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EVACUATION AND RESCUE IN AUTOMATED GUIDEWAY TRANSIT

VOLUME II: GUIDEBOOK

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FINAL REPORT

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16. Abstract
Evacuation and rescue are significant problems in all transportation systems. Serious injuries and loss of life can result from situations in which inadequate means of evacuating and rescuing passengers exist. In conventional transportation systems, transportation personnel can help to evacuate and rescue passengers. AGT systems, however, present a number of special evacuation and rescue problems because they are highly automated systems. Operation of AGT systems with elevated guideways also presents significant problems.

This Guidebook is Volume II of the Final Report on Evacuation and Rescue in Automated Guideway Transit and provides guidelines and other information relative to evacuation and rescue of passengers from AGT systems. Included are:

o Description of the evacuation and rescue problems and solutions as they exist on conventional and AGT systems,

o Discussion of the types of planning that are required to produce satisfactory evacuation and rescue solutions, and

o Recommendations of suitable methods and procedures for AGT evacuation and rescue.

Volume I of the Final Report describes the methodology used in developing the guidelines. The report number of Volume I is UMTA-MA-06-0048-79-2.

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PREFACE

The U.S. Department of Transportation's Urban Mass Transportation Administration (UMTA), in order to examine specific Automated Guideway Transit (AGT) developments and concepts, has undertaken a new program of studies and technology investigations called the Automated Guideway Transit Technology (AGTT) program.

The objective of one segment of the AGTT program, the Systems Safety and Passenger Security Study (SS&PS), is the development of guidelines for the assurance of actual and perceived passenger safety and security in AGT systems. This work has been contracted, through the Transportation Systems Center (TSC), to a team composed of Dunlap and Associates, Inc., the University of Virginia, and the Vought Corporation.

The Systems Safety and Passenger Security (SS&PS) study has involved six related but separate tasks. Three were concerned with the development of guidebooks dealing with 1) passenger security, 2) evacuation and rescue, and 3) passenger safety and convenience services. A fourth task required the development of a passenger value structure model; a fifth involved research on the retention of seated passengers during emergency stops; and a sixth involved the conduct of a joint Government and Industry workshop to review and revise the three guidebooks.

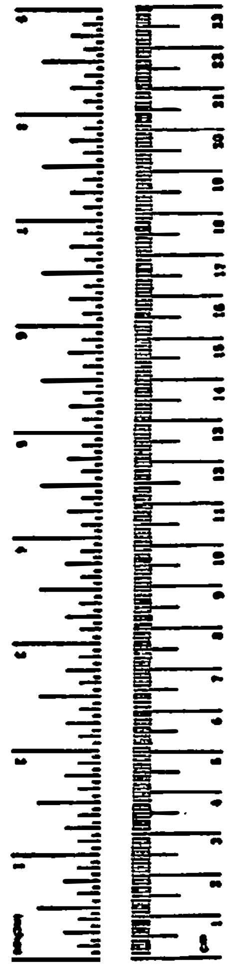
The Evacuation and Rescue task has as its objective the production of a guidebook detailing the most effective methods and procedures for providing evacuation and rescue in AGT systems.

The author wishes to acknowledge the time and cooperation received while visiting various transit properties in the U.S. and Canada. Without the cooperation of transit officials and other experts, completion of this task would have been impossible. The author also wishes to thank the UMTA and TSC technical personnel for their assistance in the performance and documentation of this work, and in particular Duncan MacKinnon and Robert Hoyler, program manager and monitor respectively for UMTA, and Donald Sussman, project monitor for TSC, and his professional associates, Janis Stoklosa and Walter Hawkins.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

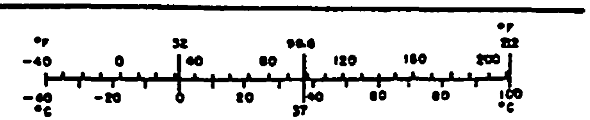


TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Evacuation and rescue of passengers from disabled transit vehicles is a problem common to all fixed guideway transit systems. Automated Guideway Transit (AGT), because of its unmanned nature and unique guideway configurations, presents several new problems related to evacuation and rescue. The purpose of this portion of the Systems Safety and Passenger Security Program was to identify these problems and, where possible, recommend solutions.

While evacuations are not common occurrences, a wide range of evacuation and rescue potential problems and responses exist in today's conventional rapid transit systems. The most severe of these problems include fire or smoke in the subway tunnels and extended service interruptions. Because of the seriousness of the hazards associated with evacuation, considerable effort is spent on trying to get stalled trains to operate prior to giving consideration to deboarding passengers. If passengers are to be deboarded, most transit systems prefer to deboard them directly onto another train, either on an adjacent track or at the front or rear of the stalled train. It is with reluctance that passengers are deboarded onto the track area. The important distinction in conventional transit is that operating personnel are always onboard the train to assist passengers in situations requiring evacuation and rescue.

Evacuation and rescue problems in AGT systems differ from conventional rapid transit systems in that AGT systems are unmanned and utilize more elevated guideway structure. In addition, several AGT technologies use guideway configurations which are unsafe for use as emergency walkways. Because AGT vehicles are unmanned, central control plays an important part in the detection, analysis and response to problems. There are a variety of evacuation and rescue provisions in existing AGT systems, ranging from wide adjacent walkways onto which passengers can evacuate, to knotted ropes which passengers are expected to climb down in the event of serious emergencies.

Because safety of transit passengers must be a primary objective of every AGT system, it requires attention from the earliest stages of the program through its entire operational life. During the formative period of the system when many concepts of system service and route alignment are being considered, basic design decisions are made which may ultimately affect the safety of the system with respect to evacuation and rescue. A safety organization is necessary early in the AGT program to review with respect to evacuation and rescue numerous design considerations, such as guideway elevation, the terrain over which the guideway will pass, the size of the vehicles and support which will be required from emergency response agencies. During specification and contractor selection, attention should be given to the guideway design and the type of electrification used, any vehicle egress constraints which may exist, and general design to minimize hazards. During detail design, construction and test, safety efforts should monitor the design to assure that no undesirable design features or hazards are incorporated into the system design. Prior to initial operation, the safety organization is key in negotiating mutual aid agreements with local emergency response agencies, in formulating evacuation and rescue procedures and in training operating personnel with respect to evacuation and rescue. After the system is open to the public, the safety organization should plan preparedness training drills to keep operating personnel familiar with procedures. Also, any incidents requiring evacuation and rescue should be reviewed to assure that existing procedures are working properly.

Evacuation and rescue techniques can be divided into two classifications depending upon the implicit degree of passenger self-sufficiency during evacuation. The first classification, self-evacuation or rescue, is restricted to those techniques in which passengers are able to egress from the vehicle to a place of safety at will and without assistance from any outside personnel. Self-evacuation and rescue capabilities are desirable for all systems, but their use should be restricted to only those situations in which passenger injury may result if passengers do not exit the vehicle immediately. Three satisfactory techniques exist for providing self-evacuation and rescue capabilities to AGT systems. These include using an adjacent walkway, using the vehicle's guideway as a walkway and providing an emergency egress path to ground level using a device such as an inflatable slide. In contrast, the second classification, assisted evacuation or rescue, relies upon the actions of personnel and/or the use of equipment from outside the vehicle. These techniques are recommended for use in situations in which time is not of critical importance. In order of preference, these techniques include:

1) Moving the vehicle to a station under manual control,

2) Push or pull the disabled vehicle to a station with another vehicle,

3) Transfer passengers into an operational vehicle that has either been pulled along side or up to the end of the disabled vehicle,

4) Assist passengers in walking to a station or another place of safety,

5) Lowering passengers to the ground using truck-mounted platform lifts or articulated booms.

The evaluation portion of this task is documented in Volume I of this Final Report. It will be of most interest to researchers in AGT safety. Volume II is a Guidebook for AGT Evacuation and Rescue and is intended for AGT planners, designers and decision makers.

CHAPTER 1. INTRODUCTION

Automated Guideway Transit (AGT) is a class of transportation in which unmanned vehicles are operated on fixed guideways along an exclusive right-of-way. The descriptive characteristics of AGT vary considerably between systems: vehicle capacities can range from one or two to more than 100 passengers, speeds range from slightly faster than walking to in excess of 50 miles per hour and guideways range from wide, roadway-like configurations to narrow concrete or steel beams.

The technological building blocks of AGT are numerous and exist at various stages of developmental maturity. For example, some AGT systems employ mature railroad control technologies which date back to the late 1800's while other systems utilize the latest in aerospace technology. Most systems rely on conventional wheeled support from under the vehicle, while others have demonstrated the feasibility of air cushion and magnetic levitations. No matter what technologies are involved, combing the technologies into system designs which can provide the traveling public with safe and dependable service is a complex process, with many problem areas. To address these problems, the Federal government has established the Automated Guideway Transit Technology (AGTT) Program.

A. Automated Guideway Transit Technology Program

The AGTT Program was established by the U. S. Department of Transportation to investigate critical problems related to AGT technology. The principle purpose of the AGTT Program is to provide information in the form of service and performance characteristics, specifications and guidelines for use by system planners, designers and government agencies. This information will assist in the making of rational and wise decisions concerning the development and deployment of new AGT systems in various application areas.

In formulating this program, five major projects were identified:

- Systems Operations Studies - To conduct comparative AGT system analysis evaluating the cost, performance and operating characteristics of a number of generic systems in representative urban network configurations; and to develop and document a set of proven computer models allowing designers and planners to perform analysis of potential AGT systems.

- Vehicle Longitudinal Control and Reliability Studies - To develop, design and demonstrate longitudinal control systems; to develop techniques for reliability enhancement; and to study automatic vehicle entrainment and platooning concepts.

- Vehicle Lateral Control and Switching Studies - To develop, design and demonstrate vehicle lateral control systems and vehicle switching systems.

- Guideway and Station Technology Studies - To investigate technologies for implementing guideway, station and power distribution systems with major emphasis on innovative construction techniques such as prefabrication, improved contracting methods and reduction of environmental impact.

- System Safety and Passenger Security Studies - To develop guidelines for the assurance of actual and perceived safety and security in AGT systems.

This Guidebook is a product of the System Safety and Passenger Security Program.

B. Guidebook Organization

This Guidebook is addressed to a diverse audience. It ranges from urban planners who are just beginning to consider an AGT application to engineers, consultants and designers who are intimately familiar with its technology. A glossary and bibliography are included for those who are unfamiliar with the terminology of AGT and the experiences of existing systems.

Numerous organizations, including APTA (American Public Transit Association) and the major transit properties, have developed guidelines, procedures and standards which touch upon the issues of passenger evacuation and rescue. This document is not intended to duplicate the previous work but rather to address primarily those evacuation and rescue problems which are unique to the world of AGT.

The Guidebook's objectives are to provide information to planners, designers, and evaluators as to the most effective methods of providing evacuation and rescue from AGT. It is not intended to be site or technology specific and is, therefore, generalized in some respects. It addresses evacuation and rescue as an integral part of systems design which begins during conceptual development of the system and continues throughout its operating life. It focuses primarily on the provision of evacuation methods which fall outside of the normal extent of emergency municipal services.

The Guidebook is organized into four sections following this Introduction:

- Definition of AGT evacuation and rescue problems.
- Discussion of what consideration of evacuation and rescue is required throughout the life of an AGT system.
- Recommended designs for the provision of evacuation and rescue functions.
- Recommended basic procedures for the performance of evacuation and rescue.

CHAPTER 2. THE EVACUATION AND RESCUE PROBLEM

Evacuation and rescue of passengers from disabled vehicles is a problem common to all fixed guideway transit systems. Guideways or tracks are frequently elevated above the ground or submerged in subway tunnels. Even when they are built at grade, they are virtually always separated from other forms of traffic and the public by fences or other physical barriers. While this separation contributes to the safety of the system, it also poses special problems with respect to evacuation and rescue of passengers during system emergencies. Elevated structures and subways significantly limit the access of normal emergency response agencies such as fire, police and ambulance to these systems. Officials of most existing conventional systems have expended considerable effort in solving these problems and have developed procedures for handling them.

Automated Guideway Transit (AGT) systems present an entirely new set of evacuation and rescue considerations. While the nature of many AGT emergencies will likely be similar to those of conventional transit, the situations are complicated by the absence of onboard personnel and the use of guideway configurations unique to AGT, such as monorails and suspended vehicles.

The purpose of this section is to familiarize the Guidebook user with the evacuation and rescue problem as it exists in conventional transit systems, to examine the differences between conventional and AGT transit, to review the evacuation and rescue characteristics of existing AGT technologies, and to identify some of the variables that should be considered before making design choices relative to evacuation and rescue.

A. Evacuation and Rescue Practices in Conventional Transit

A wide range of evacuation and rescue problems, potential problems and responses to problems exist in today's conventional transit systems such as subways and rapid rail lines. This variety is primarily attributable to variations in the characteristics of the technologies used, the environment into which the technologies have been placed and variations in philosophy of approach among the individual system designers and operators. In examining current practices, we will examine types of evacuation and rescue problems, how the problems are detected, and what actions are initiated to remove passengers to locations of safety.

1. Types of Problems

Discussions with officials at several major transit systems in the United States and Canada have indicated that the problems affecting or compounding evacuation and rescue can be divided into four categories:

- Equipment problems; such as collisions, door failures, derailments, etc., which result in fire, smoke or service interruptions.
- Access problems; such as subways, elevated guideway, over water, fences and in buildings.
- Passenger related problems; such as injuries, illness, handicaps, age (elderly and very young), panic, and trauma.
- Other problems; such as adverse weather (snow, tornados, heavy rains, extreme heat), industrial accidents, traffic accidents, tunnel flooding, and earthquakes.

The problems which have given conventional transit the greatest challenges relative to evacuation and rescue are those involving smoke and fire, particularly when the smoke and fire occur in subway tunnels. While these incidents are not frequent occurrences, transit officials feel they represent the greatest potential for serious injury or loss of life. The enclosed subway environment traps and retains toxic and noxious fumes and their lethal and debilitating effects can rapidly turn a minor fire into a disaster. The sources of the fire and smoke are many, but they often originate from electrical sources, such as the tractive power electrification system. They also may result from equipment failure, collision, arson, and a number of other causes.

Other problems to which subway systems are particularly vulnerable include flooding, cave-ins and the intrusion into the tunnel of flammable or toxic liquids and gases. All of these problems involve an immediate and serious threat to the safety of the passengers and, as such, transit operators feel response times to these emergencies are of crucial importance.

Service interruptions are a problem that is common to the entire spectrum of transit. Interruption of transportation service, for either extended or indeterminant periods of time, results in occasional situations which require removal of passengers from vehicles. These situations may result from power outages such as the 1965 blackout of large portions of the northeastern United States, derailments or equipment failures which block the line for long periods. In the case of power outage, the situations become particularly vexing because the environmental control system (heating, ventilation and air conditioning) normally runs off the primary power system. Thus, when power is lost, heat and air conditioning is also lost and the air soon becomes almost unbearable. Some systems provide emergency ventilation with gasoline or battery-powered fans to help alleviate these problems.

2. Detection of Problems

After the occurrence of a problem that is likely to require evacuation or rescue of passengers from the system, the problem must be detected before its seriousness can be assessed and emergency aid dispatched. The primary means of detecting situations requiring outside aid are onboard transit personnel, transit personnel in stations or along rights-of-way and transit central control personnel. Additionally, passengers and "neighbors" to the system are occasionally the first to report a problem.

Onboard transit personnel (train operators, conductors, and guards) are the principal source of detection of serious problems associated with train operation. To them, the problem is often obvious - the train will not operate, a collision has occurred or smoke is permeating the system. Because of their training and experience with the transit system, vehicle onboard personnel can normally be relied upon to respond to emergency situations in a rational manner and to accurately relay information concerning the nature of the situation to central control.

While most problems that might require emergency responses are detected by train onboard personnel, there are situations in which onboard personnel may be unaware of or unable to respond to a problem. In the past, these situations have included, among others, accidents in front of operating trains, collisions in which onboard personnel were injured or communications equipment rendered inoperative, fires in unoccupied cars, and tunnel flooding. In these situations, the initial detection of problems is often made by system personnel along the rights-of-way or in the stations. These employees are also reliable sources of valid information on which to assess the seriousness of the situation.

Transit central control personnel may also be among the first to be aware of the existence of a problem. Depending upon the sophistication of the equipment utilized on the system, the problem may come to their attention by a number of means, including telephone or radio communications; fire, smoke or heat alarms; malfunction or status sensors; and closed circuit television (CCTV) monitors.

3. Assessment of Problem Severity and Response

Assessment of the severity of problem situations and determination of possible initial responses is universally performed by personnel located at the central control room of the system. The individual responsible is normally the central control supervisor.

The central control supervisor collects information from all of the detection sources identified in the preceding section, and based upon experience, judgment and established procedures, assesses the severity of the situation. It is then his responsibility to determine what initial actions should be taken and to see that they are performed. Established written procedures provide considerable guidance on the actions to be taken.

Initial actions which the central control supervisor may order include:

- Calling for aid from the fire department
- Calling for aid from transit and/or municipal police
- Calling for an ambulance
- Dispatching of transit personnel (maintenance and supervisory)
- Removing power from sections of guideway
- Ceasing train operation in vicinity of the problem
- Dispatching another train to pick up stranded passengers
- Dispatching alternate means of transportation, such as buses

- Communicating with vehicles involved

- Communicating with stations involved

True emergencies requiring actual rescue of passengers from dangerous situations are typically performed by fire and police personnel with assistance from transit personnel. Education and training programs exist by which fire and police department personnel are instructed in any special procedures relating to transit system emergencies. Instructions are also given concerning safety equipment available in the transit system and the hazards along the right-of-way. Particular attention is directed at the dangers associated with system electrification.

Less severe emergencies which require routine evacuations are handled differently. Transit officials indicate that the safest place for a passenger is inside the vehicle or station. The many potential hazards that exist along the right-of-way, particularly those associated with system electrification and moving vehicles, make emergency unloading of passengers extremely dangerous without adequate safety precautions and instructions.

Because of the hazards associated with evacuation, transit officials normally expend considerable effort trying to get a stalled train to operate at least into a station before they consider removal of passengers. If their efforts fail and evacuation is necessary, transit officials prefer to push or tow the disabled train with another train or to load passengers directly onto another train rather than walking them from the system. Depending on the system design and the details of the particular situation, another train is either pulled along side or to the front or rear of the disabled train. One system even has a special folding "plank" onboard each vehicle which can be extended from one car to another to provide passengers a walkway to an adjacent train.

In those situations in which transfer to another train is not possible, passengers must be evacuated to the nearest station or point of access by walking. This involves several safety precautions including:

- Dispatch of trained personnel to instruct, guide and assist passengers

- Removal of system electrical power in the vicinity of the evacuation

- Cessation of traffic on adjacent tracks

The path along which this evacuation takes place varies considerably between transit systems and technologies employed. Some subway rail rapid transit systems have walkways in the tunnels along which passengers can walk. These walkways are often quite narrow and difficult for some people to walk along. The situation is often further complicated by equipment mounted onto the tunnel wall and protruding into the walkway. Other systems require passengers to climb down a short ladder and walk along the roadbed. Depending upon the kind of roadbed used by the system, the surface on which the passengers must walk can range from relatively smooth and free of obstacles to very irregular. Where there are long distances between stations, emergency stairways to the street level may be used. These stairways, however, are often quite steep and narrow and do not lend themselves to use in any but the most serious situations.

B. Evacuation and Rescue in Existing AGT Systems

Because AGT is a comparatively new mode of transportation with few installations, there has been considerably less experience with AGT evacuation and rescue than with conventional transit. There is, however, a great deal to be learned from these limited AGT deployments, as the existing systems show a diversity of technologies and attitudes relative to evacuation and rescue of passengers.

This subsection will address the differences that exist between AGT and conventional transit, review the characteristics of several generic AGT technologies and examine the evacuation and rescue problems which have been encountered at existing AGT installations.

1. AGT Definition

The Office of Technology Assessment of the U. S. Congress defines AGT as follows:

> "Automated Guideway Transit (AGT) is a class of transportation systems in which unmanned vehicles are operated on fixed guideways along an exclusive right of way. The capacity of the vehicles ranges from one or two up to 100 passengers. Single units or trains may be operated. Speeds are from 10 to 40 miles per hour. Headway (the time interval between

vehicles moving along a main route) varies from one or two seconds to a minute. There may be a single route or branching and interconnecting lines."[1]

The fundamental concept behind AGT which distinguishes it from conventional transit is the use of automation to perform as many of the functions of transit operation as is possible within the constraints of safety. Trains are automatically controlled and run over electrified guideway and through switches which are automatically set for the proper direction. In stations, fares are collected by automated turnstiles and monitored remotely from central location via closed-circuit television, and automated graphics and announcements indicate the arrival and route of individual trains. Few, if any, AGT personnel are visible to the traveling public during the course of normal system operations.

2. AGT Technologies

Numerous design aspects of AGT systems affect their characteristics with respect to evacuation and rescue. Of particular importance are the vehicle and guideway configuration and the type of guideway electrification system.

a. Vehicle and Guideway Configurations

Generally speaking, there are two basic AGT suspension types - bottom supported and top supported - with numerous variations of each type. Figure 2-1 illustrates these basic suspension types and configurations which are variations of them. It should be noted that for elevated guideway only the supported vehicle with a continuous running surface allows passengers and rescue personnel to safely use the guideway for walking. Several system designs take advantage of this feature and have emergency exits from the vehicle onto the guideway. The other configurations all require additional provisions for emergency egress and access.

b. Guideway Electrification

The configuration of the guideway electrification systems is important to evacuation and rescue because of the hazards it imposes to the safety of the guideway running surface as an evacuation path.

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[1] United States Congress, "Automated Guideway Transit, An Assessment of PRT and Other New Systems," Office of Technology Assessment, June 1975.

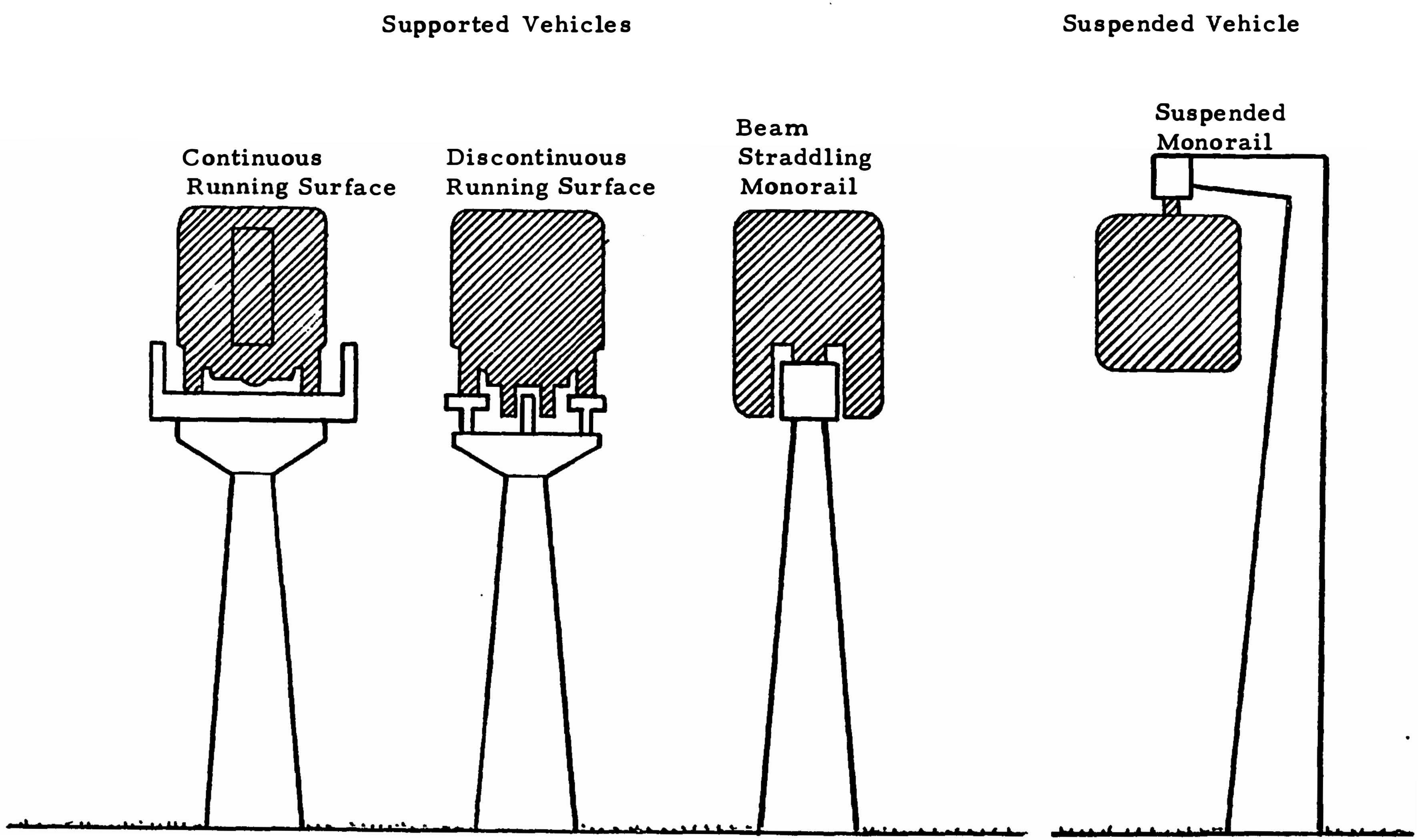


FIGURE 2-1. BASIC AGT VEHICLE/GUIDEWAY CONFIGURATIONS

Most AGT technologies employ electrification systems of sufficient voltage to electrocute anyone coming in contact with the power rails, and so it is necessary to protect passengers using the guideway as an evacuation route. Figure 2-2 illustrates schematically several types of electrification rails commonly used.

Three basic methods have been used in AGT to protect passengers from the power rails:

- Automatic or manual power shutdown actuated by unscheduled opening of vehicle doors.

- Recessing of the power rails into the side of the guideway to reduce the likelihood of passengers coming in contact with them.

- Shielding the rails with an insulating sheath of plastic material or protective metal cover.

3. AGT Installations

Numerous AGT installations exist around the world, but none of them are typical of expected future urban applications. With the exception of the Morgantown People Mover at West Virginia University and the AIRTRANS system at Dallas/ Fort Worth Airport, all of the existing installations are limited in scale with few vehicles and short guideway length. All AGT installations to date have been in the protected environments such as airports, amusement centers, hospitals, university campuses, and test centers. Only recently has serious planning begun on true urban deployment of AGT. It is not surprising, therefore, that there is limited historical information relative to AGT evacuation and rescue.

a. Types of Problems

The problems which require evacuation or rescue of AGT passengers are quite similar to those of conventional transit systems, but with variations in frequency of occurrence due to application and technology differences. For example, only one U. S. AGT installation is located in a subway-type tunnel (SeaTac) while virtually all conventional systems operate in a tunnel along some part of their routes.

Severe winter weather has created situations requiring evacuation of passengers from AGT which are somewhat

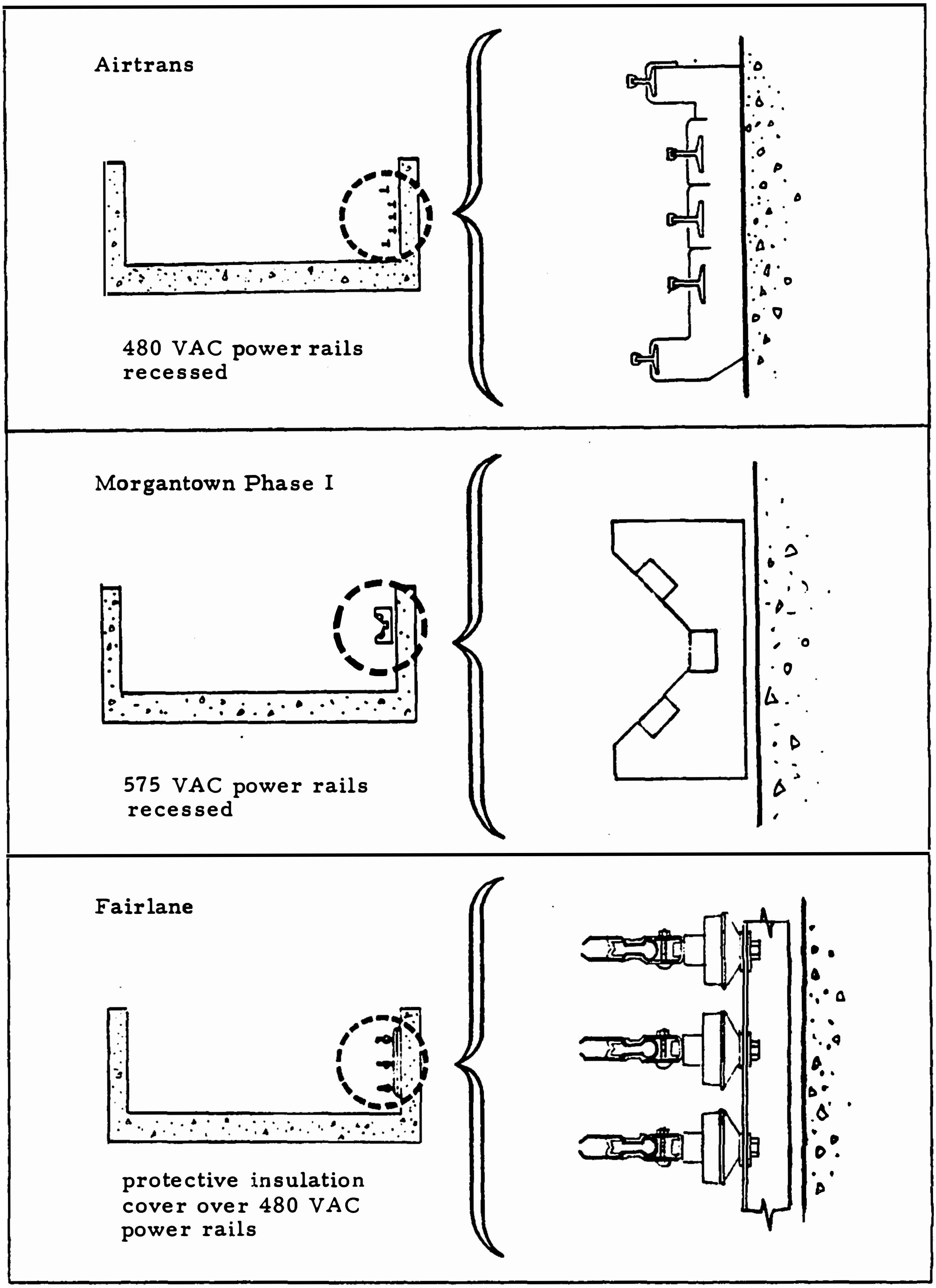


FIGURE 2-2. SCHEMATICS OF TYPICAL POWER RAIL CONFIGURATIONS

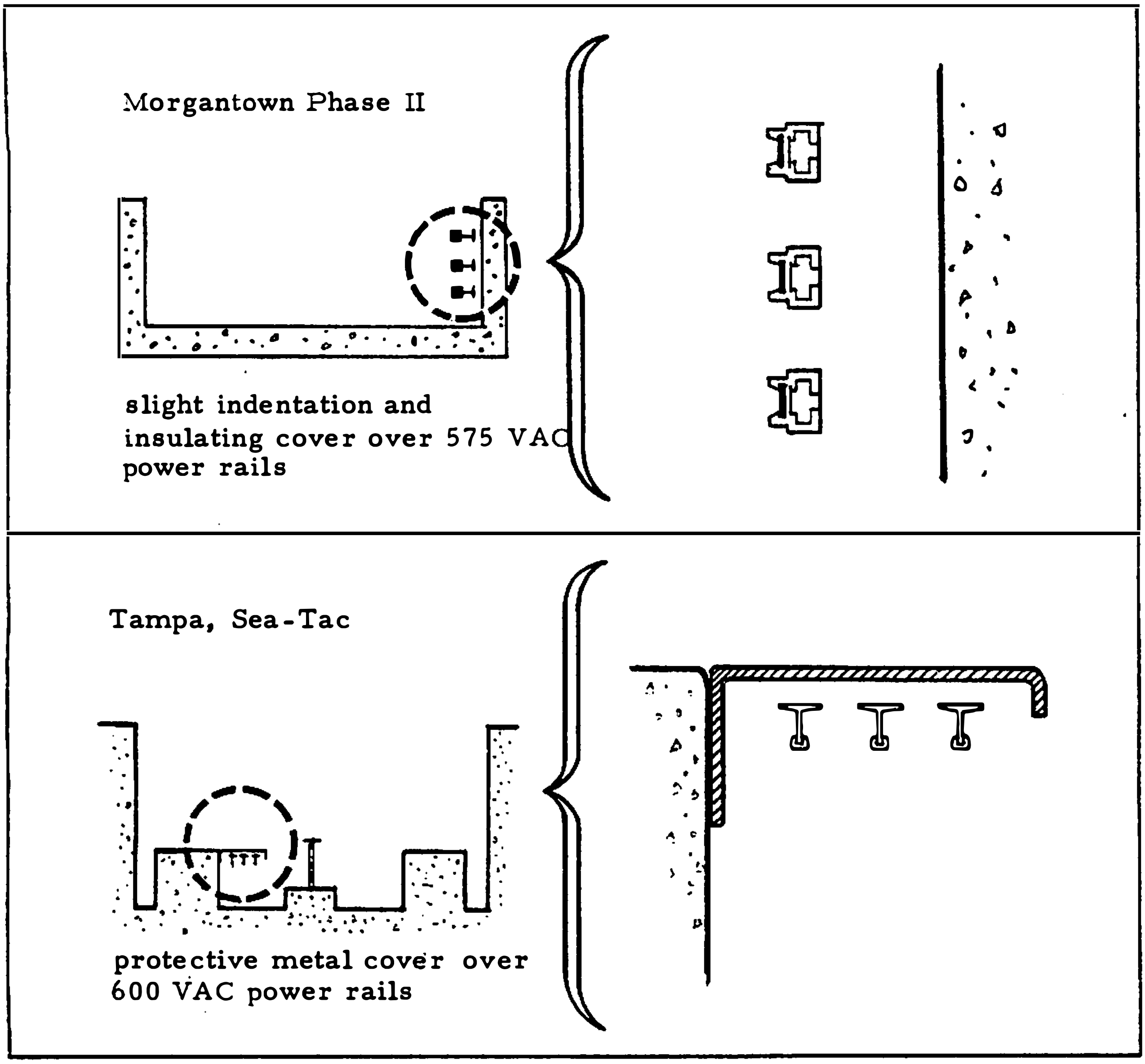


FIGURE 2-2. SCHEMATICS OF TYPICAL POWER RAIL CONFIGURATIONS (CONTINUED)

unique. AGT is susceptible to the effects of ice and snow, for example, problems related to traction and power collection. These problems are particularly evident when snow or freezing rain falls on a system designed for a normally temperate climate. The result is that the system can be incapacitated almost immediately after the onset of severe weather. In one instance, the entire 13-mile AIR-TRANS system was shut down with three minutes of the beginning of a freezing rain shower. Vehicle were simultaneously stranded over the entire system, unable to move because of ice glaze on the traction surface and power and signal rails.

Another type of evacuation and rescue problem which seems to be almost totally restricted to AGT is the unscheduled, unauthorized and unsupervised evacuation of passengers from vehicles. These passenger-initiated evacuations occur when passengers become impatient with interruptions in service and choose to abandon their vehicle and walk to the next station or point of access. The path they follow may be either along side or in the guideway. To date, these problems seem to have been confined to the more advanced AGT systems like MPM and AIRTRANS. Both systems report that the problems diminished greatly as service reliability improved and that presently these problems occur very infrequently.

b. Detection and Assessment of Problems

While central control is an important source of information for problem detection on all transit systems, it is particularly important to AGT systems. Since the AGT systems have no onboard personnel and few, if any, employees stationed along the system's route, central control is the primary detector of system operational problems. AGT system designs compensate for the lack of humans in the system by providing much more complete sensor and diagnostic information to central control personnel than do most conventional systems. Readily available information includes vehicle performance data, equipment status and malfunction information, and the existence and location of any abnormal operating conditions. These data are an adequate source of information on which to base a problem assessment and, in many cases, surpasses data available from any source in conventional transit. Because of the fail-safe nature of their design philosophy, however, AGT systems are occasionally plagued by sensor malfunctions. Fail-safe design methods dictate that the sensors must malfunction into a condition which is known to be safe, and so they often indicate problems which, in reality, do not exist. While these malfunctions do not impair passenger safety, they do often provide central control with problems of sorting actual system anomalies from false reports.

Figure 2-3 shows the central control areas of the D/FW AIRTRANS system. It is similar in concept to others, and it is probably typical of those that will be used with future systems. The left side of the control console is the power system controls which control the network protectors and circuit breakers for the traction electrification system. Toward the center of the console is the system status panel. This panel, in combination with the CRT display, informs the operators of vehicles and subsystem status and identifies any malfunctions that may have occurred. The right side of the board contains the CCTV and communications equipment. On the wall behind the console is the guideway schematic board which shows the location and malfunction status of all vehicles.

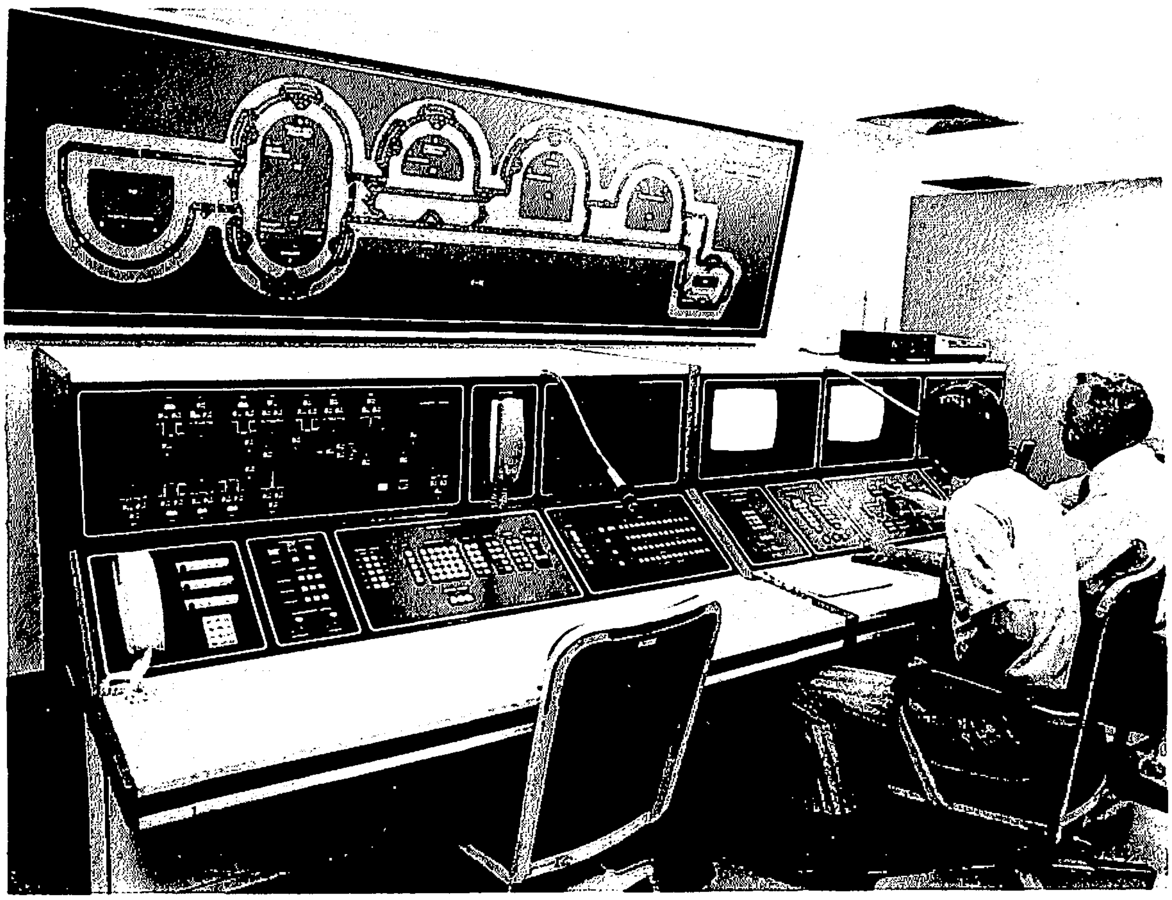


FIGURE 2-3. AIRTRANS CENTRAL CONTROL ROOM

C. Evacuation and Rescue Provisions

The evacuation and rescue provisions on existing AGT systems fall into three categories:

- Passenger self-rescuing techniques
- Rescue by moving vehicles into stations
- Rescue using special devices

1. Passenger Self-Rescuing Techniques

Self-rescuing system provisions are typified by a design which allows evacuation of the vehicle with no aid from the outside. This is normally incorporated by providing doors or panels on the vehicle which can be opened from within. These portals may be either the normal service doors or special emergency exit doors or panels. They may open either onto a walkway adjacent to the guideway or onto the guideway running surface. Most systems incorporate control system sensors which bring the vehicle to an emergency stop when any vehicle door is opened at locations other than stations.

Considerable differences exist in the convenience of using self-rescue provisions on existing AGT systems. Several of the systems which incorporate emergency doors or push out panels which open onto the guideway do not provide easy access to them. Designs often require passengers to climb over seats and large equipment compartments to reach emergency exists and to drop several feet to the guideway surface. Other designs provide unobstructed access to emergency exits but still require considerable agility to safely reach the guideway surface. Some designs have incorporated steps from the vehicle to the guideway surface to facilitate emergency egress. Only the AGT installation at the Tampa Airport seems to accommodate self-rescue of elderly and handicapped passengers. This is accomplished by the provision for emergency egress onto a wide walkway adjacent to the guideway.

After passengers have safely exited the vehicle, there are still two guideway hazards from which they must be protected--moving vehicles on adjacent guideways and the guideway electrification system. To date, this protection has been rather limited. Automatic removal of guideway electrification when passengers may be on the guideway has been used but does not seem to be a totally satisfactory solution. With automatic power shutdown, anomalous signals of an open emergency exit produce major disruptions of system operation and restoration of service may be difficult. Even if automatic power shutdown is incorporated in a system design, it is often possible for passengers to walk only a few feet into an adjacent "hot" power zone. At least one major existing AGT installation has provision for automatic power shutdown but it has disabled it and provides the same function manually from central control.

Other methods of emergency self-rescue have been proposed. These include aviation-type inflatable slides, cloth evacuation chutes, suspended vehicles with floors which could be lowered to the ground and a variety of ladder devices. However, none of these methods of egress have yet been incorporated into revenue-producing AGT systems. These will be discussed in Chapter 4, B. and C.

2. Rescue by Moving Vehicles into Stations

As passengers are safest inside the vehicle, all systems prefer to unload passengers at stations. Some systems, however, do not incorporate features for self-rescue and rely almost entirely on being able to move disabled vehicles into stations after breakdowns. Three approaches have been either used or seriously proposed.

- Move the vehicle to a station under its own power but under manual control of on-board personnel
- Use gravitational forces to coast the vehicle into a station under the supervision of on-board personnel
- Use another on-guideway vehicle to push or tow the disabled vehicle into a station.

Using on-board personnel and manual controls to move disabled vehicles is common to all AGT systems. Some vehicle designs incorporate built-in control panels often behind a removable cover while others require the use of a portable manual control box. Under manual control, vehicles can be moved which are experiencing many types of control systems and mechanical problems. There are, however, many types of problems which do not allow manual control. These include loss of electrical power from the utility, locked axles, and propulsion system failures.

Some systems which have relatively short elevated guideway lengths do not provide for self-rescue on the elevated guideway. To reduce the evacuation problem, they have incorporated grades into the guideway which under many conditions allow vehicles to coast into stations or other areas where passengers can safely disembark. This procedure can only be performed safely with a manual control operator onboard the vehicle and is subject to many of the limitations of manual control. This procedure can only be effective when the rolling resistance of the vehicle can be made less than the longitudinal component of the gravitational forces acting upon the vehicle.

While the use of a serviceable train to push or tow a disabled train loaded with passengers is a fairly common rapid transit practice, it has not yet become popular in AGT. The reason for this is a combination of the inconvenience associated with the pushing or coupling operation and the ability of system designers to meet the system specifications for evacuation and failure management using other techniques. With most of the existing systems which can operate in multiple vehicle trains, the coupling of vehicles together is a difficult and time consuming task.

The use of guideway adaptations of gasoline-powered jeeps and industrial-type tow vehicles is more common. When fitted with guidewheels, couplers and any necessary fixtures for control system presence detection, these tow vehicles can enter the guideway to retrieve malfunctioning vehicles and tow them either to a station, siding or maintenance area for repairs. These vehicles are not normally used for passenger evacuation because of the length of time required to dispatch a tow vehicle.

3. Rescue Using Special Devices

In situations which do not allow evacuation of passengers along the guideway and in which movement of the disabled train under manual control is not possible, passenger evacuation problems require other solutions. In the past, these solutions have taken two forms:

- Transfer passengers from the disabled vehicle into a serviceable vehicle
- Transfer passengers to ground level using special devices

Transfer of passengers between disabled and serviceable vehicle is not a commonly used technique in AGT but has been demonstrated at a European Hospital and at test facilities. Two versions of the technique have been proposed for suspended vehicles. In one version, the serviceable vehicle is moved up behind the disabled vehicle and a platform is extended along the sides of the vehicles. Passengers then walk on the platform from the disabled vehicle into the serviceable vehicle. The serviceable vehicle may be either of normal design or a special rescue configuration.

The second version of the technique calls for vehicles with emergency end doors. In this technique, the serviceable vehicle approaches the disabled vehicle in much the same fashion as before. Upon contact, passengers are evacuated out the end doors of the disabled vehicle across a portable gangplank directly into the functional vehicle.

Transfer of passengers to the ground from elevated guideways potentially may use many types of devices. Devices which have been used in previous systems include:

- Articulated booms (cherry-pickers)
- Ladders
- Knotted hemp rope

Of these, the knotted rope used on an early suspended system (Jetrail) was totally unsatisfactory because of the difficulty and danger associated with its use and was subsequently removed.

4. Summary of Current AGT Practices

Table 2-1 provides a summary of the primary emergency egress strategies employed for nine AGT technologies which are expected to be qualified for deployment in upcoming federally-funded programs.

TABLE 2-1.

EVACUATION METHODS FROM EXISTING AGT INSTALLATIONS

MANUFACTURER	SYSTEM	INSTALLATION	PRIMARY EMERGENCY EGRESS METHODS
Boeing	Morgantown People Mover	West Virginia University, Morgantown, West Virginia	Passengers egress through either vehicle rear windows onto guideway or side doors onto relatively narrow walkway. Vehicle will not stop for emergency egress unless rear window is opened. Exit from rear window requires crawling across equipment compartment and significant drop to guideway. Power is removed automatically or can be removed from central control.
Community Transportation Services	WEDway	Walt Disney World, Orlando, Florida	Passengers exit vehicle onto a walkway adjacent to guideway and walk to station.
DEMAG/MBB	Cabinenlift	Ziegenhain, Germany	A self-propelled specialized rescue cage can be motored out to a stranded vehicle and passengers evacuated into the rescue vehicle using the operational side door.
		Test Facility Hagen, Germany	Vehicles are equipped with extendable platforms which allow passengers to transfer from disabled to operational vehicles.
Ford	ACT (Automatically Controlled Transportation)	Fairlane Shopping Center, Detroit, Michigan and Bradley Airport, Hartford, Connecticut	Passengers egress from either end of the vehicle through top-hinged emergency doors onto guideway surface. To use the doors, passengers must crawl across an equipment compartment and drop to the guideway surface. Power is removed from the guideway when the emergency doors are opened.

TABLE 2-1.

EVACUATION METHODS FROM EXISTING AGT INSTALLATIONS (Continued)

MANUFACTURER	SYSTEM	INSTALLATION	PRIMARY EMERGENCY EGRESS METHODS
Rohr	"P" Series Monotrain	Pearlridge Shopping Center, Honolulu, Hawaii	Guideway is constructed with a continuous grade which allows vehicles to coast into station where passengers exit through normal operation doors.
Universal Mobility	Type II	All installations	No apparent provisions for egress from elevated guideway. Vehicles are towed or moved under manual control into station. Future systems may transfer passengers to gasoline powered emergency vehicle.
Vought	AIRTRANS	Dallas-Ft. Worth Airport, Texas	Passengers egress from either end of vehicle through full height emergency doors. Step-down required from vehicle bumper to guideway surface. Guideway power is removed manually from central control although system originally used automatic power shutdown.
Westinghouse	Transit Expressway	Tampa Airport, Florida SeaTac Airport, Washington Busch Gardens, Williamsburg, Virginia	Vehicle side doors are used to egress onto an adjacent walkway. Guideway power can be removed from central control. On elevated guideway, grades are built in which allow vehicle to coast to at-grade guideway section. Once at grade, side doors are used with step down required.
		South Park, Pittsburgh, Pennsylvania	No provisions are evident except for a short section of experimental emergency walkway with a lowering stairway beneath the walkway.
Otis/TTD	GRT	Duke University, Durham, North Carolina	End windows are hinged and used as emergency exits. Passengers must cross equipment compartment to reach exit. Ledge on vehicle exterior may be used to step down. Automatic power shutdown is incorporated.

CHAPTER 3

EVACUATION AND RESCUE DURING THE LIFE OF THE SYSTEM

Safety of transit passengers must be a primary objective of every AGT system. Safety should not be considered a nuisance item to which consideration will be given later. Rather, it is an item that requires attention from the very earliest planning phase, through specification, design construction and the entire operational life of the system.

This section of the guidebook will identify evacuation and rescue considerations which should be addressed at various times during the life of an AGT project. The transit system's life has been divided into four periods:

- Planning and Preliminary Design
- Specification and Contractor Selection
- Detailed Design, Construction and Test
- Revenue Operations

A. Planning and Preliminary Design

During the formative period of the system, when many concepts of system service and alignment are being considered, basic design decisions are made which may ultimately affect the safety of the system with respect to evacuation and rescue. For this reason, consideration of how to accommodate the problems of system safety must begin in the earliest stages of an AGT system's design if their solutions are to be integrated into the final product.

1. Safety Organization

To be effective in solving the safety problems associated with an AGT system, including those problems related to evacuation and rescue, an integrated approach to assuring safety is required. This integrated approach has two basic parts. First, the concern for safety should transcend all organizational lines with responsibility delegated to those individuals in each area of system design most suitable for accomplishing the task of safety assurance. Ultimately, the responsibility for safety of a particular design must rest upon the individual design decision makers; i.e., the designer or his supervisor.

Often, however, it is not possible from the limited vantage point of individual designers, to comprehend the system-wide impact of many design decisions. For this reason, it is also desirable to identify one or more specialists to oversee the system-wide safety assurance function. The responsibilities of this group include assuring that the design incorporates a satisfactory level of system safety, assuring that no avoidable hazards are introduced into the system design and assuring that all options which concern safety are adequately evaluated prior to an irrevocable decision. To effectively function, this system safety assurance organization must have direct access to the senior decision makers of the project. This may be accomplished either by making the safety assurance function a staff position which reports directly to the senior decision makers or through the formation of a safety review board which includes both safety specialists and senior decision makers. In either case, personnel assigned responsibility for system-wide safety assurance must be respected members of the design team, be capable of making their views known and understood, and responsible for assuring that solutions are implemented to all safety problems.

2. Design Considerations

During the planning and preliminary design phases of the AGT program, certain design decisions are likely to have significant impact on the provision of evacuation and rescue services. These decisions are primarily in the choices of alignment of system, both horizontal and vertical, and in the service concept to be employed such as choices between small vehicles and short headways and larger vehicles and longer headways.

a. Guideway Elevation

Guideway elevation has considerable influence on the accessibility of AGT vehicles to evacuation and rescue personnel. Variations in guideway elevation, when combined with other factors, may result in extreme variations in evacuation and rescue procedures and the equipment required to execute the procedures. Obviously, a system is likely to have a range of guideway elevations.

The range of AGT guideway elevations that exist or have been seriously proposed for previous AGT systems have ranged from 60 feet subterranean (subway) to about 65 feet elevated. For the purpose of evaluating evacuation and rescue methods and procedures, these can be divided into four ranges:

- Subway, all levels
- At grade

- Moderately elevated, 30 feet or less

- High elevated, above 30 feet

Because of construction costs, subways are not commonly proposed for AGT applications. When subways are proposed, they are often adaptations of existing tunnels to a new use as AGT right-of-way.

Evacuation and rescue of passengers from AGT vehicles in subways poses all the problems of similar operations from conventional subway systems. Among these are limited numbers of tunnel access points, entrapment of smoke, fumes and heat, and lack of natural light and ventilation. Because of these problems, specialized procedures and equipment are required for evacuation and rescue of passengers from subway tunnels and provisions for these must be considered in the early stages of system design. Included are provisions for:

- ventilation

- emergency walkways

- emergency exits to ground level

- design features to reduce flammability and smoke toxicity

- emergency lighting.

At-grade guideways run along the surface of the ground, on embankments or in man-made channels cut into the ground. Since AGT systems are by definition grade-separated from other modes, at-grade guideway is used most commonly in newly developed areas where problems associated with existing streets are not severe.

Because it is located on the surface, an at-grade guideway typically is the most accessible of the guideway elevation types to evacuation and rescue personnel. Since access is not constrained, except possibly by fences, no special equipment is normally required to reach the system. Additionally, passengers have available to them numerous paths of egress once they leave the vehicle. This is the easiest type of guideway for which to design for evacuation and rescue. At-grade guideway does have associated with it some related problems, particularly in its susceptibility to vandalism. Provision of an egress route out of the system for passengers during emergencies will often result in a route into the system for unauthorized persons, dogs, cats and other animals. This could also result in a vandalism problem.

Two height ranges of elevated guideway have been identified here because of the differences in difficulty of providing evacuation and rescue capability from them. Thirty feet was selected as the limit between moderate and high guideway elevations because it represents the approximate upper limits of many ladder and lift truck apparatus. For guideways heights above 30 feet in which no walkways are provided, specialized equipment is likely to be required to provide access of evacuation and rescue personnel to the vehicles and guideway. During planning and preliminary design, the use of very high guideways may seem to eliminate many alignment problems. It is essential, however, that early consideration must be given to the safety problems which are created.

b. Terrain/Geography

In addition to guideway elevation, the physical features in the vicinity of an AGT system will have considerable effect on the accessibility of the system to evacuation and rescue personnel. Urban geographic considerations are particularly important when determining response time of emergency personnel to various locations within the system and in assessing what type of equipment is required. Public roadways may not provide adequate access to all points along the system's route. If public roadways do exist along the route, consideration should be given to how various degrees of congestion may hinder their effectiveness.

Four types of terrain and geographical impacts on system accessibility to rescue personnel and equipment can be identified.

- virtually inaccessible to conventional vehicles
- accessible over land
- accessible by improved roads
- accessible by public roads, which may be congested.

While installations of AGT systems at locations in which portions of the system are inaccessible by conventional land-borne vehicles have not often been proposed, they have at least occasionally been considered. Typically, these applications call for the system to cross a body of water such as a river, saltwater shipping channel or bay. If rescuers at these systems are to access the guideway from the surface, specialized rescue equipment would be required. These problems must be fully considered before making any irrevocable decisions concerning alignment.

Most of the systems proposed have had paved roads which could be used for emergency access running along virtually their entire length. Where these roads are public thoroughfares, consideration must be given to problems of private vehicle congestion. This problem could be especially taxing after major or "spectacular" accidents because of the large numbers of onlookers who would be attracted and the traffic congestion which they would generate.

c. Passenger Group Size

One of the most basic decisions which is made during the preliminary planning stages of an AGT system deployment has to do with the type of service which the system is to provide. Past proposals for AGT systems have ranged from personal rapid transit (PRT) systems, which would provide private, on-demand transit using many small (two to nine passenger) vehicles operating on short headways, to large vehicles, capable of carrying in excess of 100 passengers operating similarly to existing rapid rail systems. These variations in vehicle sizes may affect the evacuation and rescue provisions required since some techniques are capable of handling only a few passengers per minute while others can safely accommodate even very large groups of passengers. These variations should be considered to assure that there will be no serious impact on system design.

3. Emergency Response Agencies

To assure the support that will be required from emergency response agencies after system operations begin, plans need to be coordinated with these agencies beginning early in the program. For this reason, it is desirable to contact officials from local fire, police and emergency medical organizations during the preliminary design phase and to advise them of plans for the system and any support which they will be expected to provide when the system becomes operational. As fire, police and emergency medical personnal are experienced professionals, working in disciplines which overlap working with evacuation and rescue, they are well qualified to review preliminary evacuation and rescue plans and to offer valuable suggestions as to how they may be improved. Their assistance should be sought. Particular attention should be given to any special communications equipment which may be required such as direct telephone lines and radio relay devices (repeaters).

During this phase of the program, communications should also take place with the appropriate organization to determine what impacts local codes may have on system designs. If major problems are encountered, the use of code waivers should be investigated. Discussions and negotiations performed in the early phases of the program can reduce the likelihood of schedule disrupting conflicts later.

B. Specification and Contractor Selection

After preliminary planning and design efforts are complete and a concept has been selected, the next step in the transit system procurement process involves the production of a series of system specifications and the selection of contractors to supply the required equipment. Consideration of safety, including evacuation and rescue, is a particularly important part of this phase of the program as several serious issues must be addressed. The major questions which will be confronted during this phase is concerned with the type and extent of evacuation and rescue provisions to be required.

1. Types of Emergencies

Situations requiring evacuation and rescue of passengers from AGT vehicles will occur on all systems and therefore must be addressed in the specifications for the system. In specifying evacuation and rescue provisions for an AGT system, it is necessary that these provisions be capable of accommodating the entire range of situations that are likely to occur with the system. These situations will range from those which have an immediate threat to life and property to those in which only passenger convenience is threatened. Emergency situations which may lead to evacuation or rescue can be categorized into three levels of severity:

- critical emergencies with continuing threat of passenger injury
- critical emergencies without threat of further passenger injury
- non-critical emergencies.

Critical emergencies are the situations which all transit properties fear. They are often the result of the failure of some critical system component or human error. In all cases, they potentially involve human injuries. For the purpose of determining evacuation and rescue requirements, it is important to differentiate between critical emergencies with continuing threat to passengers from those situations which have been stabilized. Fire or smoke onboard a vehicle is an example of an emergency with a continuing threat to life or property. It is categorized as such because further injury to passengers is possible as long as the fire and smoke persist. The first priority is removal of passengers from the hazardous situation to a location of safety. Time is of essential importance as continued exposure to the hazardous environment can result in serious injury or death to passengers. These critical emergencies generate the need for passengers to be able to egress from the vehicle to a place of safety without outside assistance.

A collision without fire, a catastrophic guideway failure or brake failure with subsequent rapid deceleration are all examples of critical emergencies which have stabilized and no longer threaten further passenger injuries. These situations are characterized by the fact that the majority of injuries sustained during the accident occur at the time of impact, guideway collapse or deceleration. Further injuries after the initial accident are less likely. The primary concern in these situations is the provision of medical attention to the injured and the removal of uninjured passengers to places of safety. The response required by these situations include dispatch of emergency medical aid as well as controlled vehicle evacuation.

Non-critical emergencies are situations involving more controlled and leisurely evacuation and rescue of passengers from vehicles. They are characterized by a less critical need for passenger removal from the system. This type of evacuation might be prompted by a power failure, guideway blockage or vehicle failure that cannot be corrected within a reasonable length of time. In AGT, these situations are likely to occur more frequently than do critical emergencies. Because of their controlled nature, they do not normally involve high levels of hazard to the evacuating passengers, but they require timely removal of passengers none the less.

An additional type of situation is likely to occur occasionally which is not an emergency but which can also result in AGT evacuation. These situations are characterized by passengers abandoning vehicles without being directed to do so. The evacuation may occur when passengers become impatient with temporary service delays or vehicle temperatures become uncomfortable after loss of electrical power for ventilation and air conditioning. Uncontrolled evacuation may result in passengers walking along the guideway into an operational area and thereby being exposed to serious hazards. These situations are particularly troublesome to systems operation because restoration of service must be delayed until it is determined that the guideway is free of passengers.

Chapters 4 and 5 of this guidebook will identify suitable techniques and basic procedures which can be used to accommodate these situations.

2. Guideway and Electrification

During the specification phase of the program, decisions will be made concerning guideway and its electrification which will affect evacuation and rescue. As described in the previous section, numerous approaches exist to the design of the guideway and its supply of electrical power and several techniques for prevention of accidental electrical shock have been used. These include recessing high voltage rails, use of insulating and protective shields over power rails and judicious removal of guideway power, either manually or automatically, when passengers are suspected to be on the guideway. The way in which the electrification system is designed and integrated into the guideway is important in determining to what extent passengers in an AGT installation are capable of safe self-rescue.

While existing and proposed AGT guideway configurations span quite a full range of designs, they fall into three basic categories:

- guideway safe for walking with power rails energized
- guideway safe for walking with power off
- guideway unsafe for walking.

Use of an automatic electrical guideway power shutdown system should be given serious consideration during this phase of the program, especially for designs which use the guideway running surface as an emergency egress route. Such a system, when activated by a signal from the vehicle that an unscheduled door opening has occurred and that a passenger may be on the guideway, de-energizes the power rails in the power zone in which the vehicle is located. When backed up with a remote manual capability to remove or restore power from central control, such a system can significantly reduce the probability of a serious injury to passengers during emergency evacuations.

Use of automatic power shutdown does not remove all the hazards that exist along the guideway. Even with power removed from the power zone in which an evacuation has taken place, it is possible for passengers to walk into adjacent power zones and be exposed to all of the hazards of a "hot" guideway. The distance to adjacent power zones may range from a few feet to several hundred feet, depending upon where the vehicle has stopped relative to the power zone boundaries. Additionally, if passengers were to walk beyond a merge switch or onto another section of unaffected guideway, they could encounter hazards associated with moving vehicles. For these reasons, it is necessary for passengers involved in emergency egress to always consider the guideway power to be on and to stay as close to the abandoned vehicle as safety allows until assistance arrives.

3. Additional Design Considerations

Several additional design considerations which affect evacuation and rescue should be taken into account when specifying and evaluating AGT designs.

a. Vehicle Towability

Many proposed AGT systems plan to tow or push disabled vehicles with functional vehicles under manual control. The existence of such a capability would allow increased flexibility in selection of evacuation methods and procedures during non-critical emergency situations. Specifications should cover equipment necessary to operate vehicles under manual control, coupling equipment and bumpers, and the conditions under which towing or pushing operations are to be safely possible. If these operations are to be performed with passengers onboard the vehicle, care must be taken to assure that vehicle contact forces are adequately absorbed to reduce the likelihood of passenger injury resulting from the coupling impact.

b. Vehicle Egress Constraints

The specific evacuation and rescue methodology selected for a particular application will have associated with it requirements for varying degrees of passenger egress freedom. These include the ability of passengers to pass between entrained vehicles and to open doors to the outside without assistance. These design considerations will affect the system's ability to use self-rescue and vehicle-to-vehicle evacuation techniques. Any egress constraints must be consistent with the requirements of the planned evacuation and rescue methodology.

c. System Emergency Egress

The choice of evacuation method for a particular situation may depend upon the distance to the closest station or point of system access to ground level. Depending upon the distance, and its acceptability based upon other factors such as guideway type, weather and passenger number and condition, walking may be used to remove passengers from disabled vehicles to a place of safety. For long sections of elevated and subterranean guideway, paths for emergency access between the guideway and ground level should be specified. The specified distance between access points will depend upon the terrain and environment in which the system is to operate. It is worth noting that access routes used by passengers and rescue personnel into and out of the system during emergencies may, if not properly designed, also be used by vandals and youthful saboteurs to gain access to the system.

d. Emergency Lighting

Adequate emergency lighting has been shown to be an important factor in the success of emergency evacuations in aircraft and is also likely to be a factor in safe AGT evacuation and rescue. While most AGT installations will be in urban areas with relatively high ambient light levels even at night, evacuation and rescue operations during darkness will require additional external illumination along portions of the system. The source of this lighting should be battery or auxiliary powered lights onboard the vehicle and along the guideway. Particular attention should be paid to illumination of any emergency egress routes, all onboard communication equipment such as vehicle two-way radios (also on emergency power) and any other emergency equipment. The capacity of the emergency power system should be consistent with the worst case evacuation times. Additional illumination may also be supplied by emergency response and system maintenance vehicles.

e. Attendant on Vehicle

While AGT systems do not normally employ onboard attendants, some specialized applications such as amusement parks may use personnel onboard vehicles to perform a "spieler" function. If these people were properly trained, they would significantly alter the nature of the evacuation and rescue problem and should be accounted for in the specification.

f. Design to Minimize Hazards

Within the framework of cost effectiveness, all aspects of system design should be evaluated to assure a high level of concern for passenger safety and the use of design practices which minimize the hazards to which passengers and employees are exposed. Efforts should be directed at preventing the occurrence of situations requiring evacuation and rescue. These include:

- adherance to guidelines for flammability and smoke toxicity minimization
- ventilation of equipment which may overheat to produce smoke to the exterior of the vehicle rather than into the passenger compartment

- incorporporation of fire and smoke detectors in high risk locations

- incorporation of methods of preventing veh icles from stopping in stations in which there is a fire.

C. Detail Design, Construction and Test

After the selection of contractors to supply the specified transit equipments, efforts relative to evacuation and rescue fall primarily into the areas of monitoring design efforts and preparing for initiation of system operation.

1. Design Monitoring

As the detailed design is prepared and system construction is underway, the primary activities associated with evacuation and rescue have to do with monitoring the details of the evacuation and rescue provisions being supplied by the contractors to assure that they satisfy all specified requirements. It is important to assure that in attempts to meet demanding design and construction schedules that hazards or other undesirable design features are not incorporated into the system design.

In this phase of the program, frequent reviews of the safety of pertinent design features by the system designers, safety assurance personnel and program management are desirable. It is much easier and cheaper to correct any safety deficiencies when they are in the design phase rather than after the design has been converted to hardware.

2. Mutual Aid Agreements

As initiation of revenue operations approaches, consideration must be given toward the formalization of mutual aid agreements between the transit property and local emergency response agencies such as fire, police and emergency medical services.

The purpose of developing a mutual aid agreement is to establish procedures under which transit system personnel and emergency response agencies can cooperate in assuring the safety and well being of transit passengers and the public. These procedures should indicate the responsibilities and duties of each agency as well as the conditions under which each agency may be summoned.

If local emergency response agencies have been kept informed of expected assistance throughout the design and construction phase of the program, formalization of an agreement will likely be a fairly simple process. If they have not been kept informed, reaching an agreement may be more difficult.

3. Development of Procedures

Also during this period, responsible members of the transportation operating staff, in cooperation with the system hardware contractors and local emergency response agencies, should prepare the necessary evacuation and rescue procedures to be used during system operation. Chapter 5 of this document contains generalized procedures which may be useful in the preparation of detailed procedures.

Development of good procedures for emergency situations is a difficult task. Procedures must be written to the depth necessary to guide personnel in their approach to resolution of problems without being overly detailed and difficult to use. This allows evacuation and rescue personnel the flexibility necessary to respond to the infinite number of different situations which they may face in the safest and most efficient manner possible.

4. Personnel Training

Prior to initiation of system operations, transit employees and emergency response personnel who may be called upon during system emergencies should receive instruction concerning their duties in these situations. Included in this instruction should be indepth training relative to:

- Procedures which apply during emergencies
- Responsibilities of each agency
- Provisions which exist within the system for emergencies
- Primary methods by which evacuation and rescues are to be performed
- Hazards which exist within the system to which emergency personnel and passengers may be exposed.

After completion of the classroom portion of the training, personnel should perform mock evacuation and rescue exercises of a variety of emergency situations. These exercises should include actual evacuation and rescues of simulated transit passengers. If these training exercises reveal procedural deficiencies, the procedures should be revised to reflect solutions to the problems.

As the physical condition and emotional state of passengers involved in evacuation and rescue operations greatly influence the amount of assistance that they require, passengers should simulate a range of physical mobilities, including:

- Non-ambulatory
- Ambulant with assistance
- Able bodied.

Non-ambulatory passengers may be the result of physical injuries received during a transit accident. Passengers may possess a wide variety of injuries and require a range of first aid medical treatment. In addition, the strain encountered after a severe accident may result in trauma that disables some passengers. However, accidents should not be considered the only source of non-ambulatory passengers. As transit systems become increasingly accessible to them, elderly and handicapped non-ambulatory passengers will become regular system riders. Non-ambulant passengers will require being carried from the system by a stretcher or wheelchair.

Some passengers are strong enough to walk but may be unsteady to the point of requiring support from another person. Passengers with less severe handicaps, the elderly, children and those persons who have only minor injury or are just "shaken-up" fit into this category. These passengers can walk from the system with assistance from rescue personnel or other passengers.

Able-bodied passengers are normally capable of exiting the vehicle under their own power. These passengers can be called upon in an emergency to assist in getting other passengers out of the vehicle.

Training exercises not only reinforce previous classroom instruction, but also provide valuable empirical information as to the adequacy of existing evacuation and rescue procedures and provisions. If any serious deficiences are uncovered, they should be corrected prior to initiation of revenue operations.

D. Operations

With the exception of the rare instances in which actual emergencies occur, AGT system evacuation and rescue activities which take place during periods of transit operations are directed primarily at assuring preparedness. This, however, is not a static process. Experience with the operation of the system and its passengers may indicate procedural or hardware modifications which are desirable to reduce any hazards that may exist within the system or the frequency of situations requiring evacuation and rescue.

1. Preparedness Training

Situations requiring the use of evacuation and rescue techniques are likely to be infrequent, and so periodic review of these techniques with relevant personnel are necessary to assure a high level of personnel preparedness. Also, changes in personnel within both the transit system and emergency response agencies, will necessitate instructions to new personnel. Emergency preparedness drills in the form of simulations of emergency situations are again one of the best ways to reinforce classroom instruction and to promote its retention by students. These drills should be conducted one to two times a year and may be combined and coordinated with periodic community-wide disaster drills.

2. Incident Evaluation

After the occurrence of any situation which results in evacuation or rescue of passengers, an evaluation should be made of the incident and the way it was responded to. The purpose of this evaluation is to determine the adequacy of the actions taken and to identify desirable modifications of existing methods and procedures. If changes are indicated, they should be incorporated and the necessary personnel notified.

3. Media Relations

Public perceptions of the safety and performance of an AGT system can be significantly altered by news media coverage of the system. The public relations function is therefore important to the success of any AGT system. The news media should be recognized as an effective method of public education and should be used to the transit system's advantage whenever possible. However, to minimize news media criticism that might result from passenger evacuations, care must be taken to prevent the occurrence of situations which could be sensationalized. The following precautions should be considered:

- do not overreact to minor incidents
- avoid use of evacuation techniques that are dramatic in appearance
- refer all news media inquiries to the public relations office
- establish cooperative relationships with the press to assure the dissemination of the transit system's version of incidents.

CHAPTER 4.

TECHNIQUES FOR AGT EVACUATION AND RESCUE

Numerous techniques for providing evacuation and rescue capabilities have been prepared for AGT systems. These techniques have ranged from those that are similar to the ones employed by conventional transit systems to techniques which employ futuristic or heroic methods. This section of the guidebook will identify techniques which are considered to be safe and suitable to AGT applications. It will include a review of the criteria that should be used in selecting evacuation and rescue techniques for a particular application, a general discussion of the techniques which should be considered and detailed comments concerning individual techniques.

A. Criteria for Evaluating Evacuation and Rescue Techniques

When selecting evacuation and rescue techniques, care must be taken to select the techniques which provide the safest and surest means of moving passengers to locations of safety under a variety of emergency conditions in a cost-effective manner. To make this decision, several performance measures should be considered:

- Response Time - the time required from occurrence of a situation requiring evacuation or rescue until first passengers reach location of relative safety.
- Capacity - Rate at which passengers can be moved to location of safety.
- Safety - Relative magnitude of the hazards to which passengers are exposed as they egress from the vehicle to a location of safety.
- Cost - The incremental expense of adding provisions for the evacuation technique to the basic AGT system design.
- Dependability - The likelihood that the technique will be capable of performing the required function when call ed upon.
- Versatility - The capability of the evacuation system to adequately perform under a range of emergency conditions, including a variety of locations within the system.

- Inconvenience - The amount of awkwardness or discomfort (either physical or emotional) that passengers are likely to experience in using the technique.

- Aesthetics - The impact of any required equipment or provisions on the architectural or natural beauty of the surrounding environment.

- E&H Compatibility - Capability of the method or procedure to accommodate evacuation of elderly and handicapped passengers.

- Required Technology - A measure of the availability of the components or technologies required to implement the evacuation or rescue technique.

- Resistance to Vandalism - The susceptibility of the techniques to destructive acts of vandalism which could impair the function of the technique in an emergency.

- Resistance to Unauthorized Use - The capability of restricting the use of a technique to those situations in which its use is required or warranted.

In addition to these general measures, it is also necessary to assess the applicability of the techniques to the specific design variables of the AGT application. These include:

- Guideway type to be used
- Guideway elevations
- Terrain and geography into which guideway is to be placed
- Vehicle egress constraints
- Vehicle passenger capacity
- Vehicle towability
- Vehicle onboard personnel
- Frequency of system access points.

The impact of these design variables upon evacuation and rescue is discussed in Chapter 3 of this guidebook.

Only after consideration of all of these variables is it possible to make sound decisions concerning the evacuation and rescue provisions for a particular system application.

B. Recommended Evacuation and Rescue Techniques

Evacuation and rescue techniques can be divided into two classifications depending upon the implicit degree of passenger self-sufficiency during evacuation.

The first classification, self-evacuation or rescue, is restricted to those techniques in which passengers are able to egress from the vehicle to a place of safety at will without the assistance of any outside personnel. To qualify as a self-evacuation or rescue technique, all of the equipment and procedural information required for safe egress from the vehicle must be constantly available to the passengers.

Self-evacuation and rescue capabilities are desirable for all systems, but their use should be restricted to only those situations in which passenger injury may result if passengers do not exit the vehicle immediately.

In contrast, the second classification, assisted evacuation or rescue, relies upon the actions of personnel and the use of equipment from outside the vehicle. As personnel and equipment may be dispatched to the scene of the emergency from another location, assisted evacuation and rescue techniques would be expected to have longer response times associated with them. These techniques should be used in evacuations in which time is not of critical importance.

1. Self-Evacuation and Rescue

Three basic techniques exist for providing self-evacuation and rescue capabilities to AGT systems. These include the using of an adjacent walkway, using the vehicle guideway as a walkway and providing an emergency egress path to ground level.

a. Adjacent Walkways

The use of adjacent walkways as a means of providing emergency evacuation capabilities from transit vehicles is a technique which has been used by conventional transit for many years. Walkways exist in the subway tunnels and on the bridges of almost all major conventional transit systems.

1) Description

The use of this technique in AGT is similar to its use in conventional transit except that passengers cannot receive assistance from train-operating personnel. During emergencies, AGT passengers may open the vehicle's normal service doors by activating an emergency latch. Passengers then exit from the vehicle onto the adjacent walkway and move to a location of safety. Upon the arrival of system employees or emergency rescue personnel, passengers can be escorted safely to a station or other system access location.

2) Characteristics

The design characteristics which are necessary for use with this technique are straightforward. Most important is the walkway. It should be located along the entire length of the guideway with access to ground level or into stations. The walkway should be at the same height as the vehicle floor to make it convenient to use. The width of the walkway depends upon the size of the vehicles being used but should never be less than 36 inches if wheelchairs are to be accommodated, and 22 inches otherwise. If sides of narrow walkways are open, railings of at least 42 inches should be used. On sharply curved sections of guideway, the walkway should be on the side of the radius to minimize the gap between the walkway and vehicle door caused by vehicle cording across the curve. Generally, walkways should be located on the outside of sharp curves when doors are near the end of the vehicle and on the inside of the curve for centrally located vehicle doors. The walkways should be provided with a textured non-slip finish to minimize the possibility of passengers slipping and falling into the guideway. If the system is to be installed in a region where snow or ice is likely, consideration must be given to ways of keeping the walkways free of ice.

In addition to the walkway, several vehicle and control system design features are required. The vehicle service doors must have an emergency latch by which the doors may be opened in an emergency. Removal of the emergency latch cover should trigger a control system interconnect which commands the vehicle to stop immediately (if it is moving) and transmits an emergency message to central control indicating the doors have been opened. Vehicle brakes should remain locked until system personnel determine that operation can be resumed safely. As with all self-evacuation and rescue techniques, placards should be placed in the vehicle which explain the safe use of the evacuation technique and the conditions under which it should be employed. In addition, signs should be placed along the walkway to direct passengers to safety.

3) Applications

The use of an adjacent walkway to accommodate evacuation and rescue emergencies is quite flexible. It is well suited for subway, at-grade and elevated guideways and can be used with suspended as well as supported vehicles. Figures 4-1(a) and (b) illustrate its use with both types of vehicles.

In addition to its use for evacuation during serious emergencies, the walkway is also very convenient for use in assisted evacuations and for use by maintenance employees.

4) Advantages

The principle strengths associated with using emergency walkways for evacuation have to do with their safety and flexibility. By using this technique, large capacity vehicles (100 passengers or more) may be evacuated very quickly from all guideway elevations. During evacuations, passengers are exposed to a minimum of hazards. If the walkways are constructed with sufficient width and care is taken to assure that the gap between vehicles and the walkway remains small, this technique can provide good evacuation accommodation of elderly and handicapped passengers, including passengers in wheelchairs.

5) Disadvantages

The cost of constructing the walkways and their impact upon the aesthetics of elevated guideway are the primary disadvantages of using emergency walkways. While walkway construction costs are quite nominal for at-grade guideways, they can be much higher for elevated and underground guideway. This is particularly true of subway construction where the addition of an adjacent walkway may cause a requirement for a larger and much more expensive tunnel cross section.

The aesthetic impact of a walkway on elevated structure is also considerable. Because the addition of a four-foot wide walkway would increase the effective width of most single lane AGT guideway by approximately 50%, walkways may be unpopular with "neighbors" to the system.

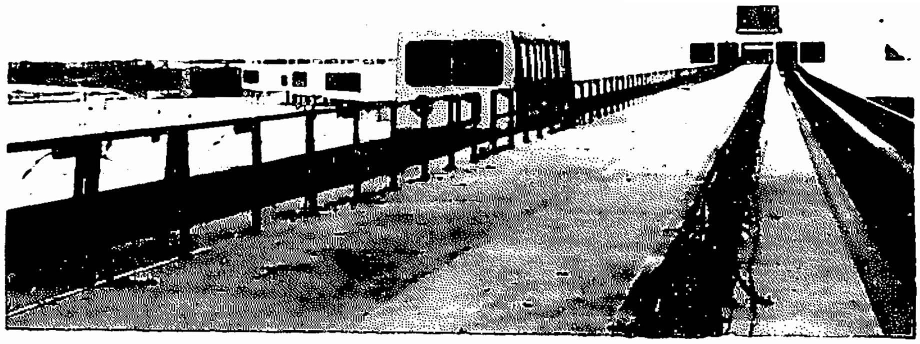


Photo Courtesy of Westinghouse Electric

A) Adjacent walkway with supported vehicle.

Photo Courtesy of DEMAG Fordertechnik

B) Adjacent walkway with suspended vehicle

FIGURE 4-1.

IMPLEMENTATION OF ADJACENT WALKWAYS

For these reasons, walkways are best suited to be common to a dual-lane guideway where their costs and aesthetic impact are spread over two lanes and are therefore less significant to the total.

b. Guideway as an Emergency Walkway

Use of the vehicle running surface of the guideway as an emergency walkway is an evacuation technique which has been used successfully on several AGT systems and is used on portions of some conventional transit systems.

1) Description

In using this technique during severe emergencies, passengers gain access to the running surface of the guideway through emergency doors in the ends of the vehicle. Emergency doors are opened using a latch accessible from within the vehicle. Passengers exit the vehicle and move in the guideway to a safe location, normally remaining near the vehicle. Passengers must then await the arrival of assisting system personnel to guide them from the system.

2) Characteristics

Emergency doors in the ends of the vehicle are a requirement for use of this technique. These doors must be capable of being easily opened from within the vehicle. If hinged doors are used they should open outward. The latches should contain a control system interconnection which, upon initiation of opening, causes the vehicle to stop and a message to be transmitted to central control indicating the existence of an emergency door opening. The emergency door should be easily accessible to passengers from the interior of the vehicle without climbing over vehicle equipment or seats. The emergency door should be at least 24 inches wide to accommodate passengers exiting rapidly from the vehicle in single file. As the vehicle floor is likely to be considerably higher than the guideway surface, a ramp or steps are desirable to make exiting from the vehicle easier and faster for passengers. Location of emergency doors should be away from potential fire or smoke sources to the extent possible.

The guideway used with this technique must be continuous (without large holes or gaps) and relatively flat. To protect passengers from hazards associated with the power rails, either automatic power shutdown or rapid manual power shutdown may be used. These should be activated by the signal transmitted from the emergency door latch to central control. Providing a protective shielding to the power rails should also be considered to further protect passengers.

Placards should be provided onboard the vehicles which describe the safe use of the emergency exits and the hazards associated with walking on the guideway. Particular attention should be focused on guideway hazards associated with power rails and moving vehicles. Signs should also be located on the guideway to direct passengers to safety and to warn them of power zone boundaries, danger from moving vehicles and other hazards.

3) Applications

The guideway can be used for an emergency egress path on all elevations of the guideway but is only applicable to systems using supported vehicles with continuous running surfaces. This technique is also suitable for use in assisted evacuations when supplemented by system employees or rescue personnel. Use of end doors will have limited usefulness on long trains.

Figure 4-2 illustrates the use of the technique as it is being constructed at a Japanese installation.

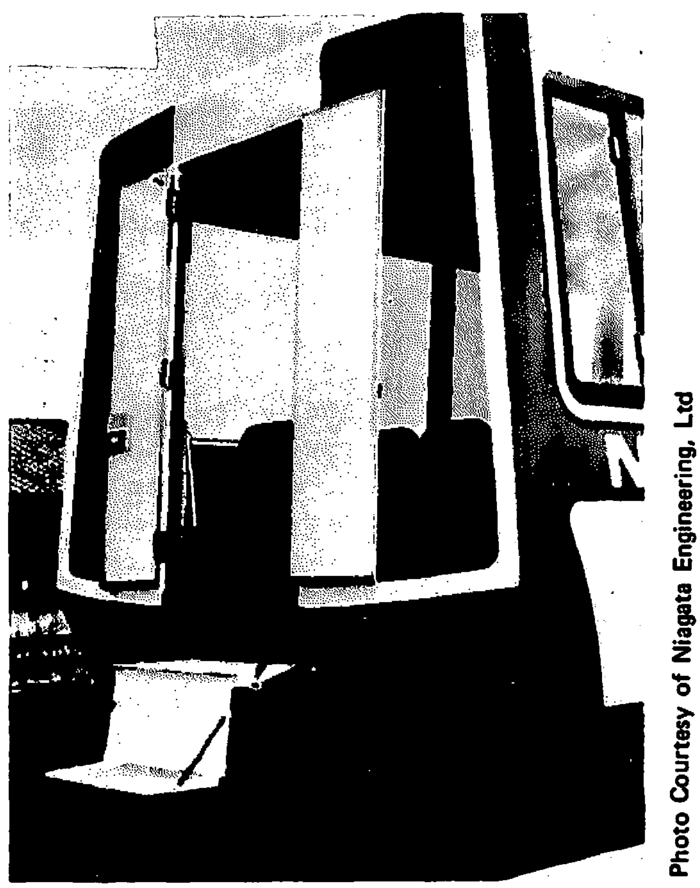


FIGURE 4-2.
EMERGENCY EXIT TO GUIDEWAY WITH STEP

4) Advantages

The principal advantage of using the guideway for an emergency walkway is that it provides many of the functional attractions of an adjacent walkway without the cost and aesthetic impacts. With the incorporation of proper safety precautions, this technique can be used to provide rapid and safe emergency egress capability from medium to large capacity AGT vehicles. Egress is made relatively easy by the steps from the vehicle to the guideway, and so it can be used by many elderly and handicapped passengers.

5) Disadvantages

Two disadvantages are associated with using the guideway as an emergency walkway. First, the technique does not accommodate all elderly and handicapped passengers, particularly those passengers confined to wheelchairs. Second, passengers who do not remain near the vehicle may be exposed to guideway hazards such as moving vehicles and "hot" power rails.

c. Egress to Ground Level

Two methods of emergency egress to ground level are satisfactory for AGT systems which do not provide walkways for passengers. While the technology for these techniques is well established, neither has been previously deployed as part of an AGT installation.

1) Description

The first technique for passenger egress to ground level during severe emergencies uses inflatable aviation type slides similar to those used for emergency evacuation on commercial airliners. These slides can be located in a compartment under the vehicle service or emergency doors. Upon opening the door during an emergency, the slide is deployed either automatically or by pulling an inflation activation lanyard. In both cases, inflation pressures are supplied by a canister of compressed CO_2 gas. After the slide has completed inflation (3 to 5 seconds) evacuation of the vehicle can begin with passengers sliding, feet first to the ground. If the slide inflates at a height less than its design height, it may be necessary for passengers to use their hands to assist them in sliding.

The second technique for emergency passenger egress to ground level utilizes a folding or retractable stair or ramp device attached to the vehicle. The device would be similar to the folding stairs that are used in many home attics. These devices can be located in compartments on one or both ends of a suspended vehicle and can be accessed by passengers through emergency doors. After the vehicle has stopped, passengers can lower the device to the ground. Deployment of the device can be assisted by gravity, counterweights and dampers. Passengers can then use the device to exit the vehicle to the ground.

2) Characteristics

The design characteristics required for both of these techniques are similar. They both require doors which may be opened by an emergency latch from within the vehicle. The latches should have control system interconnections which transmit a message to central control and assure that the vehicle is stopped prior to deployment of the slide or stair. Both the inflatable slide and emergency stair designs must be capable of deployment over the entire range of vehicle elevations which exist in the system.

The deployment and use of both the slides and stairs will be relatively complex tasks, especially considering that they will be performed by passengers under emergency conditions. For this reason, it is necessary to make the procedures for their use as simple as possible and to conspicuously post placards in the vehicles providing detailed information relative to their use.

3) Applications

Emergency evacuation of passengers from suspended AGT vehicles is a serious problem with few solutions. These two techniques, while not as desirable as walkways for emergency egress, could possibly achieve satisfactory levels of performance with proper design. Inflatable slides may also find application with supported technologies which do not easily accept walkways.

Figure 4 -3 shows an artist's concept of how an inflatable evacuation slide might be used with a suspended AGT vehicle.

4) Advantages

The advantages associated with both of these techniques are essentially the same. They are capable of providing rapid evacuation of medium capacity AGT vehicles and they are applicable to technologies in which self-rescue provisions are difficult to provide.

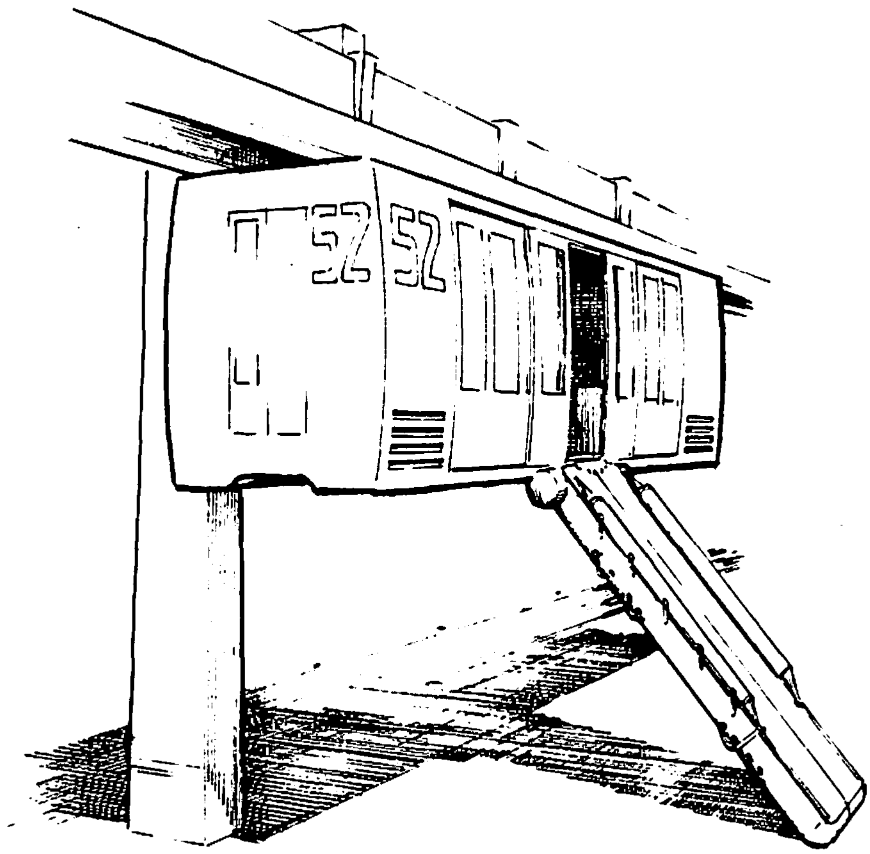


FIGURE 4-3.
EVACUATION SLIDE AS APPLIED TO AGT

5) Disadvantages

The disadvantages associated with both techniques are also similar. Neither technique provides full emergency accommodations for elderly or handicapped passengers, particularly passengers in wheelchairs. Also, both techniques require detailed instructions on safe usage. This is very difficult to provide in the unmanned environment of AGT. Both techniques may additionally be limited in the variation in guideway elevations and terrains to which they are applicable. Additionally, they may deposit passengers into dangerous locations such as busy streets.

Inflatable slides have three additional disadvantages. Because of their rubberized cloth construction, they would be susceptible to cuts by vandals unless adequately protected. Also, airline experience with inflatable slides show that passengers using them during emergencies often sustain leg and ankle injuries, and they are occassionally rendered unusable by very hot fires.[2]

[2] National Transportation Safety Board, "Safety Aspects of Emergency Evacuations from Air Carrier Aircraft", Report No. PB-238-269, 13 November 1974.

d. Comparison of Self-Evacuation and Rescue Techniques

Figure 4-4 illustrates the characteristics of the self-evacuation and rescue techniques described with respect to response time and rate of egress (capacity). The rates of egress shown were estimated on a "per device" basis, so that if, for example, a vehicle incorporated dual evacuation slides the egress rate would be twice the rate shown. The response time, however, would remain unchanged.

For comparative purposes, Figure 4-5 illustrates the general configurations of the devices that may be used to provide self-evacuation or rescue capabilities for passengers.

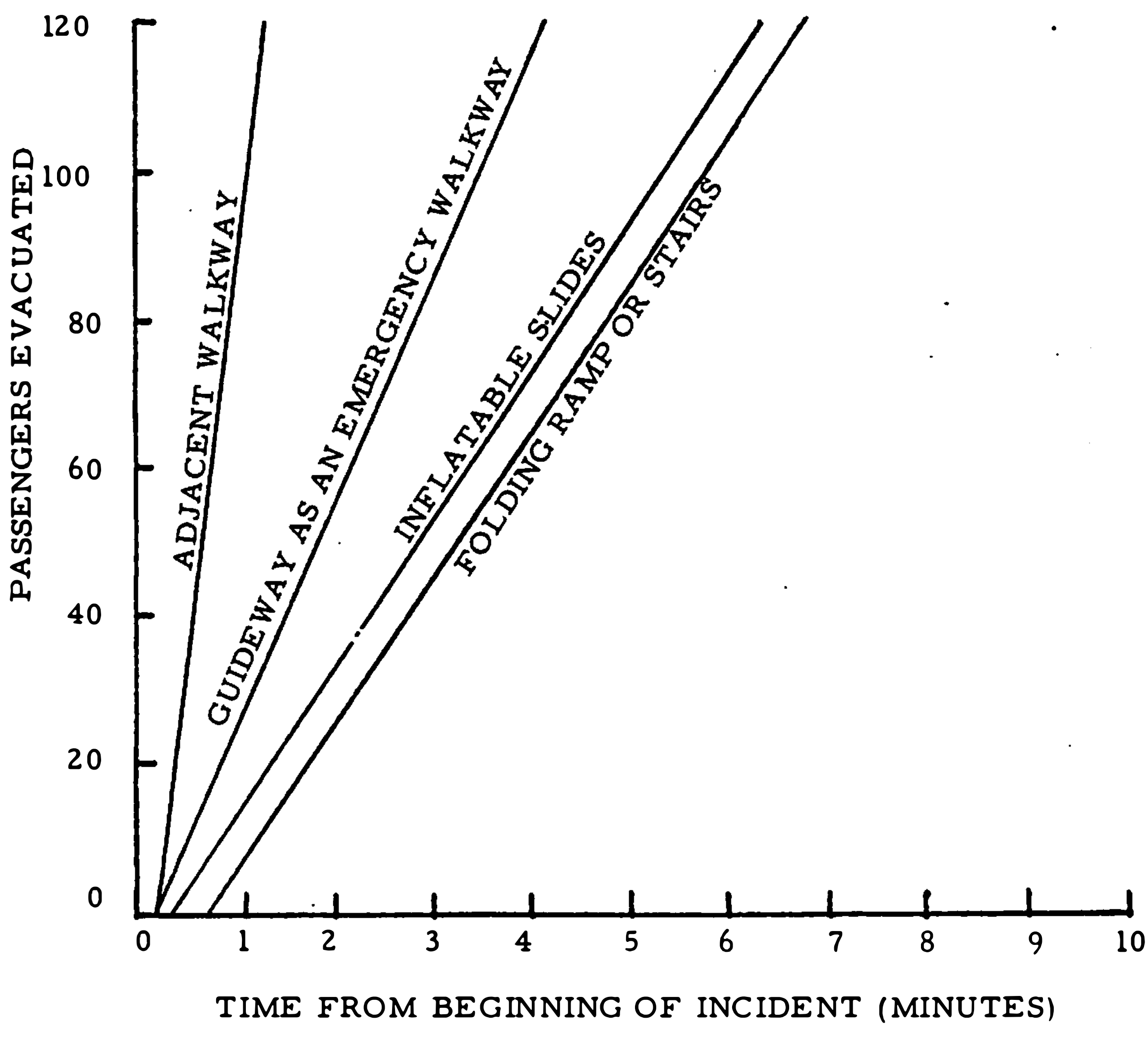


FIGURE 4-4. CHARACTERISTICS OF RECOMMENDED SELF-EVACUATION AND RESCUE TECHNIQUES

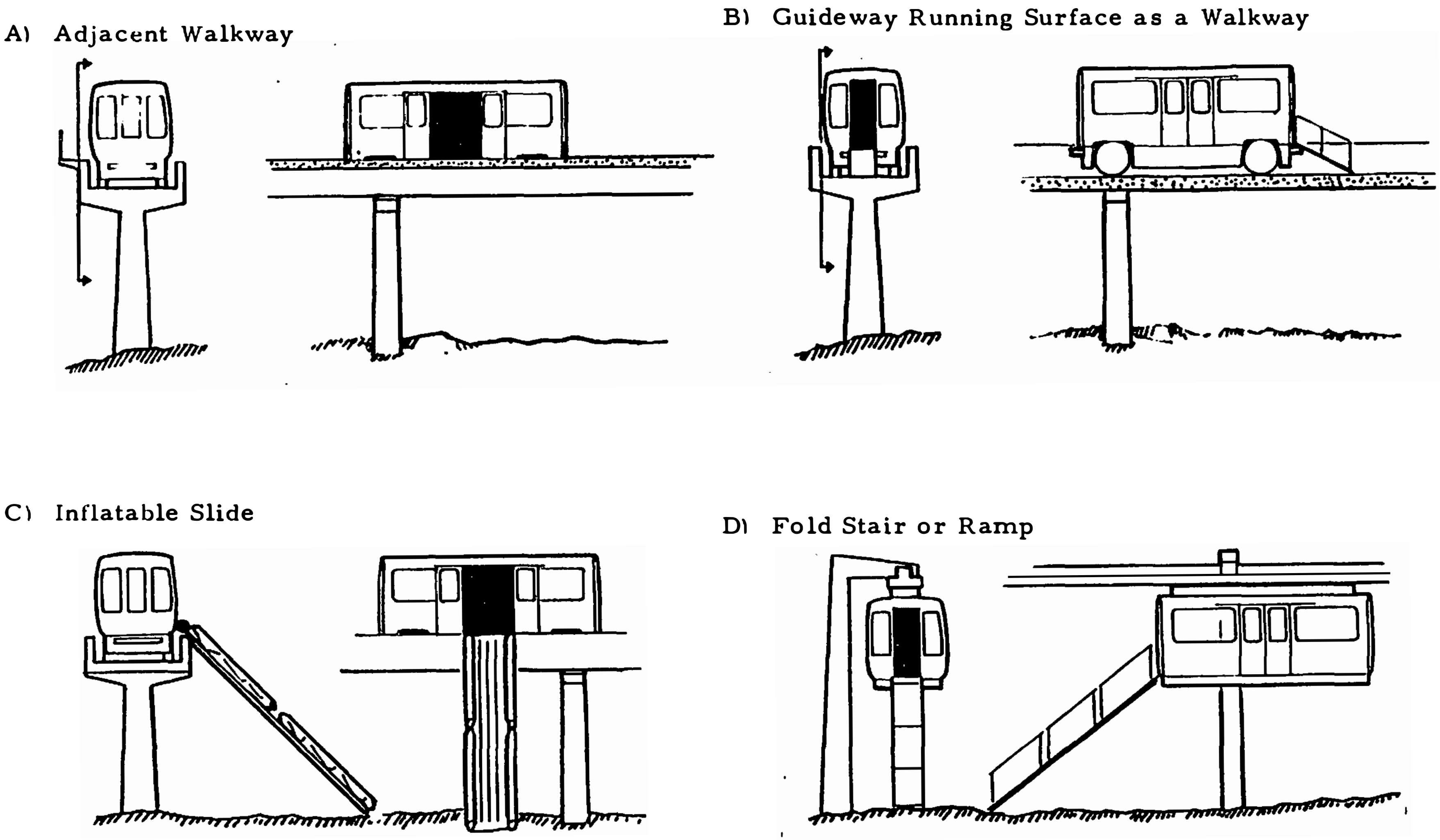


FIGURE 4-5. GENERAL CONFIGURATIONS OF RECOMMENDED SELF-EVACUATION AND RESCUE DEVICES

2. Assisted Evacuation and Rescue

Assisted evacuation and rescue of AGT passengers will occur during situations in which time is not a critical factor. These evacuations will often utilize the equipment and techniques described above, but with additional assistance being provided by transit employees to insure safety. There are three other basic techniques which can be applied when providing assisted evacuations. These include moving the disabled vehicle into a station, transfering passengers from the disabled vehicle into a serviceable vehicle and transfering passengers to the ground using special rescue equipment.

a. Moving Disabled Vehicles to Stations

Transit operators agree that under almost all conditions the safest place for passengers is inside the passenger compartment of the transit vehicle. It is therefore logical to attempt to move the disabled vehicles into a station prior to unloading passengers.

1) Description

Two satisfactory methods exist for moving a disabled vehicle into a station: move it under manual control or use another vehicle to push or tow it.

Before moving a vehicle into a station under manual control, it is first necessary for a transit system maintenance personnel or other qualified employees to be dispatched to the disabled vehicle. The method of reaching the vehicle and the time required will vary by system design and location of the disabled vehicle. Upon boarding the disabled vehicle, the maintenance person attempts to identify the source of the problem and a means for correcting it. If the nature of the problem is such that it cannot be easily corrected, a check is made to determine if the situation allows for the vehicle to be moved under manual control. If manual controlled movement of the vehicle is possible, it is motored to the next station and passengers are unloaded to await another train. The disabled vehicle is then driven to the maintenance area or other location for repairs.

If attempts to motor the vehicle under manual control fail, it may be possible to move the vehicle to a station by towing or pushing the disabled vehicle with a serviceable vehicle. In these situations, it is often necessary for safety reasons, to have maintenance people on both the disabled and serviceable vehicles. Care should be taken to minimize the relative velocities of the vehicles as they come together and the resulting jolt. Passengers are again unloaded in the station and the disabled vehicle removed from service to the maintenance area or other location for repairs.

2) Characteristics

Both of these methods require that maintenance personnel be capable of reaching and boarding disabled vehicles. Access may be achieved by walking along the guideway or by using ladders, articulated booms or other devices. Once onboard the vehicle, it is necessary for the maintenance person to be able to diagnose the nature of the problem to determine if the vehicle can be moved under manual control or be pushed or towed.

Suitable equipment should be provided if the vehicle is to be operated under manual control. A manual control console and instrumentation must be available to the operator. These may be either built into the vehicle or carried by the maintenance employee. If they are to built into the vehicle, care must be taken to prevent their use by unauthorized individuals. For pushing or towing, there is an additional requirement to have vehicle couplers or bumpers for protection of the interface between vehicles. For safety, manual operators of vehicles must have a clear line of sight to the guideway ahead and between vehicles.

3) Applications

Manual control and pushing or pulling techniques can be applied to all basic vehicle and guideway technologies.

4) Advantages

Because moving vehicles to a station prior to unloading keeps passengers in the vehicle, this technique is safe for all passengers and fully compatible with the problems of elderly and handicapped passengers.

5) Disadvantages

The primary disadvantage associated with moving disabled vehicles to a station prior to unloading passengers is that there are numerous situations in which movement is impossible For this reason, the technique must be augmeted by alternative methods of assisted evacuation.

b. Transfer Passengers to a Serviceable Vehicle

If it is not possible to keep passengers in the safety of the vehicle, then the time to which they are exposed to hazards outside the vehicle should be minimized. One approach to achieving this is to transfer passengers directly from a disabled vehicle into a serviceable vehicle.

1) Description

The serviceable vehicle into which passengers are transferred may be either a vehicle in service which happens to be near the failed vehicle or an empty vehicle put into service specifically for the evacuation. If the vehicle is already in service, it is necessary to dispatch a system employee to the vehicle and assure that adequate space is available for transferring passengers. If space is not available, the vehicle is moved into a station and passengers unloaded. The vehicle is then moved under manual control to a location adjacent to the disabled vehicle in preparation for passenger transfer. Approach may be on the same or adjacent guideway and transfer of passengers takes place through the appropriate doors of the vehicle. Passengers are then taken to a nearby station while maintenance crews attempt to repair or remove the disabled vehicle.

2) Characteristics

As the approach of the serviceable vehicle to the disabled vehicle is under manual control, use of this technique requires all of the design characteristics identified above for moving vehicles under manual control. There is also an additional requirement for walkways or gangplank devices which may be extended between vehicles to minimize the hazards associated with passenger transfer. Walkways should be equipped with handrails if significant distances are to be traversed and should be rigid to provide passengers with a feeling of security. Walkways may be stored onboard vehicles or carried to the vehicles by system employees when required.

3) Applications

Transfer of passengers between vehicles is feasible for all basic AGT technologies and is applicable to a wide range of situations.

4) Advantages

While passengers do not remain in the vehicle, they are not exposed to guideway hazards. It is possible for the evacuation to be performed quickly and safely while being supervised by only a few system employees.

5) Disadvantages

As with moving disabled vehicles into a station, situations may be encountered such as power outages in which this technique cannot be used. It is therefore necessary to have alternative plans for these situations. When it is possible to employ this technique, evacuation of passengers confined to wheelchairs may be difficult.

c. Transfer Passengers to the Ground

Two types of truck mounted equipment are particularly well suited for evacuation of passengers from vehicles on elevated guideway structures: articulated booms and platform lifts.

1) Description

Situations may occur in which the only practical means for removing passengers from vehicles on elevated guideway is to lower them to the ground using special rescue devices. While a number of devices are available for safely performing this function, truck mounted articulated booms (also called cherry pickers) and platform lifts are among the best suited. Both types of equipment are common in most urban areas.

Articulated booms are frequently used by electric companies to service power lines atop poles or towers. A wide range of sizes are available from many different sources. The booms are in long sections with a basket or platform at the end and an articulation joint between the booms. When carried on a truck, the base is normally mounted on a turret which provides the device with directional capabilities. Control of the device can be from either the basket or the truck. Stability of the device is often augmeted by outriggers attached to the truck when work is being performed at heights above 15 feet or when a great deal of lateral reach is required. Outriggers are also necessary for safe operation on soft ground, mud, ice or snow.

Platform lifts are also used by public utilities but are more familiar from their use at airports. Two basic types of truck mounted lifts are available. The first type uses a large extending hydraulic cylinder to raise the platform. After the platform has been elevated, it may be rotated and, in some designs, extended forward. The second type uses a hydraulic powered scissors mechanism to raise the platform. It may also be equipped so that the platform may be rotated or extended. Control of the device may be from the platform or from the truck. Outriggers may also be required for platform lift trucks if working heights or reach requirements are extreme.

The use of these devices to perform evacuations is uncomplicated. When an emergency occurs, trucks carrying the devices are dispatched to the location. Outriggers are deployed to stabilize the truck if required. An operator boards the basket or platform and maneuvers it into position at the vehicle door. The door is opened and passengers are assisted into the basket or platform and lowered to the ground. Several trips may be required to empty a single vehicle.

2) Characteristics

Numerous designs and manufacturers exist for both articulated boom and platform lift devices. Procurement of satisfactory equipment for a particular application should be straightforward.

Required AGT system design consideration are primarily related to accessibility. A clear path must be provided to all locations to which equipment may be called. If access is through undeveloped land, care should be taken to assure proper drainage of the path to prevent the path from becoming impossible to rescue equipment. Overhead wires, particularly electric wires, may pose hazards to the safe operation of these devices and should be relocated away from the guideway.

3) Applications

Both devices are applicable to all basic AGT technologies. As compared to platform lifts, articulated booms are particularly well suited for use with higher guideway elevations (above 20 feet) and applications which require considerable lateral reach. Articulated booms are normally somewhat restricted in their load carrying capacities and will often produce slower rates of evacuation than will platform lifts.

4) Advantages

Both devices provide reliable and relatively flexible means of evacuating passengers from AGT vehicles on elevated guideways in situations when other techniques cannot be applied. With assisting personnel, they can safely accommodate all passengers including elderly and handicapped.

5) Disadvantages

Both techniques require access to the disabled vehicle location by a roadway or firm ground. Also, both methods may provide low evacuation rates, meaning that evacuation of larger vehicles may take considerable time.

d. Comparison of Assisted Evacuation and Rescue Techniques

Figure 4-6 illustrates the characteristics of the assisted evacuation and rescue techniques described above with respect to response time and rate of egress (capacity). As the response times and rates are dependent upon the location of the disabled vehicle and the guideway elevation, these factors have been normalized to allow comparison of the responses. Platform lift and articulated boom data is on a "per device" basis. Data for transferring passengers to an operating vehicle includes travel time to a station.

Figure 4-7 illustrates in order of preference the acceptable methods of evacuating passengers in non-critical emergencies.

C. Assessment of Evacuation and Rescue Requirements

Provision of emergency passenger evacuation and rescue capabilities should be a requirement of all AGT systems. The most cost-effective method of providing this capability, however, is likely to vary considerably between various system technologies and applications. This section will describe the minimum requirements that should exist for all systems and illustrate how other requirements may vary depending upon the specific characteristics of the system.

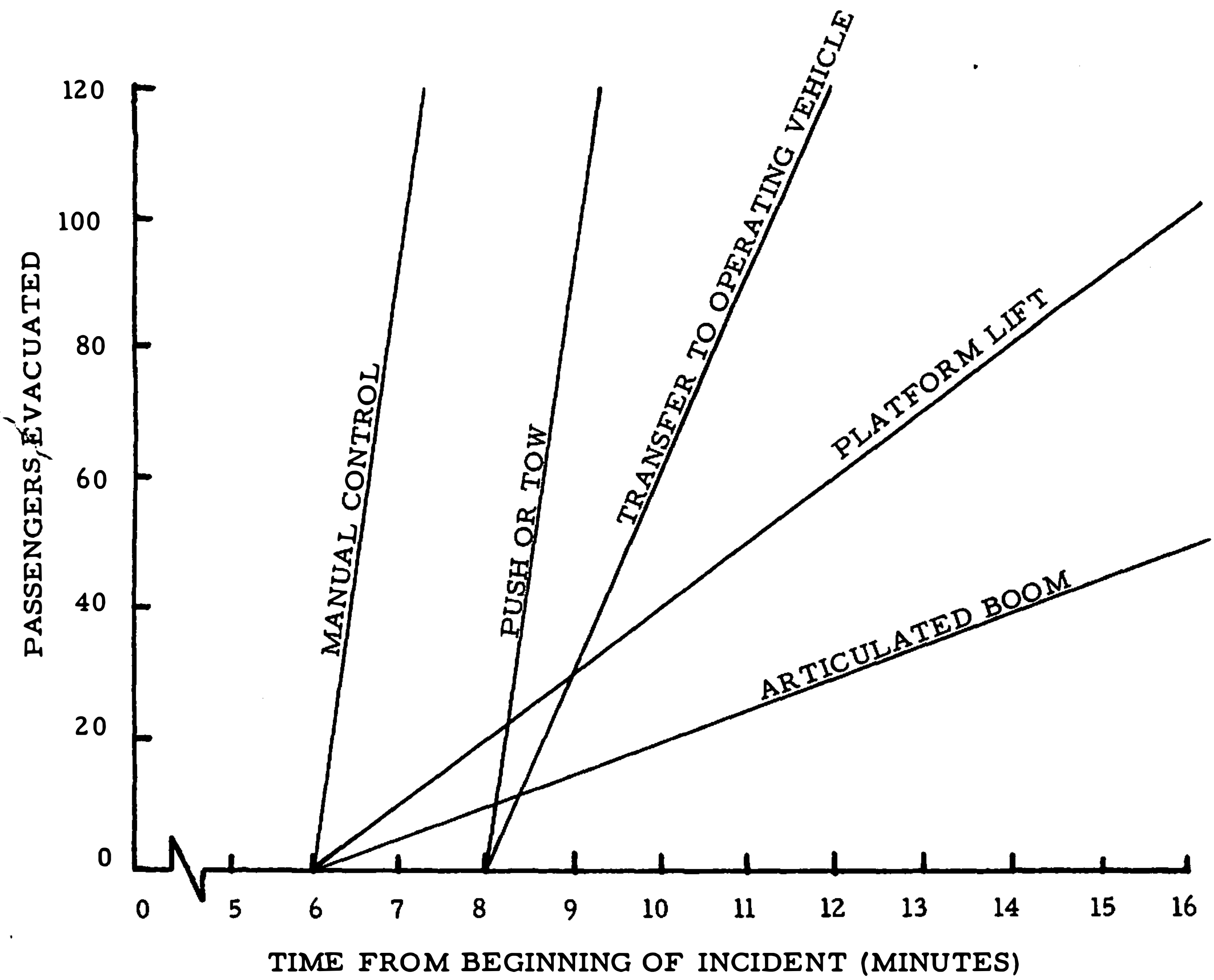


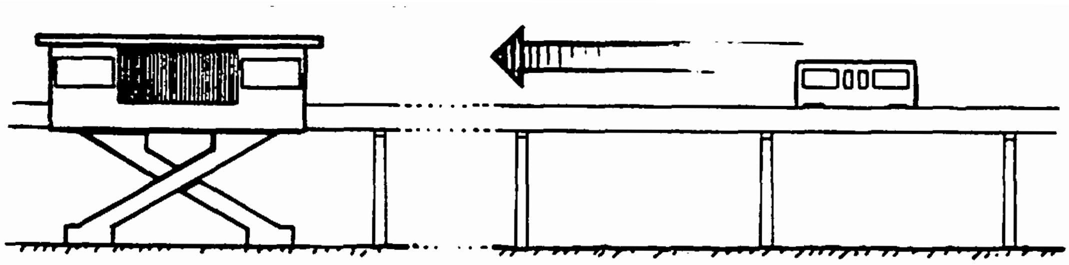
FIGURE 4-6. CHARACTERISTICS OF RECOMMENDED ASSISTED EVACUATION AND RESCUE TECHNIQUES

1. General Requirements

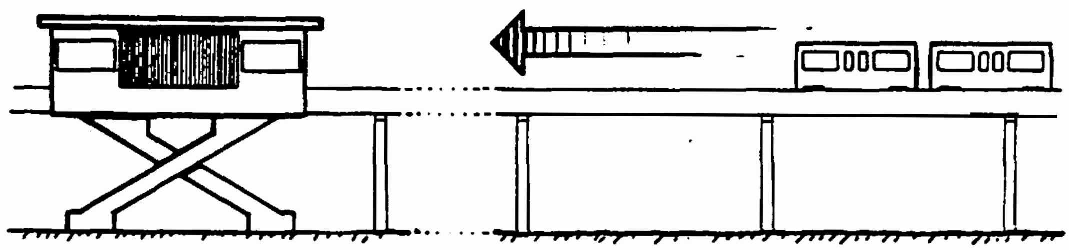
The safest place for passengers is inside the vehicle in nearly all situations except those involving advanced fire or smoke. For this reason, all AGT systems should be provided with the capability of transporting passengers into a station after all but the most severe malfunctions. Specifically, the following should be considered for all AGT systems:

- the ability of system personnel to board vehicles, safely override or bypass malfunctioning equipment, and move vehicles under manual control into a station.

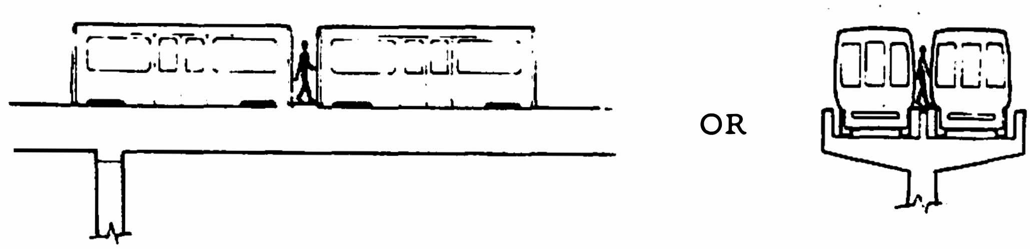
A) Move the vehicle to a station under manual control



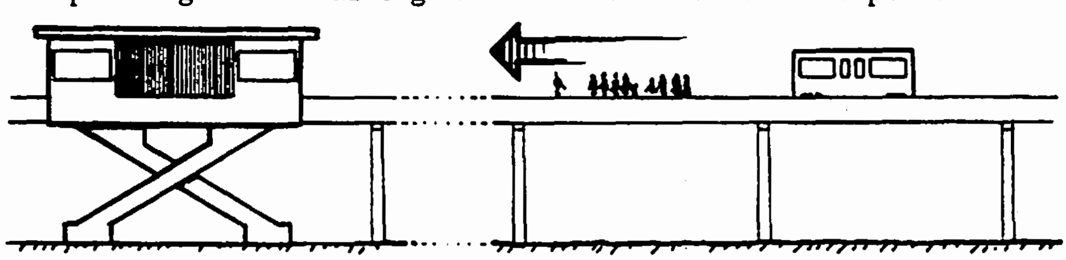
B) Push or pull the disabled vehicle to a station with another vehicle



C) Transfer passengers into an operational vehicle



D) Assist passengers in walking to station or another safe place



E) Lower passengers to the ground

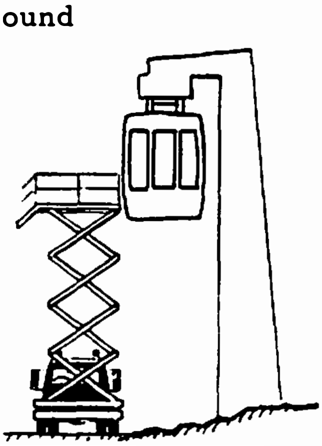


FIGURE 4-7. ACCEPTABLE METHODS OF PASSENGER EVACUATION IN NON-CRITICAL EMERGENCIES

- disabled vehicles should be capable of being pushed or pulled to a station by another vehicle under manual control in situations in which operation under manual control is not possible.

- the capability for transferring passengers from disabled vehicles to other vehicles in situations in which neither of the above are possible.

2. <u>System Specific Requirements</u>

Evacuation and rescue requirements for a particular AGT vehicle should depend in part, upon its resistance to producing or sustaining fire and smoke. All AGT vehicles will be required to be fire-resistant. The technology does exist, however, to construct a vehicle which is designed to be virtually fireproof. The vehicle could be constructed primarily of light alloy materials and use a compressed gas fire extinguishing system (such as Halon). Such a vehicle would not itself support combustion and combustion of any articles carried onto the vehicle would be quickly extinguished.

Obviously, such a vehicle is not necessarily a cost effective solution to the problem of protecting passengers from fire and smoke. But, if such a fireproof vehicle were proposed, it would require less demanding evacuation and rescue characteristics to provide passengers with the same level of safety as a fire-resistant vehicle. For this reason, evacuation and rescue requirements will vary depending upon the degree of fire resistance of the design. While a wide range of fire resistances are possible, two levels will be used for illustrative purposes.

a. <u>Fire Resistant Vehicles</u>

All AGT vehicles should be designed to minimize their susceptability to fire within reasonable limits. With only a resistance to fire, however, a vehicle could potentially generate enough heat, toxic fumes and smoke to cause a hazard to passengers. On such vehicles, it is necessary to provide passengers with a means of escaping from the fire and smoke to a place of safety. This may be accomplished by using any of the recommended self-evacuation and rescue techniques:

- use of an adjacent walkway

- use of the guideway as an emergency walkway (with power shutdown)

- use of either an inflatable slide or folding stair device for egress to the ground (heights less than about 20 feet)

None of these techniques should be employed to evacuate passengers except in severe emergencies or until after failure of attempts to:

- move the disabled vehicle under manual control to a station

- push or pull the disabled vehicle to a station

- transfer passengers into an operating vehicle.

b. Very Fire Resistant Vehicles[3]

By careful design, use of non-combustible materials, total compartmentalization of potential fire and smoke producing components and incorporation of automatic fire-extinguishment systems, vehicles which are very fire resistant can be designed Evacuation and rescue requirements imposed upon such designs should be less severe than those imposed upon conventional fire resistant AGT vehicles. Response time requirements for emergency evacuation can be relaxed to 6 to 8 minutes with assurance that adequate ventilation will be provided. This translates into the following minimum requirements beyond the general requirements identified above:

- commercially available platform lifts or articulated booms (cherry pickers) should be provided for timely rescue of passengers from lower elevations

- for guideway elevations above 25 feet but still within the reach of locally available emergency rescue equipment, a narrow (18-24 inches) walkway should be provided to assist rescue personnel in removing passengers to safety or guideway if it is serving as walkway

- for guideway elevations beyond the reach of locally available rescue equipment, full walkways should be provided as described previously.

D. Other Evacuation and Rescue Techniques

Numerous other evacuation and rescue techniques have been used or proposed in the past but are not recommended for deployment with future systems. For the information of guidebook users, these are listed in Table 4-1 along with their primary advantages and disadvantages.

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[3] Note that for the purposes of this report, a very fire resistant vehicle is assumed to protect the passengers from the effects of fire and smoke for a period of 6 to 8 minutes.

TABLE 4-1.

NOT RECOMMENDED EVACUATION AND RESCUE METHODS AND PROCEDURES

TECHNIQUE	ADVANTAGES	DISADVANTAGES
Self-Evacuation or Rescue		
Egress from vehicle to ground level using synthetic cloth chutes	Simple concept which offers good dependability.	Would provide relatively low evacuation rates. Concept has difficulty handling variations in elevation May elicit claustrophobic reactions in some passengers. Requires considerable instruction on proper technique for use. Marginally compatible with young, elderly and handicapped or obese passengers.
Egress from vehicle to ground level using a rope or wire ladder	Simple concept which offers good dependability Not sensitive to elevation above ground.	Instability of ladder makes use difficult and compromises safety Would provide relatively low evacuation rates Not compatible with elderly or handicapped passengers.
Egress from vehicle to ground using a knotted rope	Inexpensive	Usable by only the most athletic passengers. Incompatible with elderly passengers. Unsafe, particularly from higher elevations. Would provide low evacuation rates

TABLE 4-1.

NOT RECOMMENDED EVACUATION AND RESCUE METHODS AND PROCEDURES (CONTINUED)

TECHNIQUE	ADVANTAGES	DISADVANTAGES
Egress from vehicle to ground level using a lowering floor	Rapid evacuation of entire vehicle. Compatible with elderly and handicapped passengers. Applicable to suspended vehicles.	May not be capable of safe operation over uneven ground levels Many unresolved technical details No cost information, but likely to be expensive.
Assisted Evacuation or Rescue		
Transfer passengers to specialized rescue vehicle	Unaffected by terrain under guideway. Limited compatibility with elderly and handicapped passengers.	Relatively slow response and evacuation rate. Unknown costs; expected to be high.
Transfer passengers to the ground using truck-mouted turret ladder	Good versatility to guideway elevations	Incompatible with many elderly or handicapped passengers. More difficult for passengers to use than platform lift or articulated boom.
Transfer passengers to the ground using portable ladders	Can be used in relatively inaccessible locations.	Length of ladder limited Requires solid support for ladder. Incompatible with many elderly and handicapped passengers.

TABLE 4-1.

NOT RECOMMENDED EVACUATION AND RESCUE METHODS AND PROCEDURES (CONTINUED)

TECHNIQUE	ADVANTAGES	DISADVANTAGES
Transfer passengers to the ground using truck-mounted portable stairs	Good safety and convenience. Relatively rapid evacuation rates.	Very inflexible with respect to height and lateral alignment. Not compatible with some elderly and handicapped passengers.
Transfer passengers to the ground using boatswain's chair	Good flexibility to terrain and elevation variations.	Very slow evacuation rates Labor intensive Not likely to be popular with passengers Ideal topic for news media sensationalism.
Remove passengers from vehicle using helicopter	Capable of use in areas totally inaccessible from the ground	Slow response time and low evacuation rates. High cost of helicopter Likely to frighten passengers Ideal topic for press sensationalism.

CHAPTER 5.

FUNDAMENTAL PROCEDURES FOR EVACUATION AND RESCUE

This section of the guidebook identifies fundamental procedures for AGT evacuation and rescue. They are for the most part independent of system technology and would be applicable to any size system. They include:

- General Procedures
- Procedures for Critical Emergencies with Continuing Hazard
- Procedures for Critical Emergencies with Stabilized Situations
- Procedures for Non-Critical Evacuation
- Procedures for Unauthorized Vehicle Egress.

A. General Procedure

1. Command Designation

At all times, one individual should have full responsibility for the minute-by-minute operation of the entire AGT system. This invidvidual should be fully cognizant of his authority and responsibility. He should be thoroughly familiar with the system, the details of how it operates and all procedures which apply to its safe operation. This individual should be located in the central control room of the system where he can best be informed of the status of the entire system. Prior to transfer of command between individuals (such as shift changes), adequate overlap of presence is required at central control to assure that the newly responsible individual will be fully familiar with all existing conditions in the system before assuming command. For convenience, this individual has been designated the central control supervisor, although the actual title may vary between systems.

2. Notification

Employees of the system, passengers, police, and neighbors to the system must all be encouraged to notify central control immediately of any emergency condition. Communications should be made by the quickest possible means, including public telephones, station telephones, vehicle two-way radios and employee carried two-way radios.

3. Necessary Information

Upon notification of a potential problem which may relate to evacuation or rescue, the central control supervisor should attempt to gather the following information:

- General nature of the problem
- Seriousness of the problem
- Location of problem
- What actions have already been taken
- Whether medical help is needed and extent of any injuries
- Vehicle identification
- Time of occurrence
- Additional information which is relevant to particular situation.

4. Responses

After notification of an emergency condition and evaluation of available information, the central control supervisor should take whatever actions are dictated by the conditions. If incomplete information is available concerning the nature of the condition, the central control supervisor should take actions which provide the greatest level of protection to passengers and employees. The general actions which may be taken if appropriate include:

- Call for assistance from non-transit emergency response agencies (fire, police and medical services)
- Remove guideway electrical power from affected portions of the system

- Dispatch employees to the scene of the problem
- Alter systems operation to minimize the impact of the problem on the rest of the system
- Contact passengers on affected vehicles
- Notify all affected passengers of the nature and probable duration of any delay (both in vehicles and stations)
- When seriousness of situation warrants, notify other key system personnel
- Arrange for evacuation of passengers as required.
- Restore operation as soon as condition permits.

Under all circumstances, passengers and rescue personnel should be instructed to consider power rails to be energized.

5. Documentation

As the problem condition takes place and is responded to, the central control supervisor should ensure that a complete chronological account of the incident is recorded in the central control log. This information may be later supplemented by information from the central control voice recordings.

B. Critical Emergencies with a Continuing Threat of Passenger Injury

1. General

Emergency situations which, when detected, pose a continuing threat of injury to passengers must be responded to in the most expeditious manner possible. The first concern must be the removal of passengers from the hazard area to a place of safety. These are the only situations in which passengers may be encouraged to egress from the vehicles without assistance. Passenger safety must be put before equipment protection. As in conventional transit, the problems which precipitate this severity of emergency are numerous; but nearly all have one thing in common: they expose the passenger to fire, smoke or noxious fumes.

In critical emergency situations, absolute cooperation between AGT system personnel and emergency response personnel is essential. This required level of cooperation must be assured prior to the occurrence of a severe emergency situation. The most successful method of assuring cooperation is through the formalization of an emergency aid agreement prior to initiation of transit service. After a period of operation, refinement of this agreement may be necessary to further streamline the cooperation.

2. Central Control

Upon notification of a critical emergency with ongoing threat to passengers, the central control supervisor should take appropriate actions which may include the following:

- If the problem occurs while vehicle is enroute and between stations, the central control supervisor should determine whether the vehicle should be allowed to continue to the next station or be stopped where it is. This decision should consider factors such as distance to the next station, accessibility of various locations to emergency personnel, and the magnitude of the threat to which the passengers are exposed.

- Call for assistance from fire, police and medical services agencies

- Dispatch system emergency personnel

- Contact vehicles exposed to hazard and advise passengers that the situation is known and the actions being taken to correct it.

- Order passengers in affected vehicle to self-evacuate if situation warrants

- Advise evacuated passengers to stay near the disabled vehicle until assistance arrives

- Remove guideway power from affected portions of the system

- Coordinate transit activities with emergency response personnel at emergency location

- Alter system operations to minimize the impact of the problem on the remainder of system

- Contact all vehicles and stations affected by the emergency and advise them of the impact that the situation will have on service to them

- Evacuate any additional passengers as may be required (See "Section D, Non-Critical Evacuations")

While the exact procedures that will be used in this type of emergency are likley to vary between systems, Figure 5-1 illustrates a typical sequence that may be applied to indications of fire or smoke onboard a vehicle.

3. Emergency Command Post

The first emergency response team at the scene of the emergency should establish an emergency command post. From this command post, all rescue activities should be directed and coordinated. Primary activities include:

- Direction of rescue efforts

- Direction of fire-fighting efforts

- Direction of emergency medical services

- Traffic and crowd control

C. Critical Emergencies Without Threat of Further Passenger Injury

A collision without fire, a catastrophic guideway failure or a brake failure with subsequent rapid deceleration are all likely to result in emergency situations with passenger injury, but in which further injury is unlikely. The primary concern in these situations is the provision of medical aid to the injured with the removal of the uninjured passengers from the vehicle a secondary consideration. As there is normally some degree of hazard associated with unassisted evacuation of passengers from vehicles, only closely supervised evacuations are recommended.

With the exception of passenger self-evacuations, the procedures used for this classification of emergency will be similar to those discussed in the previous section.

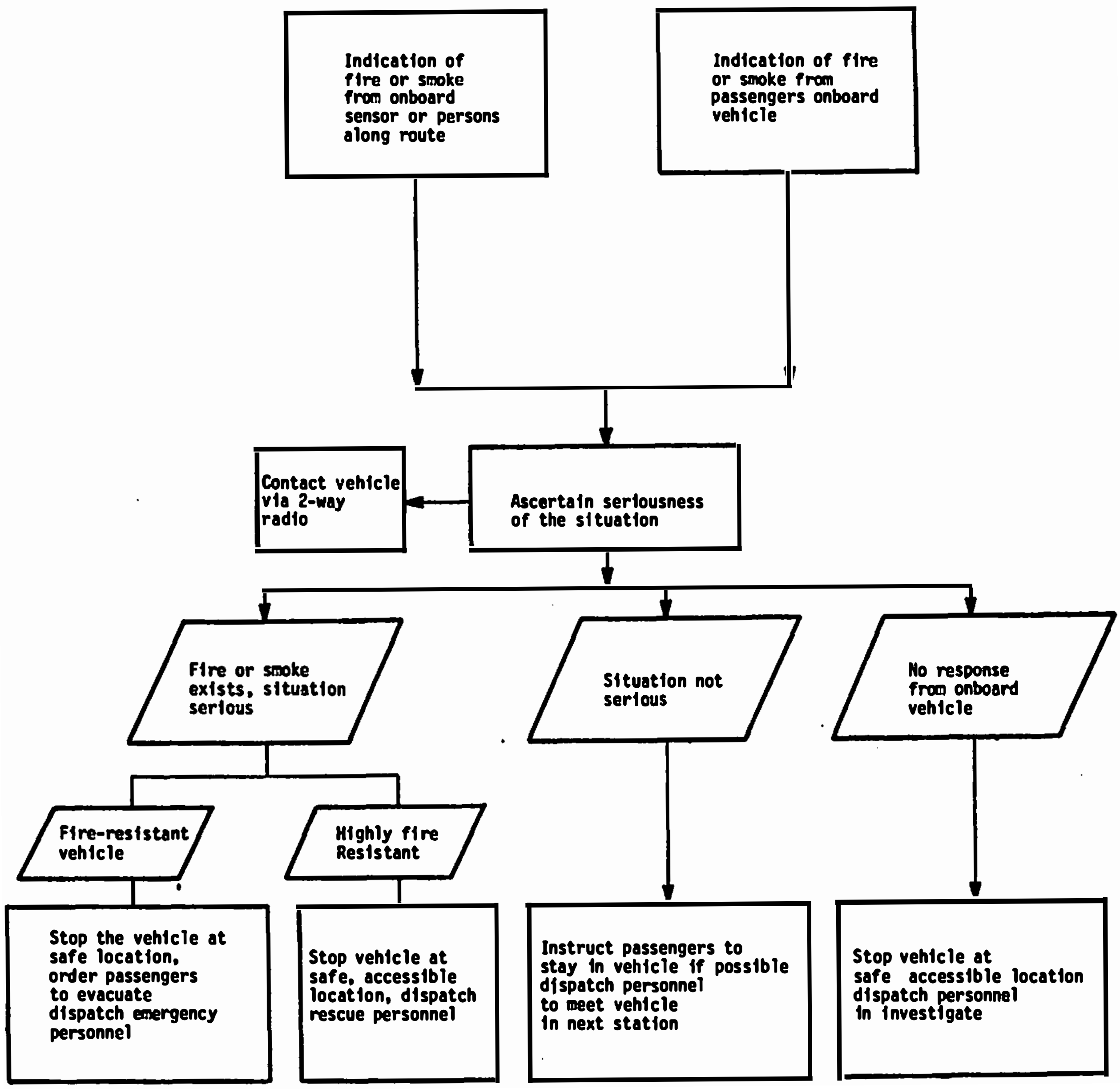

FIGURE 5-1. PROCEDURE SCHEMATIC FOR FIRE OR SMOKE ONBOARD VEHICLE

D. Non-Critical Emergencies

1. General

Occasionally situations are likely to occur which will require evacuation of one or more vehicles because of an extended service interruption. These situations include power failures, guideway blockages, or vehicle failures which cannot be quickly repaired. Evacuation of passengers taking place under these conditions must first consider passenger safety before speed of evacuation.

As inside the vehicle is the safest location for passengers during non-critical emergencies, alternative methods of moving the vehicle to the station should be exhausted prior to evacuating passengers onto the guideway. Alternatives in the following order should be attempted:

- move the vehicle into a station under manual control
- push or tow the vehicle into a station with an operating vehicle
- transfer passengers directly into an operating vehicle

If passengers cannot be removed from the vehicle within 20 to 30 minutes or if conditions inside the vehicle are extremely crowded or otherwise uncomfortable, other means of evacuation should be considered.

2. Central Control

The central control supervisor, as the responsible operations employee, should direct all passenger evacuations from central control. In this regard, the actions which he may take include:

- Evaluate the nature of the service interruption and its probable duration.
- Notify affected passengers of the nature of the problem, the expected length of delay and any plans to evacuate. Instruct passengers to remain in vehicles until assistance arrives.
- Dispatch evacuation crews and equipment, assuring that adequate personnel are available to safely perform the evacuation

- If the evacuation route exposes passengers to electrification hazard, guideway power should be removed. However, the central control supervisor should take into account the effect that removal of power has on vehicle inhabitability (i.e., the loss of heating, ventilation and air conditioning) prior to making the decision.

- Arrange for alternate transportation for passengers.

- Notify other affected stations and vehicles of the service interruption and the affect it would have on the remainder of the system.

- Periodically recontact affected vehicles and offer reassurance that help is on the way.

3. Evacuation Personnel

Evacuation personnel must realize that passenger and employee safety is the first concern during evacuation and that speed and convenience are secondary. Careful adherence to established procedures is required to assure safety.

E. Unauthorized Vehicle Evacuation

1. General

If provisions are made in the system design for passengers to evacuate from vehicles during severe emergencies such as onboard fire, passengers are also likely to exercise these provisions occasionally when conditions do not warrant. These unauthorized evacuations are most likely to occur after passengers become impatient during service interruptions or as juvenile pranks. Loss of the vehicle environmental control system (heating, ventilating and air conditioning) may exacerbate these problems.

Unauthorized evacuations are a serious concern to system operations for several reasons:

- Evacuated passengers may walk into operational portions of the system and be struck by moving vehicles

- If the evacuation is undetected, restoration of system operations may result in passengers being struck by the vehicle from which they disembarked

- If guideway power is not removed, passengers may be exposed to a serious electrical hazard. If guideway power is removed, loss of environmental control systems may result in other vehicles being evacuated.

- Restoration of system service will be delayed while system employees verify that the guideway is clear.

2. Prevention

The most successful procedures for handling problems of unauthorized evacuation seem to be those which are designed to prevent the occurrence of the problem. The actions which the central control supervisor should take can be summarized as follows:

- If warranted, remove guideway power to the affected guideway sections.

- Inform all delayed vehicles of the nature and the expected duration of any significant delays. Instruct passengers to stay in vehicle.

- Continue to offer reassurance to affected passengers frequently. Reassurance every three of five minutes has been shown to be effective on existing systems.

- Establish two-way communication and dispatch employees to any vehicles in which passengers are excessively upset.

- If vehicles are becoming very uncomfortable because of loss the environmental control system and the design permits, instruct passengers to carefully open the vehicle's doors but to remain in the vehicle.

Operating systems have demonstrated that, at least in relatively controlled environments, these techniques can be nearly 100% effective.

APPENDIX A

GLOSSARY

Automated Guideway Transit (AGT)

The current dominant means of public transportation are the transit bus and rapid rail systems. The development of computer and automation technology, particularly in the last decade, has led to the formulation of new public transportation concepts which use vehicles capable of automatic operation on separate roadways or guideways. Such systems are generally called Automated Guideway Transit (AGT).

Group Rapid Transit (GRT)

Group Rapid Transit Systems (GRT) utilize automated vehicles on more extensive networks than SLT systems. They tend to have shorter headways than SLT systems, use switching and may or may not employ off-line stations. Vehicles with a capacity of 10 to 70 passengers, operating singly or in trains with headways of 3 to 90 seconds, characterize such systems. State-of-the-Art GRT Systems (e.g., Airtrans, Morgantown) operate at headways 15 seconds or greater.

Personal Rapid Transit (PRT)

Personal Rapid Transit Systems (PRT) are usually system concepts characterized by small vehicles (2-9 passengers) carrying parties travelling together by choice. Such systems generally feature off-line stations and an extensive guideway network. Most proposed systems call for vehicles to be operated at headways of three seconds or less.

Shuttle-Loop Transit (SLT)

Shuttle-Loop Transit Systems (SLT) are the simplest type of Automated Guideway Transit Systems and are characterized by vehicles moving along short linear segments or loops with few or no switches. The vehicles may operate singly or trained. Bypasses may be permitted in the shuttle to permit intermediate stations.

APPENDIX B

ABBREVIATIONS/ACRONYMS

AGT	Automated Guideway Transit
APTA	American Public Transit Association
BART	San Francisco Bay Area Rapid Transit
CCS	Central Control Supervisor
CCTV	Closed Circuit Television
CRT	Cathode Ray Tube
DPM	Downtown People Mover
E&H	Elderly and Handicapped
GRT	Group Rapid Transit
MPM	Morgantown People Mover
NYCTA	New York City Transit Authority
PATCO	Port Authority Transit Corporation, New Jersey
PATH	Port Authority of New York and New Jersey Trans Hudson
PASS	Passenger
PRT	Personal Rapid Transit
Sea Tac	Seattle-Tacoma Airport Satellite Transit System
SLT	Shuttle-Loop Transit
TTC	Toronto Transit Commission
WMATA	Washington Metropolitan Area Transit Authority

APPENDIX C

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APPENDIX D

REPORT OF NEW TECHNOLOGY

While leading to no new technology, the work performed under this contract has identified a number of special evacuation and rescue problems associated with AGT systems. Guidelines have been developed for the planning and provision of AGT evacuation and rescue services. Several concepts are introduced which apply existing technology to new problems.

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