in Table 4-2. Virtually all of the accidents, fatal and non-fatal, began with a collision, and very few drivers were incapacitated. This is consistent with the Pennsylvania data for both transit and intercity buses, given in Table 4-3.

The Texas data for commercial buses and minibuses are given in Table 4-4. One can assume that minibuses are body-on-chassis small buses, because vans were reported as a separate category in Table 3-3. The Texas commercial bus data are very similar to the data from the sources already given. The minibus data in rural areas reveal a significant proportion of rollover accidents.

The rates of fatal and incapacitating injuries are of interest because they will help rescue forces to know what to expect. The number of occupant fatalities and the sum of fatalities and "A" (incapacitating) injuries are given in Tables 4-5 and 4-6 for the FARS and Michigan data.

It is clear from these tables that although spectacular bus accidents do occur, they are rare. There were only 116 deaths in intercity and transit bus accidents over a six year period, an average of 19 per year. Even the number of "A" injuries for commercial buses is low, with only 12 in Michigan for 1981.

4.2.3 Bus Accident Case Studies

The available statistical evidence demonstrates that in the recent past, the incidence of bus accidents has been low. Consequently, it was difficult to find many documented accidents in the literature on the subject. However, several were identified and are reviewed and discussed below. Some of the accident cases come from National Traffic Safety Board reports, which are especially well documented.

TABLE 4-1. PARS 1975-1980 BUSES: NUMBER OF VEHICLES (ACCIDENTS) AND PROBABILITY OF INVOLVEMENT IN EACH TYPE OF ACCIDENT

Accident Type				School Buses				Cross Country Buses			
Colli-sion	Roll-over	Fire	Water Immer-sion/ Sub-mersion	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-ment	No. Result-ing In Driver Incapa-citation	Proba-bility of Driver Incapa-citation	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-ment	No. Result-ing In Driver Incapa-citation	Proba-bility of Driver Incapa-citation
		●		0	0	0	0	0	0	0	0
	●			8	0.017	4	0.500	4	0.023	2	0.500
	●	●		0	0	0	0	0	0	0	0
●				449	0.928	43	0.096	161	0.925	18	0.112
●		●		6	0.012	2	0.333	1	0.006	0	0
●	●			21	0.043	8	0.381	8	0.046	2	0.250
●	●	●		0	0	0	0	0	0	0	0
			●	0	0	0	0	0	0	0	0
Total Vehicles (Accidents)				484	1.00	57	0.118	174	1.000	22	0.126
All Accidents Involving:											
●				476	0.983	53	0.111	170	0.977	20	0.117
	●			21	0.043	12	0.571	12	0.069	4	0.333
		●		6	0.012	2	0.333	1	0.006	0	0
			●	0	0	0	0	0	0	0	0

TABLE 4-1. FARS 1975-1980 BUSES: NUMBER OF VEHICLES (ACCIDENTS) AND PROBABILITY OF INVOLVEMENT IN EACH TYPE OF ACCIDENT (Continued)

Accident Type				Transit Buses				Other Buses			
Colli-sion	Roll-over	Fire	Hater Inver-sion/ Sub-mersion	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-ment	No. Result-ing In Driver Incapa-citation	Proba-bility of Driver Incapa-citation	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-ment	No. Result-ing In Driver Incapa-citation	Proba-bility of Driver Incapa-citation
		●		0	0	0	0	0	0	0	0
	●			5	0.014	3	0.600	2	0.027	2	1.00
	●	●		0	0	0	0	1	0.014	1	1.00
●				345	0.975	33	0.096	64	0.864	13	0.203
●		●		3	0.008	2	0.667	0	0	0	0
●	●			1	0.003	0	0	6	0.081	3	0.500
●	●	●		0	0	0	0	1	0.014	0	0
			●	0	0	0	0	0	0	0	0
Total Vehicles (Accidents)				354	1.00	38	0.107	74	1.00	19	0.257
All Accidents Involving:											
●				349	0.986	35	0.100	71	0.959	16	0.225
	●			6	0.017	3	0.500	10	0.135	6	0.600
		●		3	0.008	2	0.667	2	0.027	1	0.500
			●	0	0	0	0	0	0	0	0

TABLE 4-1. FARS 1975-1980 BUSES: NUMBER OF VEHICLES (ACCIDENTS) AND PROBABILITY OF INVOLVEMENT IN EACH TYPE OF ACCIDENT (Continued)

Accident Type				Unknown Buses			
Colli- sion	Roll- over	Fire	Water Immer- sion/ Sub- mersion	No. of Vehicles (Acci- dents)	Proba- bility of In- volve- ment-	No. Result- ing In Driver Incapa- citation	Proba- bility of Driver Incapa- citation
		●		0	0	0	0
	●			3	0.041	2	0.667
	●	●		0	0	0	0
●				65	0.891	10	0.154
●		●		2	0.027	1	0.500
●	●			3	0.041	1	0.333
●	●	●		0	0	0	0
			●	0	0	0	0
Total Vehicles (Accidents)				73	1.00	14	0.192
All Accidents Involving:							
●				70	0.959	12	0.171
	●			6	0.082	3	0.500
		●		2	0.027	1	0.500
			●	0	0	0	0

TABLE 4-2. MICHIGAN 1981 BUSES: NUMBER OF VEHICLES (ACCIDENTS) AND PROBABILITY OF INVOLVEMENT IN EACH TYPE OF ACCIDENT

Accident Type			School Buses				Commercial Buses			
Colli-sion	Roll-over	Fire	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-ment	No. Result-ing In Driver Incapa-citation	Proba-bility of Driver Incapa-citation	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-ment	No. Result-ing In Driver Incapa-citation	Proba-bility of Driver Incapa-citation
●			1385	0.997	6	0.004	1296	0.998	6	0.005
	●		4	0.003	1	0.250	0	0	0	0
		●	0	0	0	0	0	0	0	0
●		●	0	0	0	0	2	0.002	0	0
Total Vehicles (Accidents)			1389	1.00	7	0.005	1298	1.00	6	0.005
All Accidents Involving:										
●			1385	0.997	6	0.004	1298	1.000	6	0.005
	●		4	0.003	1	0.250	0	0	0	0
		●	0	0	0	0	2	0.002	0	0

TABLE 4-3. PENNSYLVANIA 1979 BUSES: NUMBER OF VEHICLES (ACCIDENTS) AND PROBABILITY OF INVOLVEMENT IN EACH TYPE OF ACCIDENT

Accident Type			Intercity Buses				Transit Buses			
Colli- sion	Roll- over	Fire	No. of Vehicles (Acci- dents)	Proba- bility of In- volve- ment	No. Result- ing In Driver Incapa- citation	Proba- bility of Driver Incapa- citation	No. of Vehicles (Acci- dents)	Proba- bility of In- volve- nent	No. Result- ing In Driver Incapa- citation	Proba- bility of Driver Incapa- citation
●			88	0.978	1	0.011	529	0.996	4	0.008
	●		1	0.011	0	0	0	0	0	0
		●	0	0	0	0	0	0	0	0
●	●		1	0.011	0	0	2	0.004	0	0
Total Vehicles (Accidents)			90	1.00	1	0.011	531	1.00	4	0.008
All Accidents Involving:										
●			89	0.989	1	0.011	531	1.00	4	0.008
	●		2	0.022	0	0	0	0	0	0
		●	1	0.011	0	0	0	0	0	0

TABLE 4-4. TEXAS 1981 BUSES: NUMBER OF VEHICLES (ACCIDENTS) AND PROBABILITY OF INVOLVEMENT IN EACH TYPE OF ACCIDENT

Accident Type		School Buses				Comlercial Buses (Rural)			
Colli-sion	Roll-over	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-ment	No. Result-ing In Driver Incapa-citation	Proba-bility of Driver Incapa-citation	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-ment	No. Result-ing In Driver Incapa-citation	Proba-bility of Driver Incapa-citation
●		1192	0.994	5	0.004	95	0.990	3	0.032
	●	7	0.006	0	0	1	0.010	0	0
Total Vehicles (Accidents')		1199	1.00	5	0.004	96	1.00	3	0.031

TABLE 4-4. TEXAS 1981 BUSES: NUMBER OF VEHICLES (ACCIDENTS) AND PROBABILITY OF INVOLVEMENT IN EACH TYPE OF ACCIDENT (Continued)

Accident Type		Commercial Buses (Urban)*				Mini Buses (Rural)			
Colli- sion	Roll- over	No. of Vehicles (Acci- dents)	Proba- bility of In- volve- ment	No. Result- ing In Driver Incapa- citation	Proba- bility of Driver Incapa- citation	No. of Vehicles (Acci- dents)	Proba- bility of In- volve- ment	No. Result- ing In Driver Incapa- citation	Proba- bility of Driver Incapa- citation
●		1412	0.999	4	0.003	35	0.833	5	0.143
	●	1	0.001	0	0	7	0.167	0	0
Total Vehicles (Accidents)		1413	1.00	4	0.003	42	1.00	5	0.119

*Drban as used here includes all accidents that occurred in a community with a population of over 5,000. Otherwise, the accident was classed as rural.

TABLE 4-4. TEXAS 1981 BUSES: NUMBER OF VEHICLES (ACCIDENTS) AND PROBABILITY OF INVOLVEMENT IN EACH TYPE OF ACCIDENT (Continued)

Accident Type		Mini Buses (Urban)*			
Colll-sion	Roll-over	No. of Vehicles (Acci-dents)	Proba-bility of In-volve-Bent	No. Result-ing In Driver Incapa-citation	Proba-bility of Driver Incapa-citation
●		256	0.985	5	0.020
	●	4	0.015	0	0
Total Vehicles (Accidents)		260	1.00	5	0.019

*Urban as used here includes all accidents that occurred in comunity with a population of over 5,000. Otherwise, the accident was classed as rural.

TABLE 4-5. FARS 1975-1980: BUS OCCUPANCY AND INJURY

Vehicle Type	Number of Vehicles	Number of Occupants	Number of Fatalities	Number of Fatalities and "A" Injuries
School Bus	785	7556* 2271**	101	392
Cross-Country Bus	220	2981* 1385**	51	229
Transit Bus	794	4754* 1618**	65	203
Other Bus	92	693* 381**	56	124
Unknown Bus	109	784* 410**	20	87
Total	1945	16543* 6565**	264	955

*The number of occupants is missing data on 23% of the buses.

**Occupants with recorded documentation on each.

TABLE 4-6. MICHIGAN 1981: BUS OCCUPANCY AND INJURY

	School Bus	Commercial Bus	Total
Number of Vehicles	1427	1365	2792
Documented Occupants*	1551	1601	3152
Number of Fatalities	1	0	1
Number of "A" Injuries	13	12	25

*The total number of occupants in buses is not available for Michigan.

Single Vehicle Body-On-Chassis Accident. On November 24, 1981, at 2:30 P.M., a 1980 body-on-Ford chassis small bus was traveling south on 1-75 in Scott County, Kentucky, when it went off the road into the median strip. It returned to the roadway but skidded, overturned completely, and came to rest on its side. The bus contained 21 members of a college basketball team, all of whom received minor injuries.

Figure 4-13 shows the bus in its final resting position on its side. Note that the left side wall of the body became detached at the floor line, allowing the side wall and the roof to peel off and unfold onto the pavement. The rear portion of the body also appears to have come away at the floor level and is resting on the shoulder of the roadway. Figure 4-14 shows a front view of the vehicle. It appears that the Ford cab and chassis functioned quite well and demonstrated adequate crashworthiness. Rescue forces experienced little difficulty in gaining access to the victims.

Urban Transit Bus Rollover Accident. On January 7, 1982, at 7:05 A.M., a 1980 Grumman 870 transit bus was approaching an intersection in a midwestern city. The driver found that the brakes were not working, and to avoid colliding with a school bus approaching from the right, he attempted to turn right at the corner. Because of its speed, the bus left the roadway and turned over onto its left side.

Figure 4-15 shows the bus at rest. Note that the front door was still operable and was used in the rescue. Also note, in Figure 4-16, that the last side window on the right side and one of the middle windows are ajar and were presumably used by the passengers or rescuers. It is not known if the escape hatches in the roof were used. Of thre 29 passengers on board, 17 were shown in the police report to have had "probable-not apparent" injuries. The passengers ranged in age from 20 to 62.

Passengers helped each other out the door and window exits and walked alongside the bus to gain safe ground.

Source: Kentucky State Police.

FIGURE 4-13. BODY-ON-CHASSIS SMALL BUS ACCIDENT: SCOTT COUNTY, KENTUCKY

Source: Kentucky State Police.

FIGURE 4-14. BODY-ON-CHASSIS SMALL BUS ACCIDENT: SCOTT COUNTY, KENTUCKY

Source: Local Police Department.

FIGURE 4-15. URBAN TRANSIT BUS ACCIDENT IN MIDWESTERN CITY

Source: Local Police Department.

FIGURE 4-16. URBAN TRANSIT BUS ACCIDENT IN MIDWESTERN CITY

Commuter Transit Bus Run-off-Roadway Accident. About 4:36 P.M., on February 18, 1981, a 1959 GMC commuter transit bus occupied by the driver and 23 passengers was southbound in the middle lane of 1-95 near Triangle, Virginia. As the bus approached the Chopawarasic Creek bridge, it veered to the right, traveled across the right traffic lane, and off the pavement. The right front of the bus struck and rode over a guardrail, 59 feet north of the Chopawamsic Creek bridge parapet. After the left front of the bus struck the north end of the parapet, the bus vaulted about 84 feet horizontally before landing on its right front in the creek, about 25 feet below the highway surface. The bus came to rest on its right side, in about 2 feet of water. Eleven of the occupants, including the driver, were killed, and 13 passengers were injured.

Figure 4-17 shows the bus in its final position. Note that access to the interior was gained through the side windows and the left rear emergency door of this rather old bus. Figure 4-18 shows the frontal area of the bus after it had been uprighted. Note the severe crush and damage to the vehicle. The windshield and rear window were missing. There was severe buckling of the roof for the entire length of the bus, but it was less severe toward the rear. The right side panels of the bus buckled and the underfloor cargo loading doors were torn from both sides. Numerous bus seat legs came away from the floor, because their anchor bolts were pulled from the floor pan.

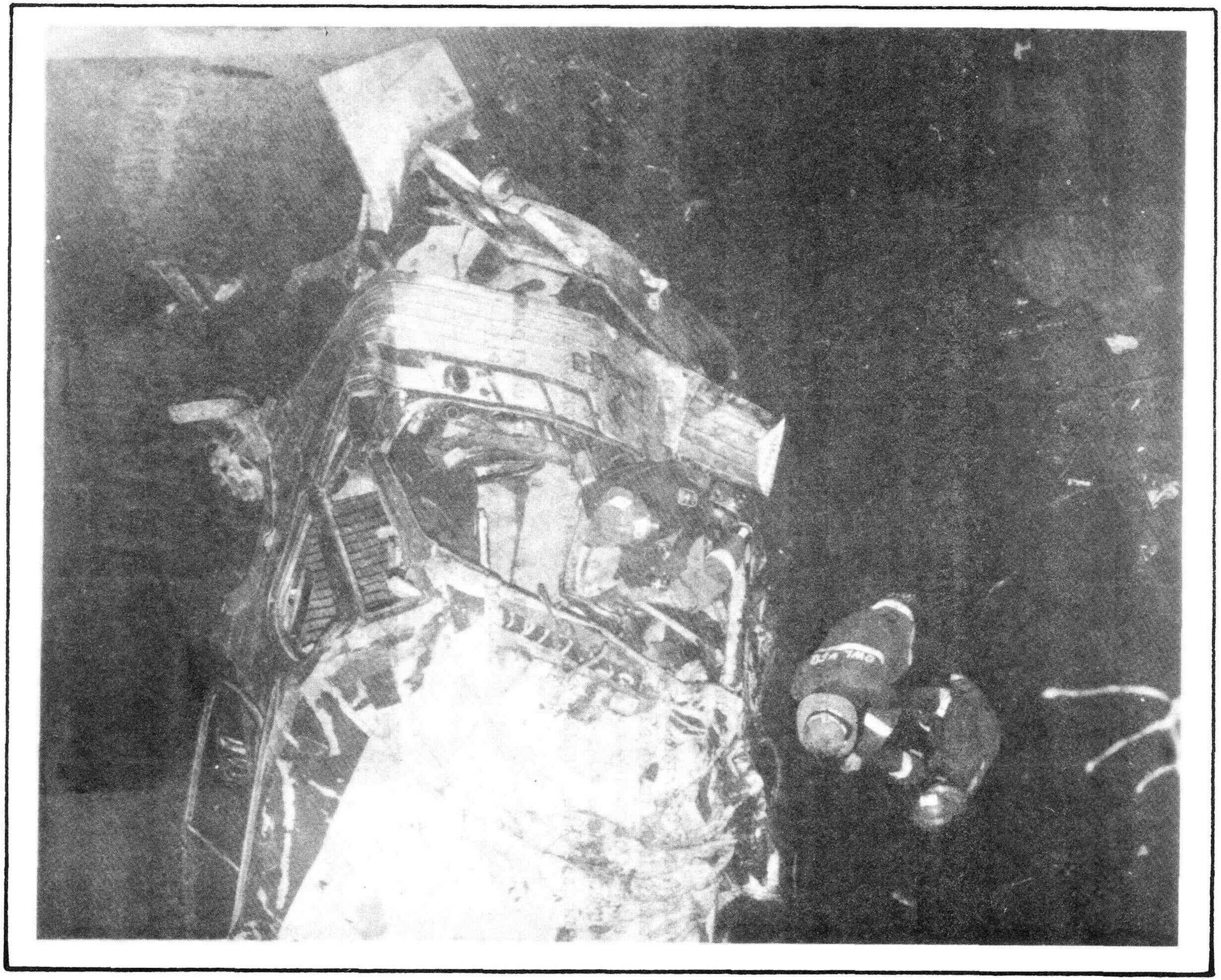
The least injured survivors said they moved from their seats and crouched or lay on the floor between the seats when they recognized that an accident was imminent.

All fatalities resulted from blunt trauma injuries sustained in the crash. There were no drownings.

A Virginia State Police Sergeant who witnessed the accident immediately reported it over his two-way radio. He then began to set out flares for traffic control. Other witnesses, including an emergency medical technician, a fireman with emergency medical training, and a truck driver, stopped to assist in rescue operations. None of the passengers was ejected from the vehicle. One passenger

Source: Reference 104.

FIGURE 4-17. TRIANGLE, VIRGINIA, TRANSIT BUS ACCIDENT: FINAL RESTING POSITION



Source: Reference 104.

FIGURE 4-18. TRIANGLE, VIRGINIA, TRANSIT BUS ACCIDENT: FRONT OF BUS AFTER BEING UPRIGHTED got out of the bus unassisted. Emergency rescue vehicles arrived at the scene about 7 to 8 minutes after the accident occurred.

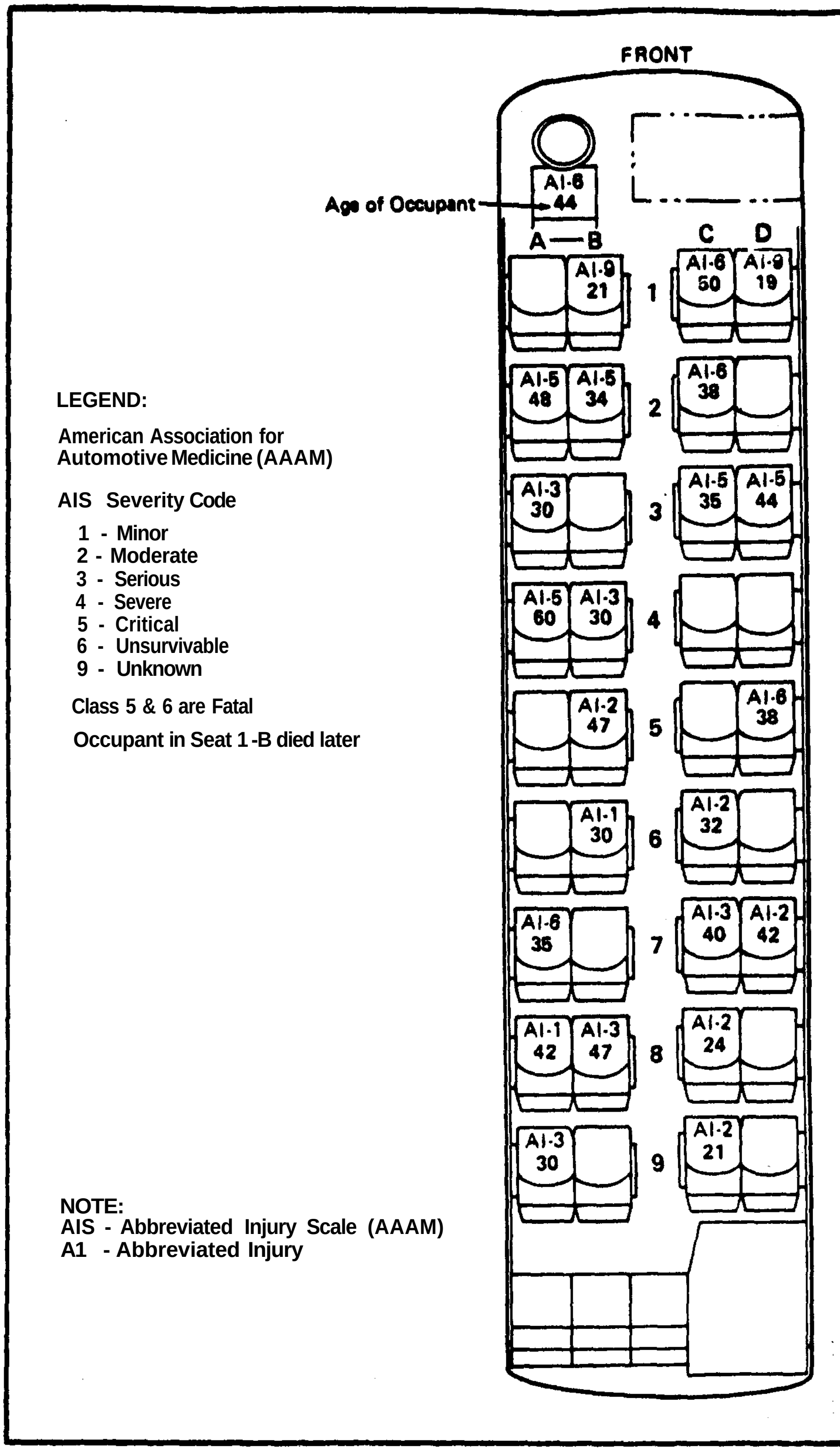
The ages of the bus occupants ranged from 19 to 60 years. Figure 4-19 shows their age, seat position, and degree of injury.

Off-The-Road Intercity Bus Accident. On June 5, 1980, about 12:47 A.M., a 1967 Silver Eagle intercity motor coach occupied by the driver and 32 passengers, mostly elderly people, accelerated out of control while descending a long, curved, steep grade on State Route 7 about 1 mile south of Jasper, Arkansas. The bus failed to negotiate a left curve, and ran off the right edge of the pavement into a drainage channel. It continued for 280 feet, hit a berm at a concrete culvert, caromed back across the highway, vaulted down a steep embankment and came to rest against a rock 38 feet below the pavement. Twenty of the occupants, including the driver, were killed, and the remaining 13 passengers were injured.

The driver and two passengers were ejected when the bus struck the berm. Two more passengers were ejected when the bus went down the embankment, and several were ejected when the bus came to rest against the rock (Figure 4-20).

The front of the bus was crushed rearward and was skewed to the right. The right front corner was crushed about 4.5 feet rearward. Several panels in the right-front area and both windshields were missing. As shown in Figure 4-21, the right forward roof structure was displaced about 2 feet inboard and rearward. Sheet metal along the right side of the bus buckled severely and was crushed inward. The passenger loading door was torn from its supporting structure as it was twisted rearward. All right side windows were missing, and the window pillars were displaced Inward. The roof buckled inward as much as 2 feet in some places. Body structural members were forced rearward and contacted the outside tire of the right drive axle. The rear window was missing, and its frame was distorted.

As the bus scraped along the embankment flanking the ditch, the windshield and right windows were shattered, causing glass fragments to be propelled into the bus and permitting partial ejection of some



Source: Reference 104.

FIGURE 4-19. TRIANGLE, VIRGINIA, TRANSIT BUS ACCIDENT: OCCUPANT SEATING DIAGRAM, INJURY CLASSIFICATION, AND AGE

Source: Reference 103.

FIGURE 4-20. JASPER, ARKANSAS, INTERCITY MOTOR COACH BUS ACCIDENT: FINAL RESTING POSITION

Source: Reference 103.

FIGURE 4-21. JASPER, ARKANSAS, INTERCITY MOTOR COACH BUS ACCIDENT: RIGHT SIDE VEHICLE DAMAGE occupants. Accelerative forces caused occupants to be thrown about within the vehicle. Rescuers reported that several of the occupants who remained in the bus were thrown together in the front right.

The passengers ranged in age from 44 to 91. Their ages, their seat positions, and the severity of their injuries are shown in Figure 4-22.

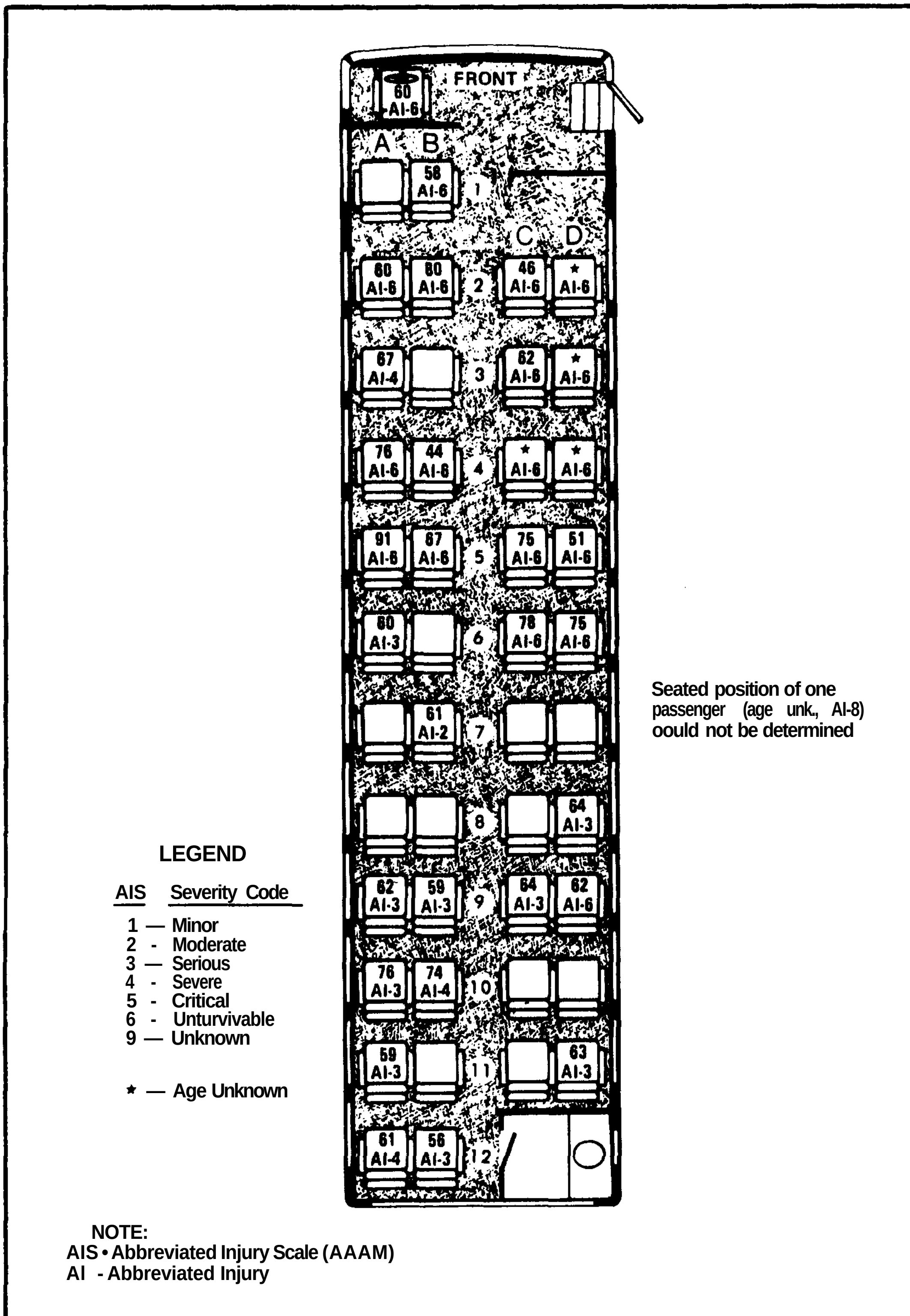
4.2.4 On-Board Passenger Accidents

Some studies have dealt with injuries caused to passengers by intentional acceleration or deceleration. Such injuries may occur during braking, cornering or evasive maneuvers. The seat test conducted under the Transbus Program indicated that for severe fore and aft impacts up to 20 raph, the Head Injuries Criteria (HIC) set by Federal Motor Vehicles Standard 208 (HIC $\leq$ 1000) were met in almost all the cases. Under the conditions of the test, the Transbus seats, which were cantilevered and wall-mounted, remained in place, although some were deformed.

These conditions are comparable to those in current production Advanced Design Buses (e.g., GFC's 870 and GMC's RTS-4 models). In contrast, the floor-track-mounted seats used in conventional transit buses failed at the seat mountings and ejected several of the test dummies, although the level of acceleration experienced in such cases reduced the estimated HIC values.

4.3 PROPOSALS FOR PREPARATION AND RESCUE

As in the case of paratransit vans, the available literature on the rescue of elderly and disabled passengers from small and large transit buses is scarce. For the most part, specific techniques for rescue from buses have not been developed. However, there are some similarities between rescue from automobiles and rescue from buses, and the procedures discussed in Subsection 3-3 also apply, to a limited extent, to buses. Those readers who have started with this section because of their interest in buses are advised to read Subsection 3.3 before continuing.



Source: Reference 103.

FIGURE U-22. JASPER. ARKANSAS INTERCITY MOTOR COACH BUS ACCIDENT: BUS OCCUPANT SEATING DIAGRAM AND INJURY CLASSIFICATION

To some degree, the lack of literature reflects the reasonably good overall standard of safety provided bus passengers. As one might expect, this is very much the case for full-size, heavy-duty transit buses and, to a lesser extent, for body-on-chassis small buses, as was shown at the beginning of the preceding subsection.

There does exist a body of literature on the safety of transit buses in particular, however. It includes:

- research, by means of human factor studies and crash simulations, into the on-board convenience and the safety of passengers;
- standard operating procedures for rescue;
- reports of specific accidents involving buses; and
- research into the safety impact of specific materials that are or might be used on transit buses.

The first and second items are discussed below. The third was considered in subsection 4.2.3. The fourth item is beyond the purview of this study but the reader who is interested may pursue it in Reference 72.

4.3.1 Preparing for Accidents

There are two ways in which rescue agencies, transit service operators, and vehicle manufacturers can greatly improve preparedness for accidents: more rigorous and comprehensive training of rescuers, and improved equipment design and supply. In this subsection, these two points will be considered.

Training. Fire companies, rescue forces, and emergency medical service teams regularly familiarize themselves with certain characteristics of automobiles and learn how to gain access to the victims by removing parts of the vehicle. They also familiarize themselves with the kinds of injury that are usually sustained by automobile passengers. In contrast, they have almost no training with the three kinds of buses discussed here and are not taught the characteristics of the elderly and disabled persons who often use these buses as their primary, or in some cases, their sole means of transportation.

Many operators of body-on-chassis small buses who provide transportation to such clients regularly schedule "sensitivity training" sessions for their drivers, dispatchers, and call takers. However, it is not yet common practice to involve fire company personnel, rescue forces, and emergency medical technicians in such programs.

Very few emergency personnel have had any training with urban transit buses. When training programs are set up, it is usually because of an accident. For example, in Johnstown, PA, a transit bus recently became wedged between a utility pole and a store front after the driver had become incapacitated. Emergency forces did not know how to gain access to the bus or how to turn off the engine. As a result of this experience, the Cambria County Transportation Authority developed a training film that addresses these problems and has used it successfully in its service area.

A highly successful program of public information and education on rescue from intercity motor coaches is being conducted by Capitol Trailways of Pennsylvania. They have written a handout explaining how rescuers can enter their vehicles, make use of the various egress points, and shut down the engine by throwing a cut-off or battery switch or by cutting the battery cables. The handout is reproduced as Figure 4-23. Upon request, Capitol Trailways will go to any location within their service area and provide a training session to the local fire company, rescue force, and emergency medical personnel. A bus is brought to the site and used for demonstration. Participants are given experience with the vehicle and are provided with the handout. The author participated in one of these sessions and considered it very effective. It is strongly recommended that this type of program be instituted across the country.

Emergency units seldom simulate accidents with body-on-chassis small buses, heavy duty transit buses, and intercity motor coaches, or with real elderly or disabled persons or actors as victims. Consequently, when they arrive on the scene of a bus accident, they attempt to use the standard automobile techniques, the ones they know best.

GMC COACH MODEL PD 4106-38 PASSENGERS (to 1965)

Access may be gained through the windshields. Both are mounted in rubber and can be pushed out from the inside or pulled out from the outside of the coach. Access can also be gained through the rear glass; it is also mounted in rubber and can be pushed out from inside or pulled out to provide an exit.

The side window sash can be opened from the inside by pushing firmly on the bottom of the window sash to release the sash from its locks and swung upward on the hinges to provide exits. These can also be sprung open from the outside by using a screw driver or similar pry tool inserted about a foot from the ends of the sash to pry out and up to release the locks.

To cut off electrical power, it is necessary to either remove or cut the battery cables from the batteries which are located in the compartment on the left side of the coach in front of the rear wheels. This coach is equipped with a 12-volt electrical system, and carries 140 gallons of Diesel fuel.

MCI COACH MODEL MC7-47 PASSENGERS (to 1975)

Access may be gained through the windshields, as both are mounted in rubber and can be pushed out from inside or pulled out from outside if necessary. The rear center window is equipped with a release mechanism which can be used to unlock the sash to provide an exit out the rear.

The side windows can be opened from inside by raising up on the release bar at the bottom of the window frame to unlock the sash. It then may be swung out on its hinges to provide exits. All side windows will open.

To cut off electrical power, it is necessary to first open the front or first baggage compartment door to reach the battery cut-off switch, located just inside on the forward wall on the right side of the coach. Power can also be cutoff by opening the door to the batteries and removing or cutting the cables. This coach has a 24-volt electrical system and carries 175 gallons of diesel fuel.

MCI COACH MODEL MC8-46 PASSENGERS (to 1978)

Access may be gained through the windshields, as both are mounted in rubber and can be pushed out from the inside or pulled out from the outside to provide exits. There is no exit through the rear of the coach, as this is covered with a fiber-

FIGURE 4-23. INSTRUCTIONS FOR RESCUE FORCES: GAINING ACCESS TO AN INTERCITY MOTOR COACH, OPENING THE EXIT POINTS, AND SHUTTING DOWN THE ENGINE glass panel. An escape hatch is provided in the roof at the rear of the coach which is opened from the inside by pulling down on the handle and pushing the hatch cover open.

The side windows can be opened from inside by raising up on the release bar across the bottom of the window frame, and pushing out on the sash to provide an exit.

To cut off electrical power, open the battery compartment door on the right side of the coach behind the right front wheel. Turn the battery cut off switch to "off, or "disconnect" or cut the battery cables. This coach is equipped with a 24-volt electrical system, and has a fuel capacity of 175 gallons of diesel fuel.

MCI COACH MODEL MC9-31 & 46

Access may be gained through the windshields, as both are mounted in rubber and can be pushed out from the inside, or pulled out from outside to provide exits. There is no exit through the rear; however, the coach is equipped with two escape hatches in the front and rear of the roof. They can be opened from the inside by pulling down on the handle, and pushing up on the hatch cover assembly to provide exits.

The side windows can be opened by raising up on the release bars to unlock the sash and pushing out at the bottom and swinging them away from the coach to permit exiting.

To cut off electrical power, open the battery compartment door on the right front side of the coach behind the right front wheel, and move the battery switch to the "off" position, or disconnect or cut the cables. This coach is equipped with a 24-volt electrical system and carries 175 gallons of diesel fuel.

All MCI Coaches are equipped with air locks on the passenger entrance doors which can be opened from outside the coach, should a panic situation occur inside the coach. Pushing firmly on the button located near the center of the coach on the front below the windshield area, will allow the passenger door to open.

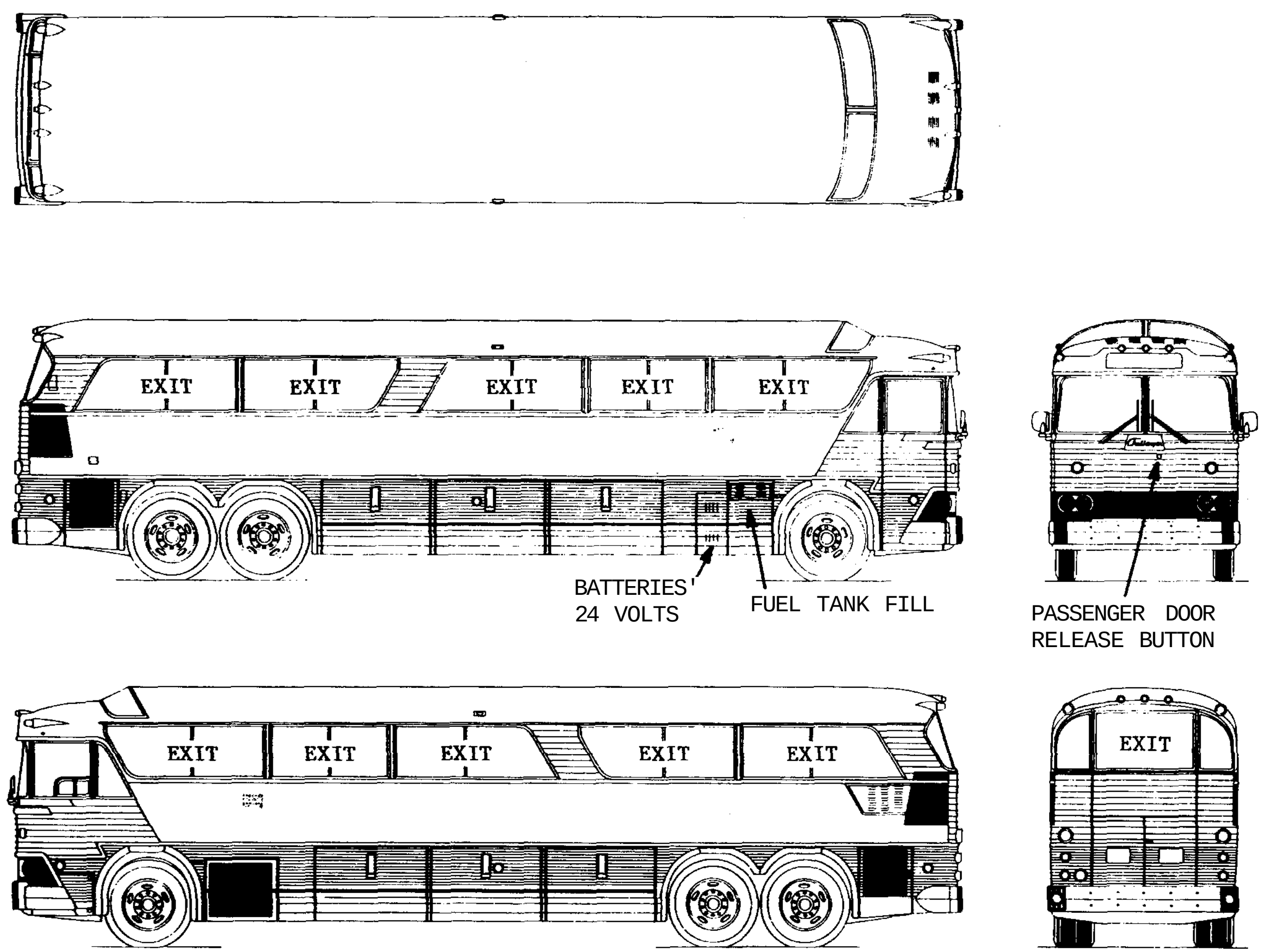
All materials used inside these coaches are fire retardant.

SEE ATTACHED DIAGRAMS FOR LOCATIONS OF EXITS ON THE MODELS OF COACHES LISTED.

For additional information, contact:

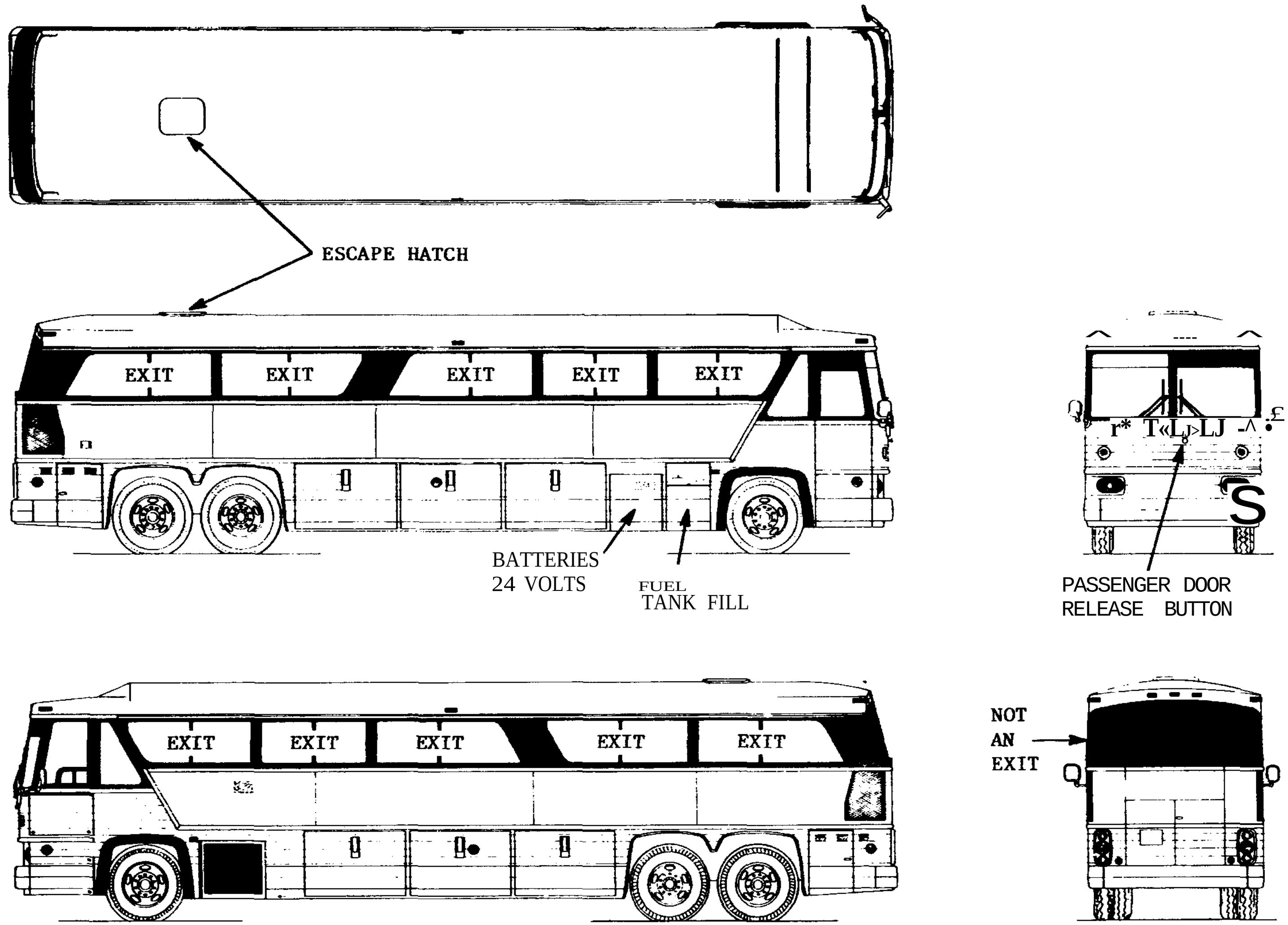
Superintendent of Maintenance
Capitol Trailways
(Capitol Bus Company)

FIGURE 4-23. INSTRUCTIONS FOR RESCUE FORCES: GAINING ACCESS TO AN INTERCITY MOTOR COACH, OPENING THE EXIT POINTS, AND SHUTTING DOWN THE ENGINES (Continued)



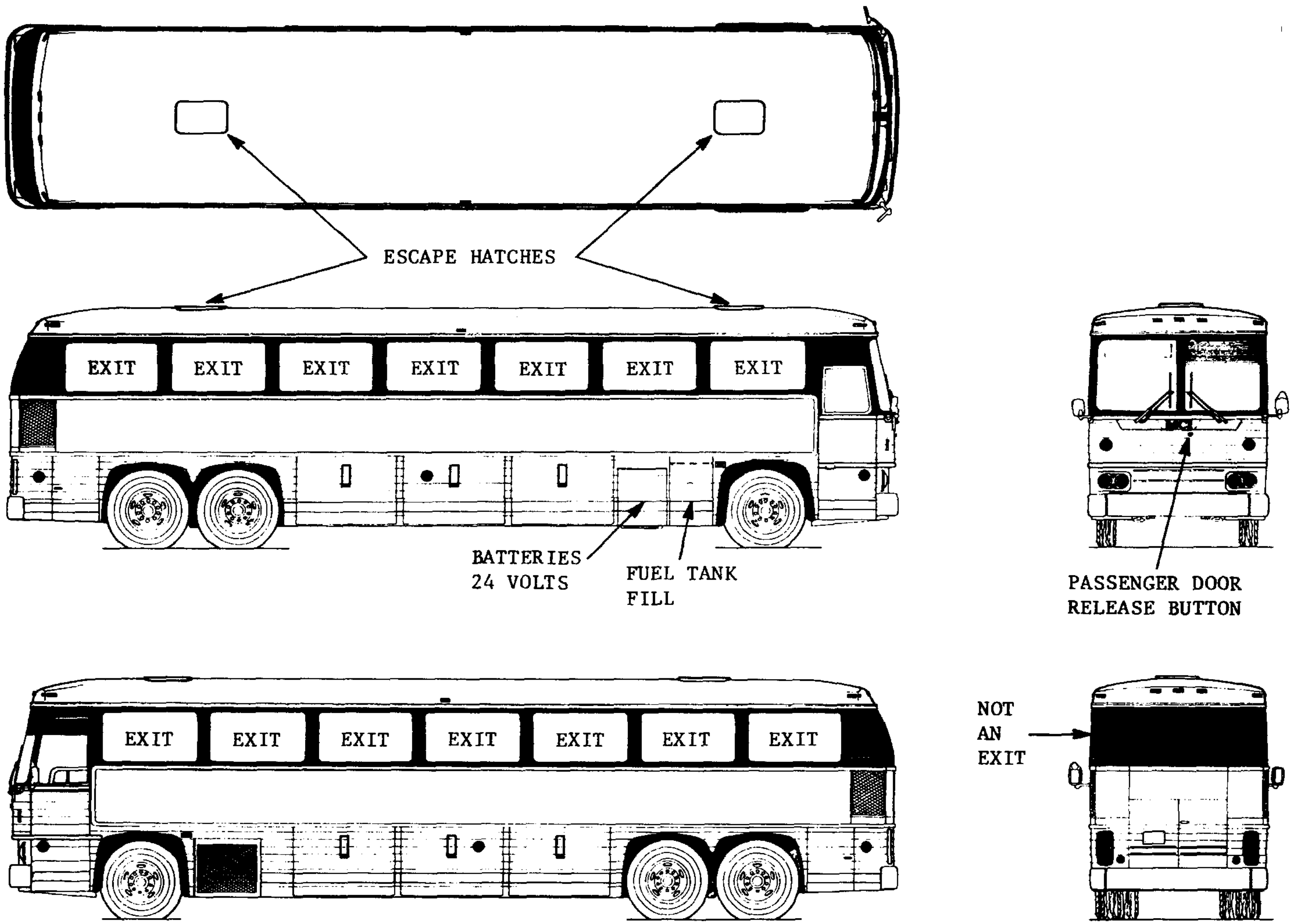
MCI Model MC-7

FIGURE 4-23. INSTRUCTIONS FOR RESCUE FORCES? GAINING ACCESS TO AN INTERCITY MOTOR COACH, OPENING THE EXIT POINTS, AND SHUTTING DOWN THE ENGINES (Continued)



MCI Model MC-8

FIGURE 4-23. INSTRUCTIONS FOR RESCUE FORCES: GAINING ACCESS TO AN INTERCITY MOTOR COACH, OPENING THE EXIT POINTS, AND SHUTTING DOWN THE ENGINES (Continued)



MCI Model MC-9

FIGURE 4-23. INSTRUCTIONS FOR RESCUE FORCES: GAINING ACCESS TO AN INTERCITY MOTOR COACH, OPENING THE EXIT POINTS, AND SHUTTING DOWN THE ENGINES (Continued)

Since bus accidents causing injury to passengers are somewhat rare, most emergency response personnel lack any experience with them. Simulation exercises can prepare rescue forces for real emergencies. Transit authorities and operators should make arrangements with the emergency preparedness forces in their areas to use their buses and transit personnel for simulation exercises. Some elderly and disabled people who are regular passengers may volunteer to act as victims.

In addition, there should be training sessions in the use of manual and powered wheelchairs, ramps and lifts and tie-down devices.

Training sessions should be conducted regularly. They must include lectures, written examinations, and simulation exercises for each type of bus used within the area of service. Transit personnel, rescue forces, and emergency medical teams must also become familiar with the characteristics of elderly and disabled passengers.

Equipment. Much of the information in Subsection 3.3.1 on paratransit vans also applies to body-on-chassis small buses. The size and structural peculiarities of heavy duty urban transit buses and intercity motor coaches necessitate special rescue equipment. However, most emergency forces are equipped to handle only automobile accidents. Some of the standard types of emergency equipment are adequate to deal with bus accidents, but new equipment, such as expandable window props and short ladders, must be developed by the system operators, the bus manufacturers, and the emergency forces.

Transit Operators. The transit operator should ensure that all buses are equipped with a hand-held fire extinguisher and a first aid kit. Drivers should be taught how to fight a fire and how to administer basic first aid.

As discussed in Subsection 3.3.1, agencies that operate buses should display their names on the sides of their vehicles and provide information to rescue forces before accidents occur. Also, information on passengers should be carried in the vehicle for use by emergency personnel after an accident.

Drivers should point out and demonstrate to passengers the use of all emergency exits.

Vehicle Manufacturers. The manufacturers of buses should supply instructions for passengers on how to get out of the bus and instructions for rescue forces on how to get in. For example, the notice on emergency exits shown in Figure 4-3 is clearly visible and is prominently and permanently displayed inside the vehicle. Each passenger should be able to leave by more than one exit. The information should include instructions on how to open the exit. Manufacturers should standardize the symbols they use and the places where they put this information.

Rescue forces need to know which windows can be used as exits. Few buses have any information on the outside that would help emergency personnel or others to gain access. There should also be a notice on the outside to indicate the existence of escape hatches in the roof. In fact, some manufacturers should re-design these hatches so that they can be easily opened from the outside. TRANSPEC already makes such a hatch.

Instructions for opening the doors should be placed on the outside of vehicles. Figure 4-10 shows an outside door opener that is not indicated in any way. The lack of indication is, of course, intentional, but some compromise between the safety of passengers and the security of the bus must be reached.

The last suggestion is that manufacturers produce a reasonably inexpensive fire suppression system for engine compartments. Several exist, but they need to be improved.

Emergency Forces. Emergency forces need devices to keep open those windows that function as emergency exists while emergency medical personnel and supplies enter the bus and injured passengers, some on backboards, are removed. Some sort of expandable pole can be used and needs to be made available at low cost to emergency forces. Rescuers also need a short ladder to reach the windows from the ground if the bus is upright or to reach the side of an overturned bus like the one shown in Figure 4-16. It must be decided whether such ladders should be carried on the vehicle during revenue service.

Emergency personnel should be made aware that a steel body-on-chassis small bus is quite rigid and that power tools may be required to out it open, although an aluminum or fiberglas shell may be easily penetrated with a standard fire ax and crowbar.

Emergency personnel should be creative in their responses to emergencies. For example, this author witnessed an accident simulation that included an actor pretending to have a spinal injury. The emergency medical technicians struggled for quite some time trying to place a canvas-and-stave spinal immobilization device on the victim. In reality, the victim probably would have suffered a great deal during this struggle. He was however, already in a contoured device, the seat, and it would have been more effective to strap him to the seat and to remove this seat from the vehicle.

The sharing of technology associated with the crashworthiness of buses and of techniques for rescue from buses is to be encouraged. A formal program organized by APTA may be the best way to distribute the cost burden of new developments among all operators.

4.3.2 Standard Operating Procedures for Evacuation and Rescue

The standard operating procedures for responding to an automobile accident can be only partially effective in response to a bus accident. For body-on-chassis small buses, an effective standard operating procedure must also include finding out the name of the operating agency, whether the bus has rolled over, and the number of occupants. For any kind of serious bus accident, it will probably be necessary to dispatch a large contingent of rescue personnel and emergency medical technicians along with an adequate number of ambulances.

The ambulatory elderly have been carried on buses for years and, indeed, in many systems have been the core of the ridership. Hence, they have been considered regular passengers, but use of transit by the non- or restricted-ambulatory is relatively recent and has not uniformly spread across the industry. The largest carrier with the most experience is Metro-Seattle. Table 4-7 is taken from their operators' manual and shows the various procedures recommended for evacuating wheelchair passengers.

One area of transportation where evacuation procedures are specified and training required is school buses. Generally, at least one evacuation exercise is required annually. Although this type of transportation service cannot be directly compared with transit operations, a review was made of the 1981 Guidelines for Bus Evacuation (35), prepared by the California State Department of Education, for possible applicability to transit buses. (California has pioneered in all forms of public transportation for the disabled.) The guidelines consist of evacuation procedures that are as standardized as possible and vary only with the types of exit available. The seven types of exit or combinations of exits are:

- o front door;
- o rear door;
- o side (left door);
- o rear and side doors;
- o rear, side (left) and front doors;
- o front and side (left) doors; and
- o left (rear) door (differs from side left door, which is ahead of the rear wheels rather than behind them, is much nearer to the center of the passenger compartment, and is more typical of trnsit vehicles).

Figure 4-24 reproduces a plan from the guidelines. Note that the window emergency exits are not mentioned. However, the guide-lines do state that training should include instruction in the use of window and windshield exits. These evacuation procedures are to be used in the event of specific problems with the bus. Two examples are presented: a front engine or dashboard fire requiring evacuation via the side (left) door, the rear and side doors, and the rear, side (left), and front doors; and a rear engine compartment fire requiring

TABLE 4-7. METRO-SEATTLE EMERGENCY PROCEDURES FOR ACCESSIBLE SERVICE

EMERGENCY RAMPS

In the event of lift breakdowns, stranded wheelchair passengers will be deboarded by means of the wooden emergency ramps located in the maintenance departments of all five operating bases. Ramps will not be used to board lift passengers; these passengers must wait until the breakdown has been corrected or until the next designated accessible service is available.

GENERAL EMERGENCY PROCEDURE

In the event an accessible coach is involved in an accident and there is no imminent danger resulting, do not remove wheelchair passengers, if the wheelchair passenger is injured, wait for Aid Car Personnel to treat and remove the individual.

EXTREME EMERGENCY/WHEELCHAIR EVACUATION

The operator should remove the wheelchair passenger from a coach, only if it is more dangerous to leave the passenger on the coach. Examples of such situations are where the coach is in imminent danger of:

- fire;
- explosion;
- bomb threat;
- traffic hazard; or
- physical peril (i.e., coach perched on a cliff).

In these situations, the operator should deboard the wheelchair passenger using the following methods (listed in order of preference).

- use the lift as per regular instructions. If not at a curb or in a curb lane, the operator should have another person stand on the right side of the coach to halt any traffic which may attempt to pass on that side of the coach. Accompany the wheelchair passenger to a secure location.

- Use the Emergency Ramp as per regular instructions. The ramp should be considered only when time is available for its delivery and use.

- Lift the wheelchair passenger (while still in the chair), with the help of others and carry off the bus through the front door. Use the back door if the front is inaccessible. Always carry the wheelchair off backwards.

TABLE 4-7. METRO-SEATTLE EMERGENCY PROCEDURES FOR ACCESSIBLE SERVICE (Continued)

- Lift the passenger (without the chair) with the help of others and carry off the bus through the front door. Use the back door if the front is inaccessible.

- Lift the impaired passenger, with the help of others, and evacuate through one of the emergency windows.

WHEELCHAIR EVACUATION/NO HELP AVAILABLE

In the event an operator is alone and unable to enlist the help of others, evacuation of a wheelchair passenger is best accomplished by:

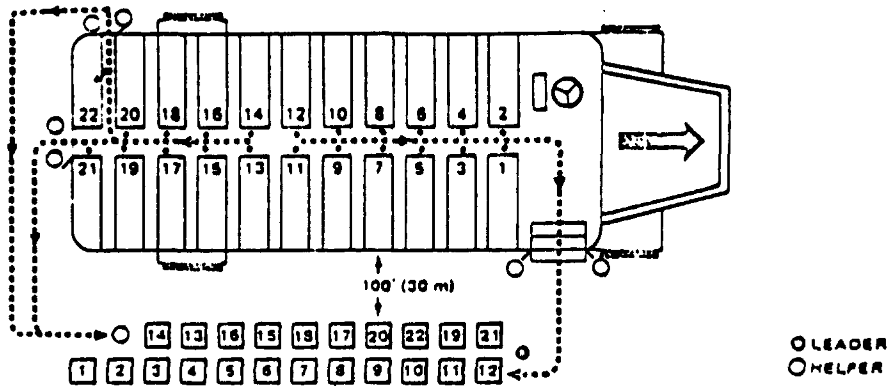
- checking with the passenger for the best way to carry him/her and proceeding accordingly; or

- if the passenger is unconscious, the best carry method is to drape the passenger's arms over the operator's shoulders and, with the passenger facing the operator's back, carry him/her to safety.

EMERGENCY EVACUATION SUMMATION

- Use lift.
- Use emergency ramp,
- Lift wheelchair through doors,
- Lift passenger through doors,
- Lift passenger through window.
- Carry passenger off on back, (when operator alone and no help available).

Rear, Side, and Front Floor-Level Doors Evacuation



Special equipment needed–Two 4' x 6' (1.2 m x 1.8m) gym mats or other suitable material placed on the ground one at the rear door and one at the side door.
Personnel needed–Seven (one leader and six assistants)
Student participation–All students

Appoint six older students, one for each side of the front door, the rear emergency door, and the left side emergency door. Assistants stand on each side of the exit doors with one hand held at shoulder Height, palms up. Students leaving the bus place their hands on those of the assistants for support in jumping to the ground. Assistants DO NOT grasp the jumpers' hands. Appoint one leader to leave by the front door to lead the other students 100 feet (30 m) or 40 paces from the bus. Two assistants should be seated near the rear emergency door, two by the left emergency door, and two assistants and the leader in the right front seat by the front entrance door.

Driver's instructions:

1. Stop the bus in the preselected location on the school grounds away from traffic.
2. Shut off the engine, and secure the parking brake.
3. Place the transmission in first or reverse gear.
4. Remove the ignition key.
5. See that gym mats are placed on the ground in the center of the rear and side emergency doors.
6. Stand, face the children, and get their attention. Open the front door.
7. Give the command: "Rear, Side, and Front Door Emergency Evacuation Drill-Remain Seated."
8. Ask the front first and second assistants to take their positions outside the front entrance door.
9. Walk to the rear door and ask assistant number three to open the rear emergency door, drop the safety chain, and jump out to take a position. Ask assistant number four to jump and take a position.
10. Face left rear emergency door. Ask assistant number five to open the door, drop the safety chain, and jump out to take a position. Ask assistant number six to take a position.
11. Walk to the front of the bus. Ask the leader to leave through the front door and take a position 100 feet (30 m) or 40 paces from the bus. Start with the left front seat and ask those students to leave through the front door, then seat number three, then four, then five. Back down the aisle, releasing students from seats on alternate sides of the bus, until the center of the bus is reached. Ask the rest of the students to stay seated. Walk back to the left side emergency door. Starting at the rear of the bus, ask all remaining students seated on the left side to leave by the left side emergency door. Stand at the left door to control the students and space their jumps so that each student has cleared the mat before allowing the next student to jump.
12. After the students on the left side of the bus have left the bus, turn to the rear door and ask the student closest to the rear door to leave. All remaining students are to leave through the rear emergency door. Again, see that each student has cleared the mat before allowing the following students to jump. Walk to the front and check to ensure that everyone has left the bus. Exit through the front door, and to to the waiting students.

The driver should evaluate the evacuation performance, pointing out improvements needed and commending the students on those activities well done. NOTE: Every precaution must be taken during the drill to prevent injury. If a student does not want to jump because of illness or physical condition (e.g., overweight) or for any other valid reason, the student should not be forced to jump. The student should leave the bus with the driver through the front door and join the other students when the drill is completed.

The purpose of this exercise is not to see how fast the drill can be done; the purpose is to train the students to leave the bus safely and in an orderly manner.

Source: Reference 35.

FIGURE 4-24. GUIDELINES FOR SCHOOL BUS EVACUATION SIMULATION evacuation through the front door, the nearest passengers leaving first. The guidelines also point out the need to maintain the equilibrium of the bus if any part of it is unsupported (for example, hanging over an embankment); to remove those students nearest the danger area first; to leave all personal belongings on the bus to save time; and, if time permits, to have the driver remove the first aid kit and fire extinguisher.

Specific attention is directed towards the disabled in one paragraph that says that drivers and aides should be taught how to:

- release or cut hold-down straps quickly;
- lift and carry students off the bus correctly; and
- remove students using wheelchairs and remove the wheelchairs when possible.

They also recommend that those students in wheelchairs who have use of their hands and arms should be taught how to use a fire extinguisher. In case of fire, these passengers can then protect themselves, if need be, while others are being evacuated.

A point that these guidelines have in common with similar documents is that they assume a major role for the drivers and give little or no consideration to situations in which they are incapacitated by sudden illness or an accident.

Transit operators need to develop standard operating procedures for drivers and dispatchers for responding to bus accidents. They must work with their local emergency forces in the development of procedures that include the special techniques and equipment that are used for elderly and disabled passengers. Once developed, these procedures need to be tested in simulated and actual accidents involving elderly and disabled passengers.

SECTION 5. EVACUATION AND RESCUE BIBLIOGRAPHY

1. Abernathy, C.N., et al. "Effects of Deceleration and Rate of Deceleration on Live Seated Human Subjects." Transportation Research Record. N646, 1977, pp. 12-17.

2. Aldman, B., Brattgard, S., and Hanson, S. Safety in Special Public Transportation. Division for Handicapped Research, Sweden: Gothenburg University, March, 197*1.

3. Alexander, G.H., Conrad, R.E., and Neale, M.R. Determination of the Tradeoffs Between Safety. Weight, and Cost of Possible Improvement to Vehicle Structure and Restraints, Columbus, Ohio:Battelle Laboratories, December 1974, 271 pp.

4. AM General Corporation. A Study of Wheelchair Access to the Current Transit Bus Design. Wayne, MI: AM General Corporation, April 1977,61 pp.

5. American Academy of Orthopedic Surgeons. Emergency Care and Transportation of the Sick and In.lured. 1977.

6. American Public Transit Association. Moving People Safely, Third Edition, 1978.

7. "Another Rail Fire." The Star Ledger. March 17, 1982.

8. APTA 1981 Rapid Transit Conference; Emergency Preparedness Workshop. PATH's Emergency Simulation Exercise. June 10, 1981.

9. "APTA Panel Investigates D.C. Crash." Passenger Transport. N.4, January 22, 1982.

10. Associated Press. "3 Die in Subway Crash after D.C. Derailment." The Philadelphia Inquirer. January 14, 1982.

11. Baehr, Guy T. "Authorities Report 19-Minute Delay in Receiving Alarm on PATH Blaze." The Star Ledger. March 17, 1982.

12. "BART Prepares for Emergencies." Passenger Transport. November 20, 1981.

13. BART (Bav Area Rapid Transit District) Fire/Life Safety Capability Profile.

14. Bay Area Rapid Transit. San Francisco Bay Area Rapid Transit District Emergency Plan. December 1, 1981.

15. Benjamin, D.E. Evacuation and Rescue in Automated Guideway Transit. Volume I; Data Collection. Scenarios, and Evaluation. Dallas, TX:Vought Corporation, December 1979, 84 pp.

16. Benjamin, D.E. Evacuation and Rescue in Automated Guideway Transit, Volume II; Guidebook, Dallas, TX: Vought Corporation, December 1979, 97 pp.

17. Bergeron, J. David. First Responder, Bowie, MD: Robert J. Brady Co., 1982.

18. Blair, William G. "Hundreds Trapped by Fire in PATH Train." The New York Times, March 17, 1982.

19. "Blame Electrical Fault for PATH Terror." New York Post, March 17, 1982.

20. Blethrow, J.G., et al. Emergency Escape of Handicapped Air Travelers, Washington, DC: Federal Aviation Administration, July 1977, 72 pp.

21. Bloom, R.F. Closed Circuit Television in Transit Stations; Application Guidelines, Darien, CT: Dunlap and Associates, Inc., August 1980, 209 pp.

22. Boeing Vertol Co. Act-1; Urban Rapid Rail Vehicle and Systems Program; Engineering Test of Act-1 Vehicle at Transportation Test Center, Washington, DC; Urban Mass Transportation Administration, December 1979, 455 pp.

23. Boeing Vertol Company. Urban Rapid Rail Vehicle and Systems Program, Philadelphia, PA: Surface Transportation Systems Department, July 1974, 125 pp.

24. Booz, Alien Applied Research and Simpson & Curtin. Transbus Operational, Passenger, and Cost Impacts, Washington, DC: Urban Mass Transportation Administration, Contract No. DOT-UT-10008, July 7, 1976.

25. Booz, Alien Applied Research. Fire Accident Report Rohr Transbus Prototype Model R45-WTA102 Urban Coach on Interstate Route 1-17, North of Phoenix, Arizona May 13, 1975, Washington, DC: Urban Mass Transportation Administration, Contract No. DOT-UT-10008, August 1975.

26. Bowman, Mark A. A Uniform Transit Safety Records System for the Commonwealth of Virginia, Virginia Highway and Transportation Research Council, February 1981.

27. Braun, E. Fire Hazard Evaluation of BART Vehicles, Washington, DC: National Bureau of Standards, March 1978, 24 pp.

28. Braun, E. Fire Hazard Evaluation of BART Vehicles, Washington, DC: National Bureau of Standards, Center for Fire Research, Report No. NBSIR-78-1421, March 1978.

29. Braun E. A Fire Hazard Evaluation of the Interior of WMATA Metrorail Cars. Washington, DC: National Bureau of Standards, Center for Fire Research, Report No. NBSIR-75-971, December 1975.

30. Bredemier, Kenneth. "Identity of Plane Crash Hero Remains a Mystery." The Washington Post. January 20, 1982.

31. Brogan, J.D., McKelvey, F.X., Witkowske, J.M., and Dublin, M.D. Equipment and Maintenance Requirements for Light-Weight Accessible Bus Operations. Department of Civil and Sanitary Engineering. Michigan State University, MDOT 79-1686, DOT-TSC-1604. May 31, 1980.

32. Bryan, J.L. Human Behavior in Fire—A Bibliography. Washington, DC: National Bureau of Standards, Center for Fire Research, Report No. NBS-GCR078-138, August 1978.

33. Burgess, John and Bredraeier, Kenneth. "Derailment Probe Finds Dangerous Errors by Metro Employees." The Washington Post. February 26, 1982.

34. Burow, K. and Fials, E. Aspects of Passenger Safety. Technische Univ., 1970 Intern. Automobile Safety Conference Compendium, Monograph HS-009 010.

35. California State Department of Education. 1981 Edition Guidelines for Bus Evacuation and Classroom Instruction in Safe Riding Practices. Sacramento, CA^1981.

36. California State Department of Education. State of California School Bus Driver's Course. Unit VIII. Emergency Procedures. Sacramento, CA, 1981.

37. Cheaney, E.S., Hoses, J.A., Thompson, R.E., and Svehla, R.L. Safety in Urban Mass Transportation; Research Report, Washington, DC: Urban Mass Transportation Administration, March 31, 1976.

38. Cheaney, E.S., Hoses, J.A., Thompson, R.E. and Svehla, R.L. Safety in Urban Transportation; Guidelines Manual and Research Report Summary. Columbus, Ohio: Battelle Columbus Laboratories, Report No. UMTA RI06-0005-751,2, May 1975.

39. Connell, W.M. Safety Priorities in Rail Rapid Transit. Volume 1 - Report. Washington, DC: Transit Development Corporation, Report No. UMTA-OC-06-0091-6-75-1, March 1975, 45 pp.

40. Connell, W.M. Safety Priorities in Rail Rapid Transit. Volume 2 - Exhibits. Washington, DC: Transit Development Corporation, Report No. UMTA-OC-06-0091-75-1, March 1975.

41. Connell, William M., and Green, Fred S. Accident Source Compilation. Final Report. Washington, DC: Transit Development Corporation, Inc., 1975, 26 pp.

42. Conrad, R.E., Alexander, G.H., and Neale, M.R. Determination of the Tradeoffs Between Safety. Weight, and Cost of Possible Improvements to Vehicle Structure and Restraints. Final Report. Columbus, Ohio: Battelle Columbus Labs, 1974, 273 pp.

43. Crain and Associates. Transportation Problems of the Handicapped: Volume I - The Transportation Handicapped Population. Definition and Counts. Washington, DC: U.S. DOT/UMTA, Report No. CA-OG-0092, August 1976.

44. Crain, J.L. "Role of Paratransit In Servicing the Needs of Special Groups." Transportation Research Board Special Report N164. 1976, pp. 183-190.

45. Grain, J.L., et al. Summary Report; 321 (b) Rail Retrofit Evaluation - Light and Commuter Rail Systems. Report No. UMTA-CA-06-0125-80-1, Final Report (Revised), December 1980.

46. Davis, Sol and Peirce, Steve. Van Crashworthiness and Aggressivity Study. Warrendale, PA: SAE Technical Paper 810090, Society of Automotive Engineers, Inc., Contract No. DOT-HS-8-01942, 1981, 27 pp.

47. Demeter, John. "Transportation for All the People." USA. 4, 1i 1977, pp. 6-11.

48. Demetsky, M.J., Hoel, L.A., and Virkler, M.R. "A Transit Station Design Process (Abridgment)". Transportation Research Record. No. 662, 1978, pp. 26-28.

49. Demetsky, M.J., Hoel, L.A., and Virkler, M.R. A Procedural Guide for the Design of Transit Stations and Terminals. Phase I, Charlottesville, Virginia: Virginia Univ., June 1977, 78 pp.

50. Demetsky, M.J., Hoel, L.A., Virkler, M.R. Methodology for the Design of Urban Transportation Interface Facilities. Charlottesville, Virginia: Virginia Univ., Department of Civil Engineering, December 1976, 117 pp.

51. Donate, George. Montreal Metro; Fire Safety. Paper Prepared for Presentation at the National Transportation Safety Board, Washington, DC, July 28-29.

52. Donnelly, R. and Arguelles, J. The Implications of BART's Land Use and Urban Development Impacts for the Transportation Disadvantaged. Berkeley, CA: Metropolitan Transportation Commission, April 1978, 58 pp.

53- Donnelly, R., and Arguelles, J. Implications of BART's Mobility and Accessibility Impacts for the Transportation Disadvantaged. Berkeley, CA: Metropolitan Transportation Commission, April 1978, 93 pp.

54. Duca, Kathleen. "700 PATH Riders Escape Fiery Trap." The News World. March 17, 1982.

55. Edmonds, Richard, Greene, Mel, and Button, Larry. "Blaze Closes PATH." Daily News. March 17, 1982.

56. Federal Emergency Management Agency and U.S. Department of Transportation. On Track to Fire and Life Safety in Rail Rapid Transit; Workshop"Handbook. Washington.DC, August 1982.

57. Fiedler, J. "Elevators At Railway and S-Bahn Stations." Eisenbahntechnische Rundschau. 2£, 4, April 1980, 93 pp.

58. "Fire Study Shows Rail Transit Safe." Passenger Transport. December 18, 1981.

59. Flynn, Lois. Emergency Medical Services; A Bibliography. Washington, DC: National Highway Traffic Safety Administration, Services Division, Report SB-07, 1976.

60. Folsom, Farnham. Extrication and Casualty Handling Techniques. Philadelphia, PA: J.P. Lippincott Company, 1975.

61. Fruin, J.J. "Designing for the Disadvantaged: Optimum Design Considers All Users." ASCE Civil Engineering. 45. 3, March 1975, pp. 65-69.

62. Fucigna, J.T., eleven, A., and Pepler, R.D. Basic Training Program for Emergency Medical Technicians—Ambulance. Concepts and Recommendations. Final Report, Dunlap and Associates, Inc., 1973.

63. Garrard, W.L., Candill, R.J., and Rushfeld, T.L. Crashworthiness and Crash Survivability in Personal Rapid Transit Vehicles. International Conference on PRT, Denver, 1975.

64. Gelick, M.S., and Silver, M.L. Design for the Handicapped in Elevated Transportation Systems. Chicago, IL: Illinois Univ., January 1975, 68 pp.

65. Gordon, Larry. "Terror in a Fiery Tunnel," The Record. March 17, 1982.

66. Grant, Harvey D. Vehicle Rescue. Bowie, MD: Robert J. Brady Co., 1975.

67. Grant, Harvey D. Vehicle Rescue—Instructor's Guide. Bowie, MD: Robert J. Brady Co., 1975.

68. Grant, Harvey D., and Murray, Robert H. Emergency Care. 2nd ed., Bowie, MD: Robert J. Brady Co., 1978~T

69. Hansen, T.B. et al. Assessment of the Inclined Elevator and Its Use in Stockholm. Washington, DC: De Leuw, Gather and Company, 1978, 73 pp.

70. Hathaway, William T. Commonalities in Transportation Fire Safety; Regulations, Research and Development, and Data Bases. Cambridge, MA:Transportation Systems Center, U.S. DOT, Report No. DOT-TSC-OST-80-5, November 1980.

71. Hathaway, William T. Fire Safety in Transit Systems. Presented at Fifth International System Safety Conference, Denver, CO, July 27-31, 1981, Transportation Systems Center, U.S. Department of Transportation.

72. Hathaway, W.T. and Flores, A.L. Identification of the Fire Threat in Urban Transit Vehicles. Washington, DC: Urban Mass Transportation Administration, Report No. UMTA-MA-06-0051-79-4, June 1980.

73. Hathaway, W.T., Flores, A.L., Markos, S.H., Goldberg, M.K., and Dinkes, I.M. Fire Safety in Transit Systems; Fault Tree Analysis. Cambridge, MA: Transportation Systems Center, U.S. DOT, Report No. UM-147-PM-81-51, September 1981.

74. Hathaway, W.T. and Litant, *I.* Assessment of Current U.S. Department of Transportation Fire Safety Efforts. Washington, DC: Urban Mass Transportation Administration, Report No. UMTA-MA-06-005 1-79-4, July 1979.

75. Henderson, William H., Dalney, Raymond, L., and Thomas, David D. Passenger Assistance Techniques: A Training Manual for Vehicle Operators of Systems Transporting the Elderly and Handicapped. Austin, TX: Management Services Associates, Inc., 1977.

76. Hieronimus, K. and Sohaper, D. "Methods and Limits of Computer-Based Crash Simulation." Fortschritt-Beriohte der VDI-Zeitsohriften. No. 31, 1978, pp. 87-104.

77. Hoel, L.A., Demetsky, M.J. and Virkler, M.R. Criteria for Evaluating Alternative Transit Station Designs. Charlottesville, Virginia: Virginia Univ. Research Laboratories for the Engineering Sciences, February 1966, 62 pp.

78. Hoel, L.A., Demetsky, M.J., Virkler, M.R. Criteria for Evaluating Alternative Transit Station Designs. Charlottesville, Virginia; Virginia University, 1976, 62 pp.

79. "Interior Lighting of Public Conveyances-Road and Rail," Journal of the Illuminating Engineering Society. July 1974, pp. 381-396.

80. Jones, G.P. Development of a Safety Program Plan for the Office of Safety and" Product Qualifications, Vol. II, Appendix D, On-Going Research by Mitigation Type, Los Angeles, CA: University of Southern California, Report No. UMTA-CA-06-0105-78-2, September 1977.

81. Kangas, R., et al. Handicapped and Elderly Vertical Movement Assessment Study, Cambridge, MA:Transportation Systems Center, February 1976, 100 pp.

82. Kelly, R.R. PATH'S Emergency Simulation Exercise, Emergency Preparedness Workshop/APTA, June 10, 1981.

83. Ketola, H.N., et al. Bus Design; Concepts and Evaluation, Final Report, UMTA Report No. NY-MTD-18, 1970.

84. Krauss, R.A., and Strother, C.E. The Effect of Vehicle Structure Characteristics on Occupant Restraint Parameters. A Parametric Study, Washington, DC: National Highway Traffic Safety Administration, May 1973, 37 pp.

85. Kremel, Franklin M. "The Vehicle and Crash Survivability." Analogy. No. 11, pp. 12-19

86. LaBelle, D.G. Barrier Collision and Related Impact Sled Tests on Buses in Intercity Services, Proceedings of the Seventh Strapp Car Crash Conference, 1965.

87. Levine, R/. BART and the Handicapped, Berkeley, CA: Metropolitan Transportation Commission, November 1974, 67 pp.

88. Litant, I. "Fire Safety Problems in Ground Mass Transportation," Journal of Fire and Flammability, (J, July 1977, pp. 255-61.

89. Lynton, Stephen J. and Vesey, Tom. "Metro Train Derails; 3 Die," The Washington Post, January 14, 1982.

90. Lynton, Stephen J. and Vesey, Tom. "Human Error Cited in Subway Crash," The Washington Post, January 15, 1982.

91. Lynton, Stephen J. "Subway Probers Focus on Supervisor's Acts," The Washington Post, January 16, 1982.

92. Lynton, Stephen J. "Supervisor Failed to Inspect Metro Train's Wheels." The Washington Post, January 20, 1982.

93. Mateyka, J. Bus Interior Design for Impact Safety, Transbus Report No. TR76-001, 1976.

94. Mateyka, J. Safety Considerations in the Design of New Transit Bus Seats, Proceedings of the Eighteenth Stapp Car Crash Conference, 1974.

95. Mattison, P.O., Palmer, D.W., and Nayak, P.R. A Report on Investigations into Rail Passenger Safety, Washington, DC: Federal Railroad Administration Office of Rail Safety Research, Report No. FRA-ORD-80/65, October 1980.

96. Mclnerney, F.T. The Feasibility of Retrofitting Lifts on Commuter and Light"Rail Vehicles, Final Report No. UMTA-MA-06-0025-80-11, September 1980.

97. Mogielnicki, R., Reter, Stevenson, Keith A., and Willemain, Thomas R. Patient and Bystander Response to Medical Emergencies, Cambridge, MA:Operations Research Center, MIT, July 1975.

98. Montgomery County Emergency Medical Services Council. Comprehensive Plan for the Emergency Medical Services Montgomery County, Pennsylvania.

99. Montgomery County Pennsylvania Civil Defense. Disaster Pre-plan Training Programs. April 30 - May 8, 1977, The County, 1977.

100. "Moorgate Tube Train Disaster." British Medical Journal, 3, 5986, September 1975, pp. 727-730.

101. Morgan, Earl and Larkins, Robert. "Third Fire Hits PATH." The Jersey Journal, March 17, 1982.

102. National Fire Protection Association, Inc. Life Safety Code, NFPA 101, 1981, The Association, Quincy, 1981.

103. National Transportation Safety Board, Bureau of Accident Investigation, Highway Accident Report; Central Texas Bus Lines, Inc., Charter Bus, State Route 7, Near Jasper, Arkansas, June 5, 1980, Washington, DC: National Transportation Safety Board, Report No. NTSB-HAR-81-1, January 21, 1981.

104. National Transportation Safety Board, Bureau of Accident Investigation. Highway Accident Report: D & J Transportation Company, Commuter Bus Run-Off-Roadway, 1-95 Near Triangle, Virginia, February 18, 1981, Washington, DC:National Transportation Safety Board, Report No. NTSB-HAR-81-6, August 25, 1981.

105. National Transportation Safety Board, Bureau of Accident Investigation. Marine Accident Report; Ramming of the Sunshine Skyway Bridge by the Liberian Bulk Carrier Summit Venture, Tampa Bay, Florida, May 9, 1980, Washington, DC: National Transportation Safety Board, Report No. NTSB-MAR-81-3, April 10, 1981.

106. National Transportation Safety Board. Highway Accident Report; Osterkamp Trucking, Inc., Truck/Full Trailer and Dodge Van Collision, U.S. 91 Near Scipioy Utah, Report No. NTSB-HAR-79-1, February 22, 1979.

107. National Transportation Safety Board. Highway Accident Report; Van/Slow-Moving Farm Vehicle Collision, U.S. Route 6/50 Near Delta, Utah, September 12, 1979, Report No. NTSB-HAR-80-2, March 20, 1980.

108. National Transportation Safety Board, Bureau of Accident Investigation. Railroad Accident Report; Rear-End Collision of Two Greater Cleveland Regional Transit Authority Trains, Cleveland, OH, Report No. NTSB-RAR-775, August 18, 1976.

109. National Transportation Safety Board. Railroad Accident Report; Collision of Port Authority of Allegheny County Trolley Car No. 1790 and Bus No. 2413, Pittsburg, PA, Report No. NTSB-RAR-78-5, February 10, 1978.

110. National Transportation Safety Board, Bureau of Plans and Programs. Safety of Multipurpose Vans, Washington, DC, Report No. NTSB/HSS-79/1, March 1979.

111. National Transportation Safety Board, Bureau of Accident Investigation. Highway-Accident Report, Cross-Median, Multiple Vehicle Collision and Fire, Cleveland, OH, Report No. NTSB-HAR-79-7, May 6, 1979.

112. National Transportation Safety Board, Bureau of Accident Investigation. Railroad Accident Report; Derailment of New York City Transit Authority Subway Train, New York, New York, December 12, 1978, Washington, DC: National Transportation Safety Board, Report No. NTSB-RAR-79-8, August 2, 1979.

113. National Transportation Safety Board, Bureau of Accident Investigation. Railroad Accident Report; Head-on Collision of Two Greater Cleveland Regional Transit Authority Trains, Cleveland, Ohio, July 8, 1977, Washington, DC: National Transportation Safety Board, Report No. NTSB-RAR-78-2, February 9, 1978.

114. National Transportation Safety Board, Bureau of Accident Investigation. Railroad Accident Report; Rear End Collision of Two Chicago Transit Authority Trains, Chicago, Illinois, February 4, 1977, Washington, DC: National Transportation Safety Board, Report No. NTSB-RAR-77-10, November 29, 1977.

115. National Transportation Safety Board, Bureau of Accident Investigation. Railroad Accident Report; Rear End Collision of Consolidated Rail Corporation Freight Trains ALPG-2 and APJ-2 Near Roversford, Pennsylvania, October 1, 1979, Washington, DC: National Transportation Safety Board, Report No. NTSB-RAR-80-2, February 14, 1980.

16. National Transportation Safety Board, Bureau of Accident Investigation. Railroad Accident Report: Rear-End Collision of SEPTA-CONRAIL Trains Nos. 406 and 472 on Conrail Tracks. North Wales. Pennsylvania. July 17. 1980. Washington, DC: National Transportation Safety Board, Report No. NTSB-RAR-80-11, December 23, 1980.

117. National Transportation Safety Board, Bureau of Surface Transportation Safety. Railroad Accident Report; Chicago Transit Authority. Collision of Trains No. 104 and No. 315 at Addison Street Station. Chicago. Illinois. January 9, 1976. Washington, DC: National Transportation Safety Board, Report No. NTSB-RAR-76-9, July b, 1976.

118. National Transportation Safety Board, Bureau of Accident Investigation. Special Investigation - Eight Subway Train Fires on New York City Transit Authority with Evacuation of Passengers. Washington, DC: National Transportation Safety Board, Report No. NTSB-SIR-81-5, September 22, 1981.

119. National Transportation Safety Board, Bureau of Surface Transportation Safety. Railroad Accident Report; Collision of the State-of-the-Art Transit Car with a Standing Car. High-speed Ground Test Center. Pueblo. Colorado. August 11. 1973. Washington, DC: National Transportation Safety Board, Report No. NTSB-RAR-74-2, May 1, 1974.

120. National Transportation Safety Board, Bureau of Surface Transportaion Safety. Safety Methodology in Rail Rapid Transit System Development. National Transportation Safety Board, Report No. NTSB-RSS-71-1, June 16, 1971, 28 pp.

121. National Transportation Safety Board, Bureau of Surface Transportation Safety. Special Study of Rail Rapid Transit Safety. National Transportation Safety Board, Report NTSB-RSS-71-1, June 16, 1971, 28 pp.

122. National Transportation Safety Board. Safety Effectiveness Evaluation of Rail Rapid Transit Safety. Report No. NTSB-SEE-81-1, January 1981.

123. National Transportation Safety Board, Bureau of Accident Investigation. Railroad Accident Report Bay Area Rapid Transit District Fire on Train No. 117 and Evacuation of Passengers While in the Transbay Tube. San Francisco. California. January 17. 1979. Washington, DC: National Transportation Safety Board, Report No. NTSB-RAR-79-5, July 1979, 63 pp.

124. National Transportation Safety Board, Bureau of Accident Investigation. Railroad Accident Report; Rear-End Collision of Two Greater Cleveland Regional Transit Authority Trains. Cleveland Ohio. August 18. 1976. Washington, DC: National Transportation Safety Board, August 1977, 20 pp.

125. Ohio State Department of Education, Division of Vocational Education. Emergency Victim Care, 1971.

126. Orne, D., Barak, E., and Fisch, R.F. Design, Test and Development of a Wheelchair Restraint System for Use in Buses, Massachusetts Institute of Technology, 1976 Monograph, 1976, pp. 271-80.

127. Orne, D., Barak, E., Fisch, R.F. "Design, Test, and Development of a Wheelchair Restraint System for Use in Buses," Stapp Car Crash Conference Proceedings, October 1976, pp. 271-302.

128. Peacock, R.D. Fire Safety Guidelines for Vehicles in a Downtown People Mover System, Washington, DC;National Bureau of Standards, January 1979, 56 pp.

129. Philadelphia Fire Department. Addendum No. 1 to Operational Procedure No. 26; Subway and Subway-Elevated Emergency Procedure, The Department, Philadelphia, PA, August 1982.

130. Philadelphia Fire Department. Subway and Subway-Elevated Emergency Procedure, Operational Procedure 26, April 1975.

131. Philadelphia Police Department. Subway and Subway-Elevated Emergency Plan No. 16, The Department, Philadelphia, PA, September 1981.

132. Port Authority Trans-Hudson Corporation. Operation Rescue—An Interagency Simulated Evacuation Drill, November 16, 1980.

133. Port Authority Trans-Hudson Corporation. Special Investigation Report; PATH Car No. 725 Fire, March 16, 1982, The Authority, Jersey City, NJ, May 25, 1982.

134. Port Authority Trans-Hudson Corporation. Special Investigation Report; PATH Car No. 725 Fire, March 16, 1982, Appendix, The Authority, Jersey City, NJ, May 25, 1982.

135. Pulling, Nathaniel H., and Vaillancourt, Donald R. Transverse Air Cushion Restraints for Commuter Vans and Small Buses, Paper Presented at the Annual Meeting of the Transportation Research Board, Washington, DC, January 1982.

136. Rees, W. Dewi. "The Immediate Care of Road Traffic and Tractor Casualties in a Rural Area," Journal of the Royal College of General Practitioners, 15, pp. 115-122.

137. Reinl, H. Effects of Panic Stops on Unsecured Wheelchairs in Transit Buses, CALTRANS Interim Report, UMTA-CA-06-0098, September 1979.

138. Rescue Training Institue. Vehicle Rescue Training Module, Ambler, PA.

139. Rescue Training Institute. Search Procedures Confined and Open Areas/ Ambler, PA.

140. Rescue Training Institute. Vehicle "Rescue" Techniques, Ambler, PA.

141. Rescue Training Institute. Water Rescue Course, Ambler, PA.

142. Rider, M.J., McDermott, M. Jr., and Thompson, J.G.H. Use of Wheelchairs as Vehicle Seats; Current Practices and Recommendations, College Station, TX: Texas A&M Univ., November 1976, 65 pp.

143. Ruegger, H. "The Fire-Extinguishing and Rescue Trains of the Swiss Federal Railways," Glaser Annelen, ZEV, 10, 2, February 1977, pp. 51-57.

144. Saczslski, K.J. Structural Problems Associated with the Prediction of Vehicle Crashworthiness, New York: American Society of Mechanical Engineers, 1973, pp. 87-108.

145. San Francisco Bay Area Rapid Transit District. Emergency Plan, The District, Oakland, CA, December 1, 1981.

146. Schirmer Engineering Corporation, and Rolf Jensen and Associates, Inc. Fire Experience and Exposure in Fixed-Guideway Transit Systems, December 1980.

147. Schneider, Lawrence W. Protection for the Severly Disabled-A New Challenge in Occupant Restraint, Ann Arbor, MI: The Highway Safety Research Institute, Washington, DC: National Institute of Handicapped Research, Department of Education, Contract No. 23-P-59-59227/5-03.

148. Schneider, L.W., and Melvin, J.W. Sled Test Evaluation of a Wheelchair Restraint System for Use by Handicapped Drivers, Ann Arbor, MI: Highway Safety Research Institute, November 1978, 24 pp.

149. Schneider, L.W. Dynamic Testing of Restraint Systems and Tie-Downs For Use with Vehicle Occupants in Powered Wheelchairs, Final Report, Highway Safety Research Institute, April 1981.

150. Schumacher, S.P. and Schumacher, J.B. Training Program for Operation of Emergency Vehicles, INNOVATRIX, Inc., Washington, DC, Report No. DOT-HS-803-669, September 1978.

151. Severy, D.M., Brink, H.M., and Baird, J.D. "School Bus Passenger Protection," SAE Transactions, 76, Section 1.

152. Shanley, J.W. Safety in Mass Transit; A Case Study of Bus Accidents in Washington. DC. Consortium of Universities, Washington, DC, Report No. UMTA-DC-11-0003-74-3, October 1974.

153. Shoemaker, N.L., Ryder, M.O., and DeLeys, N.J. "Automobile Consumer Information Crash Test Program, Vol. 1," Highway Safety Literature. 77. 2, (February 1977 Monograph).

154. Simpson and Curtin Inc. Manual of Transit Operations in Civil Emergencies. Philadelphia, PA: Simpson and Curtin Inc., Report No. UMTA-PA-06-0028-74-1, April 1974, 60 pp.

155. Smith, E.E. Transit Vehicle Material Specification Using Release Rate Tests for Flammability and Smoke. Phase I Report. Columbus, OH:Ohio State University, October 1976, 36 pp.

156. Southern California Association of Governments. Transit Safety and Security; A Design Framework. Los Angeles, CA: Criminal Justice Planning Department, April 1976, 170 pp.

157. Southeastern Pennsylvania Transportation Authority. Emergency Evacuation of Trains: Part No. 1 - Equipment and Procedures. The Authority, Philadelphia, PA, April 15, 1981.

158. Southeastern Pennsylvania Transportation Authority. Emergency Evacuation of Trains; Part No. 2 - Simulation of Procedures with Test Questions. The Authority, Philadelphia, PA, April 15, 1WT.

159. Southeastern Pennsylvania Transportation Authority. Standard Operating Procedures; Emergency Evacuation of Trains. The Authority, Philadelphia, PA.

160. State of New York Senate Committee on Investigations and Taxation. A Report on Safety in the New York City Subway System. October 3, 1981, The Senate, State of New York.

161. Statens Road foer Beagnadsforskrins St Goeranesetan. Road Tunnels and Underground Delivery Roadways. Sweden, 1976, 364 pp.

162. Stewart, C. and Reinl, H. Wheelchair Securement on Buses and Paratransit Vehicles. CALTRANS Interim Report, UMTA-CA-06-0098, February 1980.

163. Stewart, Catherine. Bus Modification to Improve Safety. Comfort, and Human Reliability. Human Factors Society, October T97T:

164. Sussman, E.D., and Winchansky, A.M. Guidelines For The Design and Evaluation of Human Factors Aspects of Automated Guideway.

165. Sutton, Chuck. "19-Minute Delay in Fire Report." The Dispatch. Hudson/Bergen Counties. NJ. March 18, 1982.

166. Sutton, Chuck. "PATH Fire Strands Hundreds." The Dispatch. Hudson/Bergen Counties. NJ. March 17, 1982.

167. Transit Systems. Cambridge: Transportation Systems Center, March 1979, 197 pp.

168. Takita, T. "Research on Prevention of Train Fire." Rail International. 8, 7/8, July 1977, pp. 395-406.

169. Tanaka, H., and Takaoka, S. "Lighting Effect in the Smoke of Tunnel Fire." Railway Technical Research Institute. 15, 2, Quarterly Report, 1974, pp. 83-84.

170. Tanner, Richard B. Development of Lightweight Crashworthy Vehicle Structures. Minicars,Inc.,1976,12 pp.

171. Teiber, Eli, Matlick, M. and Weingrad, J. "The PATH in Tunnel Fire Drama Hundreds Felled." New York Post. March 16, 1982.

172. Teiber, Eli. "Hero Cops Lead Human Chain to Safety." New York Post. March 16, 1982.

173. "Toronto Stages Disaster to Test Emergency Plan." Passenger Transport. November 27, 1981.

174. Toronto Transit Commission. Subway Emergency Simulationi Sunday. October 18. 1981. Toronto: The Commission, October 1981.

175. Transportation Safety Institute. "Bus Accident Investigation Seminar." Course Notes, January 1982.

176. Transportation Research Board. Transit Station Use By The Handicapped: Vertical Movement Technology; Unpublished Report 14. Washington. DC:Transportation Research Board Publications, April 1980, 68 pp.

177. Transportation Research Board. Planning and Design of Rapid Transit Facilities. Transportation Research Record 662, 1978.

178. U.S. Department of Transportation, Transportation Safety Institute. Bus Accident Investigation Seminar. College Park, MD: Maryland University, January 19-20, 1982.

179. U.S. Department of Transportation, National Highway Traffic Safety Administration. Emergency Medical Services, Crash Victim Extrication Training Course. April 1979.

180. U.S. Department of Transportation, Urban Mass Transportation Administration. Comments of Transit Agencies - Section 321 Rail Retrofit Studies. Washington. DC. March 1980.

181. Urban Mass Transportation Administration. Automated Guideway Transit Technology Program. System Safety and Passenger Security Pro.leot. Darien, CT: Dunlap and Associates, August 1979.

182. Varker, F.A., et al. Small Transit Bus Design and Operations. Report No. DOT-UT-40015, 1975.

183. Weissraan, Dan. "PATH Fire Probed on Response." The Star Ledger. March 18, 1982.

184. Wilson-Hill Associates, Moss Rehabilitation Hospital and M/M Associates. Measurement of Capabilities of Semi-Ambulatory Subjects to Negotiate Barriers Encountered in a Transit Bus Environment; Detailed Test Findings. Washington, DC: U.S. Department of Transportation, March 1982.

185. Wilson, Steve. "Airliner Hits Ice at Boston Field, Skids into Water." The Philadelphia Inquirer. January 24, 1982.

186. Woestendiek, John. "Engine Rams Train, Hurts 26 in Bucks." The Philadelphia Inquirer. March 30, 1982.

187. Wojcik, C.K., and Sandes, L.R., eds. School Bus Seat Restraint and Seat Anchorage Systems. Final Report. California University Institute of Transportation and Traffic, 1972, 208 pp.

188. Port Authority Trans-Hudson Corporation. Operation Rescue II - An Inter-Agency Simulated Emergency Exercise. The Authority, Jersey City, NJ, May 23, 1982.

189. Michaels, R.M., and Weiler, N.S. Transportation Needs of the Mobility Limited. Northeastern Illinois Planning Commission, Evanston, IL, 1974.

190. Grey Advertising, Inc. Summary Report of Data from National Survey of Transportation Handicapped People. Washington, DC: U.S. DOT/UMTA, June 1978.

APPENDIX

LISTS OF AGENCIES/INDIVIDUALS CONTACTED

TABLE A-1. TRANSIT OPERATORS CONTACTED

1. L. William Breiner
Superintendent of Operations
Bay Area Rapid Transit District
800 Madison Street
Oakland, CA 94607
(415) 465-4100

2. Harry Mave
Director of Insurance and Safety
Bi-State Development Agency
707 N. 1st Street
St. Louis, MO 63102
(314) 982-1420

3. Erwin James
Bi-State Development Agency
411 N. 7th Street
St. Louis, MO
(314) 982-1400

4. Glenn Gwinn
Transportation Superintendent
Bloomington-Normal Public Transit System
104 East Oakland Avenue
Bloomington, IL 61701
(309) 828-9833

5. John Atkinson
Communications Manager
Robert D. Faulkner
Superintendent of Maintenance
Capitol Trailways (of Pennsylvania)
P. O. Box 3353
1061 South Cameron Street
Harrisburg, PA 17105
(717) 233-7673

6. Roger A. Thompkins
Educational Training Officer
City of Miami
Bureau of Fire Prevention
Office of the Fire Marshall
P.O. Box 330708
Miami, FL 33133
(305) 579-6307

7. Kathleen McCabe
Planner
Coles County Regional Planning Commission
701 Monroe Avenue
P.O. Box 471
Charleston, IL 61920
(217) 348-0521

8. Mary Phillips
Accounting Manager
Delaware Administration for Specialized Transportation
P.O. Box 1347
Dover, DE 19901
(302) 736-3278

9. J. Short
Eastern Upper Peninsula Transportation Authority
Building 119
Kincheloe, MI 49788
(906) 495-5656

10. Anne Ehrlich
Executive Director
Illinois Public Transit Association
302 South Birch Street
Urbana, IL 61801
(217) 367-5825

11. Pam Hunt
President
Iowa Public Transportation Association
c/o Ottumwa Transit Authority
105 East Third Street
Ottumwa, IA 52501
(515) 683-0695

12. Gerry Mallacit
Metropolitan Transit Commission
801 American Center Building
St. Paul, MN 55161
(612) 827-4071 Ext. 614

TABLE A-l. TRANSIT OPERATORS CONTACTED (CONTINUED)

13. Charles E. Cox
Supervisor of Operations Control
Metro-Seattle
Exchange Building
821 Second Avenue
Seattle, WA 98104
(206) 447-6823

14. George Donato
Director, Engineering Department
Montreal Urban Community Transit Commission
159 W. St. Antoine Street
Montreal, Canada H2Z1H3
(514) 877-3934

15. Santo Radice
Administrative Safety Office
New York City Transit Authority
370 J Street
Brooklyn, NY 11201
(212) 330-4448

16. Frank Hill
Director
North Georgia Community Action Agency
P.O. Box 530
Jasper, GA 30043
(404) 692-5644

17. Robert K. Tice
Executive Director
Linda Yeager
Operations Manager
Kathy Baurichter
Operations Assistant
OATS, INC. (Older Adults Transportation Service)
601 Business Loop 70 West
Parkade Plaza
Columbia, MO 65201
(314) 443-4516

18. George Cancro
Port Authority Trans-Hudson Corporation
One PATH Plaza
Jersey City, NJ 07306
(201) 963-2621

19. Prank J. Scipione
Deputy Chief
Philadelphia Fire Department
Fire Administration Building
34th and Spring Garden Streets
Philadelphia, PA 19123
(215) 686-4735

20. Rose Harr
Regional Transit Authority
Box 1615
Spencer, IA 51301
(712) 262-7920

21. Sandy Rowell/John Nardini
SIEDA/Regional Planning Commission
708 E. Main Street
Ottumwa, IA 52501
(515) 684-6578

22. Michael Dewey
Manager, Small Bus Operations
Southeastern Michigan Transportation Authority
600 Woodward Avenue
Detroit, MI 48226
(313) 256-8641

23. Thomas McCann
Southeastern Pennsylvania Transportation Authority
130 South Ninth Street
The Edison Building
Philadelphia, PA 19107
(215) 574-7910

24. Michael Audino
Southwest Iowa Planning Council
18 West 6th Street
Atlantic, IA 50022
(712) 243-4196

TABLE A-l. TRANSIT OPERATORS CONTACTED (CONCLUDED)

25. Nelson Chanfrau
Safety Engineer
Risk Management Division
The Port Authority of New York & New Jersey
One PATH Plaza
4th Floor
Jersey City, NJ 07306
(201) 963-7154
(212) 466-7000 Ext. 183-7154

26. Lawrence M. Engleman
Fire Protection Coordinator
Washington Metropolitan Area Transit Authority
600 Fifth Street, N.W.
Washington, D.C. 20001
(202) 637-2563

27. Glenn LeMaster
Director
TRANSVAC
680 Haish Boulevard
Suite 300
DeKalb, IL 60115
(815) 758-0818

28. Joe Petrocelli
Westchester County DOT
County Office Building
White Plains, NY 10601
(914) 682-7941

29. Susan Orkin
Director
Montgomery County Paratransit Association, Inc.
570 West DeKalb Pike, Suite 2
King of Prussia, PA 19406

30. Don Chapman
City Coach Lines, Inc.
3733 University Boulevard, W.
SQite 212
Jacksonville, FL 32217
(904) 737-7722

31. Robert W. Bauer
Executive Director
Valley Association for Specialized Transportation
520 E. Broad Street
Bethlehem, PA 18018
(215) 685-7832

TABLE A-2. STATE DEPARTMENTS OF TRANSPORTATION CONTACTED

1. Jim Moore
   Claims Officer
   California Department of Transportation
   Post Office Box 2107
   Reading, CA 96099
   (916) 246-6410

2. Talmadge M. LeGrande
   Director, Highway Safety Division
   Department of Highways & Public Transit
   Drawer 191
   Columbia, SC 29202
   (803) 758-8975

3. Wayne Jackson
   Georgia Department of Transportation
   #2 Capital Square
   Atlanta, GA 30334
   (404) 656-6000

4. Susan Young
   Director
   Stephen Schindel
   Division of Public Transit
   Illinois Department of Transportation
   300 N. State Street, Room 1002
   Chicago, IL 60610
   (312) 793-2111

5. Vertis Park
   Superintendent of Safety/Training
   Mass Transit Administration
   Maryland Department of Transportation
   109 East Redwood Street
   Baltimore, MD 21202
   (301) 539-6281 EXT. 243

6. Gary Teachworth
   UPTRANS-Bus Transit Division
   Michigan Department of Transportation
   Post Office Box 30050
   Lansing, MI 48909
   (517) 373-7645

7. Don Hubert
   Minnesota Department of Transportation
   139 E. 12th Street
   St. Paul, MN 55101
   (612) 296-0321

8. Donna Alien
   Projects Manager
   Office of Transit Admin.
   Minnesota Dept. of Transportation
   Transportation Building
   St. Paul, MN 55101
   (612) 296-7052

TABLE A-3. EQUIPMENT MANUFACTURERS CONTACTED

1. Barbara Caldwell
American Coach Sales
16133 Ventura Boulevard
Suite 850
Enoino, CA 91436
(213) 906-1222

2. Bill Coleman
Blue Bird Body Company
City-Bird Division
P.O. Box 937
Fort Valley, GA 31030
(912) 825-2021

3. Dick O'Neill
Commercial Sales Manager
Carpenter Body Works, Inc.
Mitchell, IN 47446
(812) 849-3131

4. Duane Wiechman
Chance Manufacturing Co., Inc.
Sales Office
4219 Irving
Wichita, KS 67209
(316) 942-7411

5. Bill Shipman
John Merrill
Coach and Equipment Sales Corporation
P.O. Box 36
Penn Yan, NY 14527
(315) 536-2321

6. Vie Willems
Collins Industriers
P.O. Box 48
Hutchinson, KS 67501
(316) 663-4441

7. H. A. Hughes
Marketing Manager
CSE Corporation
600 Seco Road
Monroeville, PA 15146
(412) 856-9200

8. David Egen
President
Egen Polymatio Corporation
17 East 67th Street
New York, NY 10021
(212) 734-6222

9. Keith Rodaway
Chief Designer
Everest and Jennings, Inc.
1803 Pontius Avenue
Los Angeles, CA

10. Roger Smith
Sales and Marketing Manager
FLXETTE
Manufacturing Division
P.O. Box 410
Evergreen, AL 36401
(205) 578-1820

11. Barbara Miranda
Service Secretary
Gillig Corporation
P.O. Box 3008
Hayward, ",A 94540
(415) 785-1500

12. John S. Andrews
Manager - Sales Admin.
New Coach Sales
Hausman Bus Sales
505 North Lake Shore Drive
Suite 6106
Chicago, IL 60611
(312) 321-1004

13. Mary Beth Conry
National Coach Corporation
17129 South Kingsview Ave.
Carson, CA 90746
(213) 538-3122

14. Ron Andrews
Vice President
Marketing
Regal Industries
American Shuttle Division
3307 W. Division
Arlington, TX 76102

15. Shelli L. Villano
Sales Representative
Neoplan USA Sales
Rolf Ruppenthal & Assoc, Inc.
627 South Broadway, Suite B
Boulder, CO 80303
(303) 499-4040

TABLE A-3. EQUIPMENT MANUFACTURERS CONTACTED (CONCLUDED)

16. Bob Price
    Sales Representative
    Thomas Built Buses, Inc.
    1408 Courtesy Road
    P.O. Box 2450
    High Point, NC 27261
    (919) 889-4871

17. Loraine Mcllvaine
    Wayne Corporation
    Wayne Transportation Division
    Richmond, IN 47374
    (317) 962-7511

18. John J. Welsh
    Welsh Equipment Company, Inc.
    P.O. Box 587
    Route 51 North
    Perrypolis, PA 15473
    (412) 736-4472

19. Bill Dunstan
    Wide One Corporation
    3051 East La Palma Avenue
    Anaheira, CA 92806
    (714) 630-7933

20. Ronald Lamparter
    Transpec, Inc.
    575 Robbins Drive
    Troy, MI 48084
    (313) 588-8720

21. Don Reed
    Braun Corporation
    P.O. Box 310
    Winamac, IN 46996
    (219) 946-6157

TABLE A-4. POLICE DEPARTMENTS CONTACTED

1. Sally Burke
California Highway Patrol
2985 Johnstonville Road
Susanville, CA 96130
(916) 257-2191

2. Tammy Coleman
City of Raytown Police Department
10000 East 59th Street
Raytown, MD 64133
(816) 353-8137

3. Lt. Gary D. Hill
Director, Traffic Research and Safety Division
Department of Public Safety
(West Virginia State Police)
725 Jefferson Road
South Charleston, WV
(304) 348-6370

4. Rudolph Townsend
Florida Highway Patrol
Department of Highwawy Safety & Motor Vehicles
Accident Records
Neil Kirkman Building
Tallahassee, FL 32301
(904) 488-5017

5. Kentucky State Police
1250 Louisville Road
Frankfort, KY 40601
(502) 227-2221

6. Mrs. Danaman
Maryland State Police
Accident Records Division
1201 Reisterstown Road
Pikesville, MD 21208
(301) 486-3101, Ext. 226

7. Morton B. Solomon
Police Commissioner
Police Headquarters - Philadelphia Police Department
Suite 314, Franklin Square
Philadelphia, PA 19106
(215) MU6-3357

TABLE A-5. NEWSPAPERS AND LIBRARIES CONTACTED

NEWSPAPERS

1. The Cincinnati Enquirer
   617 Vine Street
   Cincinnati, OH 45201
   (513) 721-2700

2. The Manning Times
   Post Office Box 576
   Manning, SC 29102
   (803) 435-8422

LIBRARIES

1. Melanie Gardner
   McKelden Library
   Maryland Room Collection
   (Periodical Room)
   University of Maryland
   College Park, MD 20742
   (301) 454-3035

2. Ms. Raraona Jackson
   Howard County Library
   10375 Little Patuxtent Parkway
   Columbia, MD 21044
   (301) 997-8000

TABLE A-6. INSURANCE AGENTS CONTACTED

1. David Ellis
David Ellis Agency
Suite 207
100 Chestnut Street
Harrisburg, PA 17101
(717) 232-0991

2. Richard J. Tobin
Paul Arnold Associates, Inc.
Commercial Insurance
19 Miorolab Road
Livingston, NJ 07039
(201) 992-5500

TABLE A-7. CONSULTANTS CONTACTED

1. Ray Cavenaugh
   L.T. Klauder and Associates
   Philadelphia National Bank Building
   Philadelphia,, Pennsylvania 19106
   (215) 563-2570

2. Frank Davis
   College of Business Administration
   University of Tennessee
   Knoxville, Tennessee 37916
   (615) 974-5255

3. Peter Schauer and Associates
   Rural Route 2
   Boonville, Missouri 65233
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