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Safety Effectiveness Evaluation of
Rail Rapid Transit Safety

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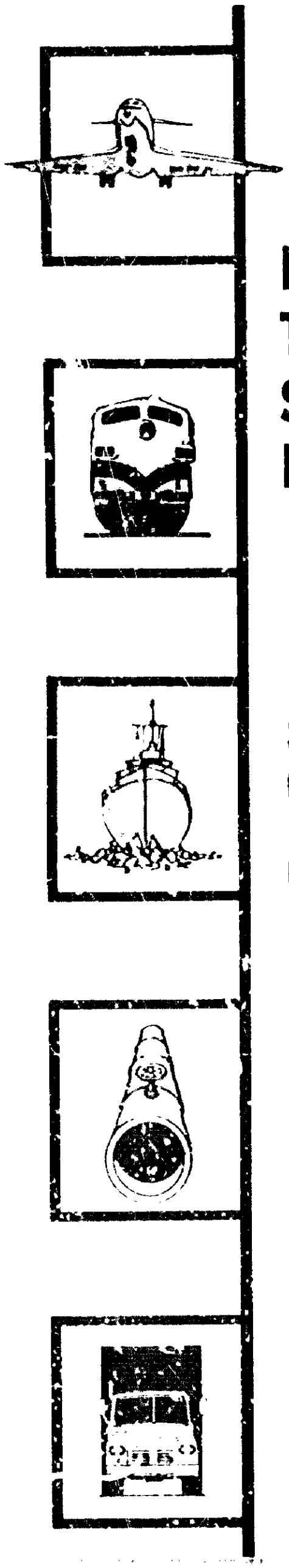

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

SAFETY EFFECTIVENESS EVALUATION OF RAIL RAPID TRANSIT SAFETY

NTSB-SEE-81-1

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16. Abstract On July 28 and 29, 1980, the National Transportation Safety Board held a public hearing on rail rapid transit safety. Twenty-five witnesses testified during the hearing on fire safety issues, emergency evacuation from rail rapid transit systems and safety oversight of transit systems. The Safety Board examined fire safety issues involving transit car design; emergency exit from cars; emergency tunnel ventilation; evacuation from tunnels; emergency procedures including training, drilling, and testing; emergency communications, equipment, and mobility; and local/State/Federal safety oversight of rail rapid transit properties.

The Safety Board issued urgent recommendations to the Urban Mass Transportation Administration for a survey of rail rapid transit systems to determine their capability for evacuation of passengers under various operational and passenger load conditions and to establish Federal guidelines for the elimination or minimization of combustible and toxic gas and smoke-generating materials in existing rail rapid transit cars. The Safety Board further recommended that the Secretary of Transportation propose Federal legislation which would explicitly authorize the establishment of safety standards for rail rapid transit systems. Other recommendations seek Federal guidelines for car and tunnel designs, safety equipment, and training; the need for 5-year safety and research and development plans; a fire research and testing program; a study of the need for fire suppression systems; and improved training for tunnel rescue efforts for employees and emergency personnel.

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

SAFETY EFFECTIVENESS EVALUATION OF RAIL RAPID TRANSIT SAFETY

Adopted: January 22, 1981

INTRODUCTION

During the last 15 years, the Federal Government, through its financial assistance programs, has played a large role in fostering the development and expansion, as well as the ongoing operation of rail rapid transit systems. 1/ In recent years, the Federal Government has joined State and local governments in an active effort to encourage the public to use these systems. This Federal involvement implies a concomitant Federal responsibility to the public to see that the rail rapid transit systems which it supports financially, and whose use it promotes, operate safely.

Historically, the safety record of rail rapid transit systems has been very good. During the 5-year period ending July 31, 1980, fatal accidents arising from the operation of rail rapid transit trains resulted in 13 deaths. 2/ However, investigations of serious rail rapid transit accidents and incidents during the same period have revealed safety problems which appear not to be unique to individual systems, but industrywide in scope.

These safety problems warrant the most serious consideration because they contain enormous potential for disaster. During peak hours, a single rail rapid transit train carries a "crushload" of 1,500 to 2,000 passengers. Under such conditions, the loss of life in an accident, fire, or other emergency could well be catastrophic.

Because of the continuing potential for catastrophe, on July 28, 1980, the National Transportation Safety Board convened a public hearing on rail rapid transit safety. The hearing brought together representatives of transit system management and labor, local fire departments, national fire safety organizations, and State and Federal agencies in an effort to explore how the safety record of the Nation's rail rapid transit systems can best be maintained.

1/ For the purpose of this report, "rail rapid transit" is intended to mean a heavy rail, transit vehicle railway system constructed on an exclusive, dedicated right-of-way with high-level platform stations and vehicles operated using an external electrical source. This definition excludes streetcar, trolley car and other light rail vehicle service, monorail service, and commuter railroads.

2/ Excludes fatalities involving passengers falling or leaping from station platforms into the path of a train.

During the 2 days of proceedings, the Safety Board heard testimony from 25 witnesses, 3/ including representatives of two Canadian systems. The hearing focused largely on fire safety and on what role the Federal Government should play in rail rapid transit safety.

This evaluation analyzes the testimony received during the hearing and other information developed through investigative and evaluation activities, and presents the findings, conclusions, and recommendations of the Safety Board.

BACKGROUND

Currently, 10 rail rapid transit systems are operating in the United States:

1. Bay Area Rapid Transit District (BART), San Francisco, California, area.

2. Chicago Transit Authority (CTA), Chicago, Illinois.

3. Greater Cleveland Regional Transit Authority (GCRTA), Cleveland, Ohio.

4. Massachusetts Bay Transportation Authority (MBTA), Boston, Massachusetts, area.

5. Metropolitan Atlanta Rapid Transit Authority (MARTA), Atlanta, Georgia.

6. New York City Transit Authority (NYCTA), New York, New York.

7. Port Authority Trans-Hudson Corporation (PATH), New York City-New Jersey area.

8. Port Authority Transit Corporation of Pennsylvania and New Jersey (PATCO), Philadelphia, Pennsylvania, to Lindenwold, New Jersey.

9. Southeastern Pennsylvania Transportation Authority (SEPTA), Philadelphia, Pennsylvania, area.

10. Washington Metropolitan Area Transit Authority (WMATA), Washington, D.C., area.

These systems range in age from about 75 years old to about 1 year old. Many of the systems now in operation are being expanded or improved, and two new systems currently are being designed or constructed:

1. Mass Transit Administration of Maryland, Baltimore, Maryland.

2. Metropolitan Dade County Transit Agency, Miami, Florida, area.

3/ Witnesses are listed at Appendix A; written comments submitted for the record by other parties are listed at Appendix B.

All of these systems are managed by local or regional transit authorities which are public bodies. External safety oversight of rail rapid transit systems is exercised to varying degrees by agencies at the local, State, or Federal levels of government.

Safety Oversight Responsibilities

State/Local Oversight.--Historically, oversight of the safety of rail rapid transit systems at the State level has been limited. According to the Office of Technology Assessment of the United States Congress:

> In many States, regulatory bodies were created in the 1900-10 period to oversee transit operation and protect the public from the monopoly power of private owners. As such, these State agencies were almost exclusively concerned with economic regulation. With the shift of local transit systems to public or quasi-public ownership and operation in the 1940 and 1950 decades, these agencies were left with vestigial responsibilities, and some ceased to exist. Few of these State agencies, then or now, have been active in safety regulation. As a practical matter, then, most local transit authorities are self-regulated in the areas of both economics and safety. 4/

Where formal safety oversight responsibilities exist at the State or local level, they may be vested in a State agency or legislative body. Examples of formal oversight bodies at the State level are: the California Public Utilities Commission for the Bay Area Rapid Transit District (BART); 5/ the Massachusetts Public Utilities Commission for the Massachusetts Bay Transportation Authority (MBTA); and the Georgia Legislature's MARTA Technical Overview Committee for the Metropolitan Atlanta Rapid Transit Authority (MARTA).

At the local level, formal safety oversight authority may be vested in a regional agency. Generally, the regional agency is itself a transit authority which has broad responsibility for all forms of public mass transportation in its regional or metropolitan area. The Chicago Regional Transit Authority, a separate and independent agency from the Chicago Transit Authority (CTA), has the authority to establish safety standards for CTA. In New York, the New York Metropolitan Transportation Authority (New York MTA), as the parent body of the New York City Transit Authority (NYCTA), can intervene in NYCTA safety matters. In November 1977, the New York MTA created the "Permanent Citizens Advisory Committee to the MTA" to represent the ridership on MTA facilities and to serve as a watchdog on MTA finances and operations, including safety matters.

In the case of some rail rapid transit systems, there is no provision for external oversight at the State or local level. For example, the Greater Cleveland

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4/ Automatic Train Control in Rail Rapid Transit, May 1976, p. 187.
5/ The acronym for an organization title is used in this report following the first full reference to the title; for reference, the acronyms used and corresponding organization titles are listed at the back of the report, following the appendixes.

Regional Transit Authority (GCRTA) and the Port Authority Transit Corporation of Pennsylvania and New Jersey (PATCO) are entirely self-regulating and are not subject to oversight by State or local bodies.

Federal Oversight.--At the Federal level, the Urban Mass Transportation Administration (UMTA) in the U.S. Department of Transportation (DOT) is the primary agency responsible for overseeing the safety of rail rapid transit systems. 6/ The agency was established by Reorganization Plan No. 2 of 1968 to administer Federal grants to mass transit under the Urban Mass Transportation Act of 1964. Under the Act, as amended, UMTA (through delegation of powers by the Secretary of Transportation) provides Federal grants to all types of urban mass transit of up to 80 percent of the cost of acquisition, construction, and improvement of facilities and equipment (capital grants), and up to 50 percent of the cost of operations (operational grants).

The Act authorized the Secretary of Transportation to make grants or loans "under such terms and conditions as he may prescribe"; however, safety was not mentioned expressly in the Act until 1970, when the Congress found that:

> ... it is imperative, if efficient, safe, and convenient transportation compatible with soundly planned urban areas is to be achieved, to continue and expand [the Urban Mass Transportation Assistance Act of 1964].... [emphasis added.] 7/

As amended, the Act also provides some general authority relating to safety. In the case of transit systems which are receiving or have received Federal funding under the Act, "no loan or grant shall be made . . . unless the Secretary determines that the applicant has or will have . . . the legal, financial and technical capacity to carry out the proposed project"; and "The Secretary shall assure . . . that the final decisions on the project are made in the best overall public interest, taking into consideration the need for fast, safe, and efficient transportation. . . ." (emphasis added).

The Secretary also is authorized to undertake research, development, and demonstration projects, to contract for and make grants for technical studies, to make grants for research in urban transportation problems and for training, and to prescribe requirements for reporting financial and operating information by transit systems.

The Congress gave the Secretary of Transportation further, explicit safety authority in Section 107 of the National Mass Transportation Assistance Act of 1974 (Public Law 93-503). That Act provides that:

6/ The Port Authority Trans-Hudson Corporation (PATH) formerly was subject to economic regulation as an interstate carrier by the Interstate Commerce Commission. Although PATH is no longer subject to Federal economic regulation, it remains subject to certain Federal Railroad Administration safety regulations for railroads.

7/ 49 U.S. Code 1601a, added by the Urban Mass Transportation Assistance Act of 1970 (Public Law 91-453).

> The Secretary of Transportation shall investigate unsafe conditions in any facility, equipment, or manner of operation financed under this Act which create a serious hazard of death or injury for the purpose of determining its nature and extent and the means which might best be employed to correct it. If the Secretary determines that such facility, equipment, or manner of operation is unsafe, he shall require the State or local public body or agency to submit to the Secretary a plan for correcting the unsafe facility, equipment, or manner of operation, and the Secretary may withhold further financial assistance to the applicant until such plan is approved or implemented. [Emphasis added.]

Before 1978, the Federal Railroad Administration (FRA) had some responsibility for rail rapid transit safety oversight. Under the Federal Railroad Safety Act of 1970 (Public Law 91-458), FRA was authorized to regulate "all areas of railroad safety." The Act, as amended, also provided FRA specific authority to prescribe rules, regulations, orders, and standards for all areas of railroad safety and to conduct research, development, testing, evaluation, and training. FRA was directed by the Act to consider relevant existing safety data and standards in rulemaking actions and to follow established Federal administrative procedures in establishing, amending, revoking, or waiving compliance with a rule, regulation, order, or standard issued under the Act.

FRA was also given general powers under the Act, including, in part, the power to conduct investigations; make reports; issue subpoenas; require production of documents; take depositions; prescribe recordkeeping and reporting requirements; perform and contract for research, development, testing, evaluation, and training; and issue orders directing compliance with the Act or with any safety rule, regulation, order, or standard issued under it. In carrying out these responsibilities, FRA personnel were authorized at reasonable times and in a reasonable manner to enter upon, inspect, and examine rail facilities, equipment, rolling stock (vehicles), operations, and to inspect pertinent records.

The authority to regulate all areas of railroad safety was interpreted by the Department of Transportation as extending to rail rapid transit safety. This interpretation was upheld by a Federal District Court in 1973. 8/

In a 1975 rulemaking, FRA proposed requiring rail rapid transit systems to submit their operating rules, testing programs, and employee training programs to the agency, as railroads are required to do. However, FRA excluded rail rapid transit systems from the requirements after receiving a petition for reconsideration from the American Public Transit Association (APTA). In announcing its decision, FRA stated that:

8/ United States v. Massachusetts Bay Transportation Authority, 360 F. Supp. 698 (D. Mass. 1973).

> In view of the many differences between urban rail rapid transit operations and railroad operations, FRA has decided to develop rail rapid transit operating rules separately from railroad operating rules. It is our understanding that the rail rapid transit industry will voluntarily furnish the necessary information to FRA in the near future. 9/

Two other rulemaking actions which would have applied to rail rapid transit systems were initiated by FRA but were not completed. One advance rulemaking notice issued in 1975 concerned the possibility of establishing requirements for use of signal equipment to provide a train protection system for commuter railroad and rail rapid transit service. 10/ The second advance rulemaking notice solicited comments concerning the possibility of requiring use of safety glass in railroad and rail rapid transit cars. 11/

In practice, the only FRA safety regulations ever applied to rail rapid transit were accident reporting requirements, and these were short-lived. In its 1971 "Special Study of Rail Rapid Transit Safety," the Safety Board found a lack of uniformity among accident data compiled by rail rapid transit systems and recommended on June 16, 1971, that:

> The Federal Railroad Administration establish, by regulation, a uniform system of data gathering and accident reporting encompassing all the rail rapid transit operations in the United States from which statistics can be compiled to determine the status of safety in rail rapid transit operations. The Safety Board is aware that FRA is studying the existing accident reporting system for railroad accidents under the Accident Reports Act, and recommends that rail rapid transit accident reporting requirements be included in any new system of accident reporting. (Safety Recommendation R-71-19.)

In December 1974, FRA issued regulations revising the procedures under which railroads were required to submit monthly reports of accidents and incidents and, in response to the Safety Board's recommendation, extended the applicability of the reporting regulations for the first time to rail rapid transit systems. In its rulemaking notice, FRA cited its authority under the Federal Railroad Safety Act of 1970 to regulate "all areas of railroad safety," which it interpreted as including rail rapid transit. 12/

APTA objected to the reporting requirements and its members did not comply with the requirements initially. While eventually rail rapid transit systems began submitting reports of accidents and incidents dating from January 1, 1975, CTA challenged FRA's authority in the courts. The accident/incident reporting requirements were overturned by a court decision which held that FRA's regulatory authority with respect to railroad safety does not extend to rail rapid transit. 13/

9/ Federal Register, v. 40, p. 2690, January 15, 1975.
10/ Federal Register, v. 40, p. 19209, May 2, 1975.
11/ Federal Register, v. 42, p. 13309, March 10, 1977.
12/ Federal Register, v. 39, p. 43222.

During 1977, while the question of FRA's safety jurisdiction was still in the courts, a major shift was occurring in the Department of Transportation's perception of its role in rail rapid transit safety. Between March and August 1977, the Office of Environment and Safety conducted a study of rail rapid transit safety, and in September 1977, a draft report was circulated within the Department. The Federal Railroad Administrator, commenting on the draft report by memo, 14/ noted that FRA had reevaluated its approach to rail rapid transit safety. According to the Administrator's memo:

> ...based on our own evaluation of the FRA role in RRT [rail rapid transit] safety, we feel constrained to offer recommendations concerning the future roles of UMTA and FRA which differ dramatically from those set forth in the study.
>
> Our view of the role of Departmental components in RRT safety proceeds from the basic premise that the Federal government should not assume a direct regulatory role over instrumentalities of State governments absent a clearly defined need to backstop the commitment of Federal funds.
>
> The traditional [Interstate Commerce Commission]/FRA role in railroad safety has been based on the manifest need for uniform national regulation of interstate commerce. Rail rapid transit systems, on the other hand, operate apart from the general system of rail transportation and perform essentially local service. The RRT systems are, without exception, enterprises conducted by instrumentalities of State governments (or interstate compacts) on a not-for-profit basis. It should be assumed that the States will discharge their responsibilities in a manner consistent with the public interest and will respond appropriately to suggestions related to improved safety.

The Administrator stated in the memo, which was dated 1 month before the court decision overturning FRA's authority, that the Department of Transportation's role in rail rapid transit safety "should be supportive rather than regulatory in a traditional sense," and recommended that UMTA be assigned the lead role within the Department.

When the Office of Environment and Safety published the final report of its study of rail rapid transit safety in February 1978, the original analysis supporting the Department's interpretation of FRA's authority was left intact. However, the report noted that since the initial draft report was completed "there have been some important developments that have had an impact on the Department's role in [rail rapid transit] safety." Those developments included discussions within the Department and the court's decision overturning FRA's regulatory authority. The report stated that:

13/ Chicago Transit Authority v. Flohr, 570 F. 2d 1305 (7th Cir. 1977).
14/ Memo to Acting Assistant Secretary for Environment, Safety and Consumer Affairs, subject: "Rail Rapid Transit (RRT) Safety Review," November 16, 1977.

> The Department has already begun to feel the effects of the decision. FRA personnel were investigating an accident on the Greater Cleveland Regional Transit Authority at the time the decision was issued, and they were not permitted [by the transit authority] to continue. After that, FRA offered to investigate an accident on the New York City Transit Authority; the offer was declined. 15/

The report adopted the approach suggested by the Federal Railroad Administrator, including some of the language used in his memo, and recommended that UMTA be given complete program responsibility for rail rapid transit safety. The following month, the Secretary of Transportation approved the report's recommendations; subsequently, UMTA was assigned complete responsibility within the Department for rail rapid transit safety.

The National Transportation Safety Board.--The Safety Board originally was established in 1967 within the Department of Transportation and was made an independent Federal agency by the Independent Safety Board Act of 1974 (Public Law 93-633). The Safety Board has an oversight role in rail rapid transit safety only to the extent that it is authorized to investigate transportation accidents, including accidents involving rail rapid transit systems; to issue investigative, study, evaluation, and other reports; and to make safety recommendations. The Safety Board has been charged by the Congress as the only Federal agency empowered to make a formal determination of the probable cause of accidents in all modes of transportation. The Safety Board's authority to investigate accidents includes, in part, the authority to require notification of accidents and, when investigating a specific accident, to enter transportation property, to collect evidence, to inspect records, and to subpoena witnesses.

The Safety Board's involvement in rail rapid transit safety dates from 1970, when it began a series of three special studies on transit safety issues. 16/

In 1975, following enactment of the Independent Safety Board Act of 1974, the Safety Board began investigating accidents involving rail rapid transit systems. Since that time, the Safety Board has investigated 15 serious accidents or fires involving 7 different rail rapid transit systems. (See table I.)

As a result of its special studies and accident investigations, the Safety Board has issued 69 safety recommendations to Federal, State, and local agencies, as well as to transit systems and APTA.

15/ "Rail Rapid Transit Safety Review: A Report to the Secretary of Transportation," February 1978.
16/ "Study of Washington Metropolitan Area Transit Authority's Safety Procedures for the Proposed METRO System," September 28, 1970 (NTSB-RAR-70-1); "Special Study of Rail Rapid Transit Safety," June 16, 1971 (NTSB-RSS-71-1); and "Safety Methodology in Rail Rapid Transit System Development," August 8, 1973 (NTSB-RSS-73-1).

Table I.--Major Accident Investigations Conducted by the Safety Board.

System	Accident Date	Accident Type	Report No.
MBTA	August 1, 1975	Rear-End Collision (3 trains)	NTSB-RAR-76-5
CTA	January 9, 1976	Rear-End Collision	NTSB-RAR-76-9
GCRTA	August 18, 1976	Rear-End Collision	NTSB-RAR-77-5
CTA	February 4, 1977	Rear-End Collision	NTSB-RAR-77-10
GCRTA	July 8, 1977	Head-On Collision	NTSB-RAR-78-2
NYCTA*	December 12, 1978	Derailment	NTSB-RAR-79-8
NYCTA*	January 15, 1979	Derailment	NTSB-RAR-79-8
BART	January 17, 1979	Train Fire and Passenger Evacuation In Tunnel	NTSB-RAR-79-5
NYCTA*	February 14, 1979	Derailment	NTSB-RAR-79-8
NYCTA*	March 21, 1979	Derailment	NTSB-RAR-79-8

Recent Field Investigations Related to Fire Safety

System	Accident Date	Accident Type	File Number
SEPTA	September 6, 1979	Train Fire In Tunnel/Station	NYC-79-FR-099
SEPTA	November 13, 1979	Train Fire On Trestle	NYC-80-FR-006
NYCTA**	June 25, 1980	Train Fire In Tunnel	NYC-80-FR-065
NYCTA	December 10, 1980	Train Fire	NYC-81-FR-019
NYCTA	December 11, 1980	Train Fire	NYC-81-FR-020

*The investigation of the NYCTA derailment of December 12, 1978, was expanded in scope to include three subsequent derailments which occurred while the original investigation was in progress. All four cases are presented in a single accident report.

**Investigation is still in progress as of this report date.

The Safety Board convened a public hearing into rail rapid transit safety because it had become increasingly concerned after finding, in its accident investigations, safety problems which appeared not to be unique to individual transit systems, but nationwide in scope. In October 1978, as a result of its increasing concern, the Safety Board designated rail rapid transit safety as one of its highest priorities and initiated a safety objective to stimulate safety improvements. Less than 4 months later, Safety Board investigators were dispatched to San Francisco to investigate the January 17, 1979, fire on a BART train in a Transbay Tube tunnel in which one firefighter died. After two additional serious train fires occurred on the Southeastern Pennsylvania Transportation Authority (SEPTA) during 1979, the Safety Board determined that rail rapid transit safety issues were of sufficient magnitude to warrant a national public inquiry.

RECENT INVESTIGATIONS OF RAIL RAPID TRANSIT FIRES

The Safety Board investigated four serious fires on rail rapid transit trains over a 17-month period. These four train fires, which occurred on three different transit systems, resulted in 1 fatality and 265 injuries.

San Francisco, California

About 6 p.m. on January 17, 1979, BART train No. 117, carrying 40 passengers and 2 BART employees, departed Oakland West Station heading toward San Francisco. Six minutes later an automatic emergency brake application stopped the train about 1 mile into the Transbay Tube under San Francisco Bay between Oakland and San Francisco. Fire began to penetrate the floors of the fifth and sixth cars of the seven-car train, and the train became stranded in the tunnel, unable to move. The fire produced a large volume of dense, black smoke and toxic gases from materials used in the construction of the cars. A BART line supervisor, who happened to be riding in the rear of the train, instructed the train's passengers to move into the lead car, where they waited about 40 minutes before being evacuated. One rescue train carried firefighters and BART policemen to the scene to evacuate the stranded passengers. During the emergency, two trains carrying passengers also were sent into the Transbay Tube as rescue trains in spite of the hazardous smoke conditions. One train with more than 1,000 passengers aboard waited for more than 30 minutes in the adjacent tunnel to pick up passengers evacuated from train No. 117; another train with passengers aboard was sent into the tunnel to evacuate injured firefighters. It took more than 7 hours to bring the fire under control. (Figures 1 and 2 show damage to the train that was on fire; figure 3 shows smoke damage to one of the rescue trains.) As a result of the fire, 1 firefighter died of smoke inhalation and cyanide poisoning after expending his 30-minute supply of oxygen, and 56 persons were injured from smoke inhalation (24 firemen, 17 passengers, 3 emergency personnel, and 12 BART employees). Investigation by the Safety Board and other organizations indicated that, had the evacuation been delayed only minutes longer, the BART fire would have been a major loss-of-life tragedy. Had the train been fully loaded with passengers, the consequences certainly could have been catastrophic.

Philadelphia, Pennsylvania

On September 6, 1979, as the five-car SEPTA Block 8 northbound train approached the Erie Street Station of the Broad Street Subway, there were loud explosions, electrical arcing, and flames beneath the second car, followed by fire and heavy smoke. The train's brakes applied in emergency and the train, filled with a standing load of 1,100 passengers, came to a stop with the first two cars alongside the Erie Street Station platform. The station and tunnel quickly filled with smoke. The train's phone and train controls, including the automatic car door controls, were inoperable.

When the train's doors did not open, passengers panicked and began smashing windows and climbing out on both sides of the train. The motorman opened the door between the operating compartment and passenger compartment of the lead car, trying to get to the car side doors so he could open them manually with his key. When the motorman's door opened, the passengers, seeing the open window in the operating compartment, pushed the motorman back through the door and

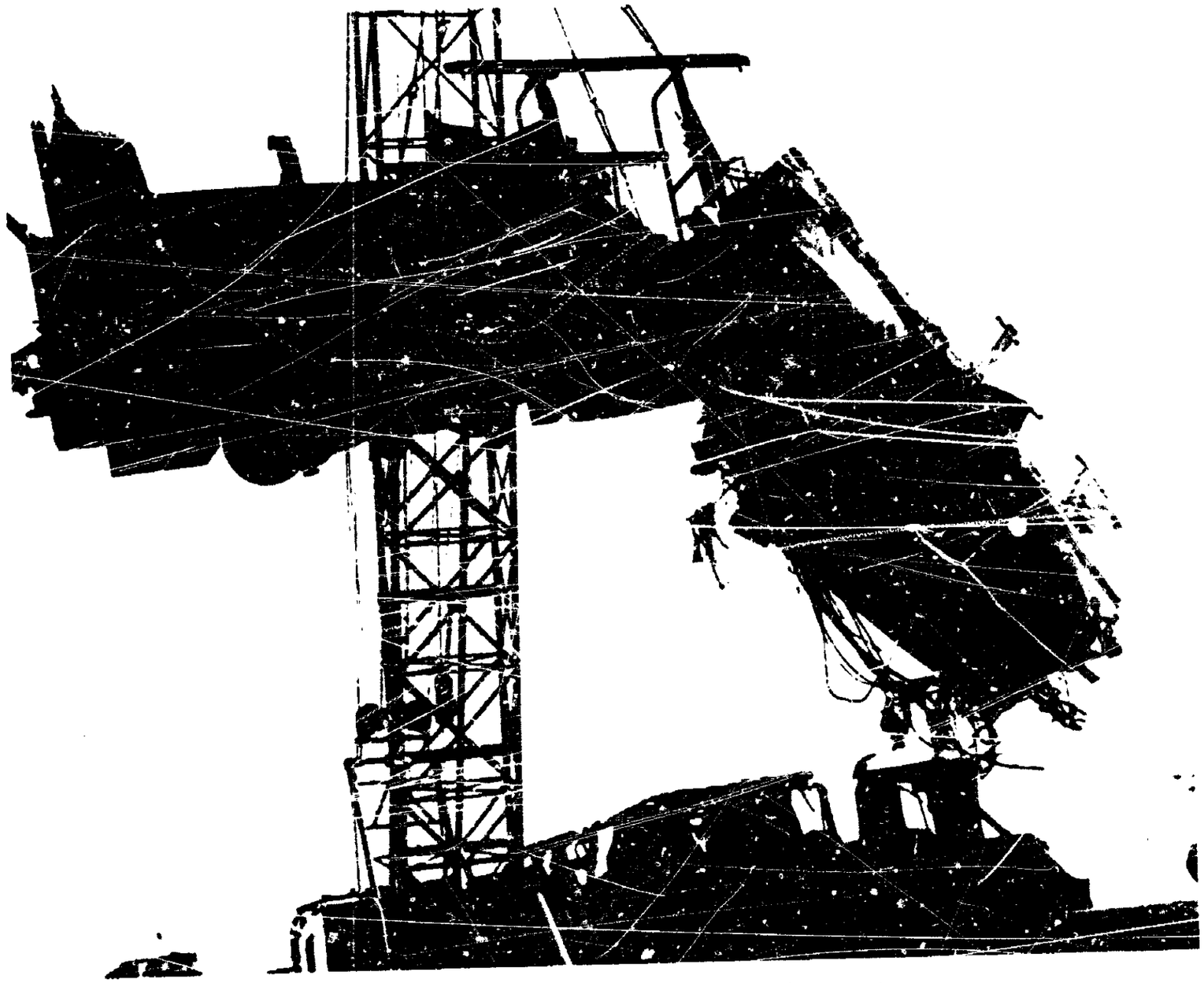

Figure 1.--A crane lifts the wreckage of a fire-gutted car from the track after the BART fire. (Photo courtesy of BART.)

Figure 2.--Train No. 117 after the BART fire, showing damage to car roof and interior. Debris on top of car roof are pieces of concrete from the ceiling of the Transbay Tube, which spalled from the intense heat. (Photo courtesy of BART.)

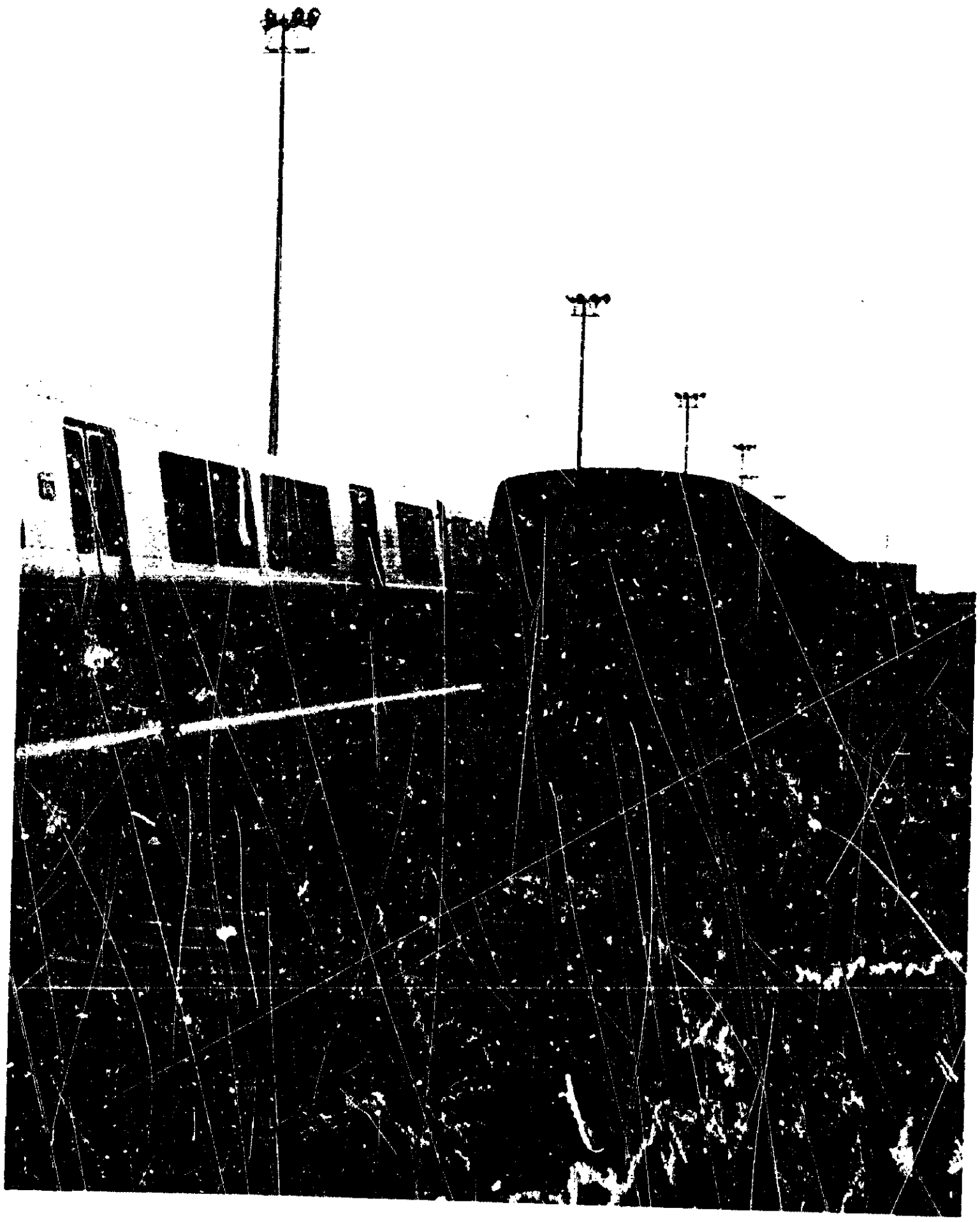

Figure 3.--An undamaged BART car (left), and Train No. 900 (right) after the BART fire. Train No. 900 carried firefighters and BART policemen into the Transbay Tube and received smoke and heat damage as it stood 200 feet behind the train on fire. (Photo courtesy of BART.)

through the window onto the station platform and began climbing through the window to escape.

The conductor, in the fourth car of the train, heard the explosions and saw the smoke. He told investigators that visibility at the time was about 3 feet at his location. He attempted to use the train phone to call for help but the phone was dead. Since the fourth car was still in the tunnel, the conductor did not attempt to open the doors of the car. He forced his way through the crowded cars to the lead car, where he unlocked a car door on the station platform side to permit the remaining passengers on the train to evacuate through the cars and onto the platform.

Electrical power to the third rails on all tracks in the vicinity was shut down, and two trains were stopped in the tunnel behind the Block 8 train. Passengers were leaving all of the trains and walking in the trackways. Some of the passengers were evacuated through the station and others were evacuated from the trackbed by firefighters using ladders placed through vents to the street. The fire was extinguished about one-half hour after it began. As a result of the accident, 148 persons were injured, suffering from smoke inhalation, cuts, bumps, and bruises.

Upper Darby, Pennsylvania

On November 13, 1979, Bullet Car 204, with approximately 63 passengers aboard, left the 69th Street terminal of SEPTA's High Speed Line. After traveling a short distance, the motorman saw sparks shooting across the floor of the passenger compartment, followed by a loud explosion and fire.

The motorman first attempted to reach an employee loading platform approximately 1,000 feet ahead, but the car filled up with dense smoke which obstructed his forward vision. Realizing that the car was over an open trestle, he let it coast forward until it appeared to be safe to discharge the passengers. The car came to a stop adjacent to SEPTA's Victory Avenue Maintenance Shops. SEPTA personnel from the shops assisted in evacuating passengers, extinguishing the fire, and transporting injured passengers to local hospitals.

Of the 51 passengers who were admitted to hospitals, 24 were treated for smoke inhalation and released immediately, 24 were released over the following 7-day period, and 3 who suffered burn injuries were transferred to a hospital having a burn unit. One burn victim remained in the burn unit for 71 days and, when released, still required physical and speech therapy.

The fire was attributed to a short circuit in a high voltage cable which ran through a wireway in the interior of the car. (See figure 4.)

New York City

On June 25, 1980, a southbound 10-car NYCTA train was moving through a tunnel when the conductor heard an explosion and saw smoke in the seventh car and signaled the motorman to stop. When the train stopped, the conductor moved the passengers from the seventh car into the forward cars. After notifying central control, the motorman started back through the cars to determine the extent of

Figure 4.--Interior of Bullet Car 204 following November 13, 1979, fire at Upper Darby, Pennsylvania. Arrow shows origin of fire in high voltage cable. (Photo courtesy of SEPTA.)

damage, but he was unable to go into or beyond the seventh car because of heavy smoke. The train would not respond to propulsion power and it could not be moved.

About 20 minutes later, another southbound 10-car train discharged its passengers at the 86th Street Station and then moved into the tunnel to bridge the distance between the station platform and the rear cars of the burning train. Passengers in the rear three cars of the burning train were then able to walk through the cars of the second train to exit onto the station platform.

The motorman on the disabled train was instructed to move the passengers in the fifth and sixth cars forward into the first four cars, uncouple those four cars from the train, and proceed to the next station. After uncoupling the first four cars, that portion of the train was able to proceed as directed to the next station, where its passengers were evacuated.

When the fire started, 200 passengers were aboard the train. Five passengers, the conductor, and four police officers suffered smoke inhalation and were taken to a hospital.

FIRE SAFETY ISSUES

Fire safety is critical in rail rapid transit systems because fire and smoke in the physical and operating environment of these systems can be extremely hazardous and especially difficult to control, particularly in the confined spaces of underground tunnels.

> "Picture a long, narrow cellar filled with thousands of people, live electrical equipment, and moving vehicles," and, according to Captain Harry Davis of [the New York City Fire Department's] Bureau of Training, you will be picturing the New York subway system. 17/

Or, to take another version, some firefighters say that a rail rapid transit tunnel is like a skyscraper without windows, lying on its side -- conjuring up visions of the disaster movie, "The Towering Inferno." But in many respects such comparisons are inadequate to convey an understanding of the number and variety of problems which complicate fire and life safety in rail rapid transit tunnels and tubes.

Local and national fire officials testified that fire safety considerations have not been adequately addressed. They are particularly concerned about what they regard as the inadequate design of transit systems for fire safety; a lack of adequate consultation with the fire services in the planning and development of systems; inaction or delayed action on fire service recommendations for safety improvements; and the failure of UMTA and the transit industry to fully involve the fire services in their safety activities. The fire officials identified a host of fire and life safety issues which they believe have not been adequately resolved. In addition, information about these issues was developed by the Safety Board through its accident investigations and evaluation activities.

17/ Alan J. Saly, "Hazard Under the Streets: Coping with Subway Fires from Coast-to-Coast," Firehouse, December 1979.

Transit Car Design

Combustibility and Toxicity of Materials.--The development of synthetic materials made available a myriad of materials which are lightweight, attractive, and convenient to use for a variety of purposes. As these materials became available, they were increasingly used in transit car seat cushions, wall paneling, electrical insulation, and other uses for reasons of weight, comfort, convenience, and aesthetics, without adequate understanding and consideration of their characteristic combustibility, smoke-generation, and toxicity when exposed to fire. Because these safety implications were not fully explored before the introduction of these materials in transit cars, their use has resulted in a generation of cars which pose substantial risks to passengers in the event of fire, and which are costly to retrofit.

Once a fire has started, combustible materials used in the interior finish of transit cars--in floors, walls, ceilings, and seats--can contribute extensively to the spread of fire. (See figure 5.) The Fire Protection Handbook of the National Fire Protection Association (NFPA) describes the potential contribution of combustible materials in an enclosed area to rapid flame spread:

> Recent full-scale room and building fire tests have shed new light on the phenomenon called "flashover." Previously, it was believed that combustible gases, released during the early stages of a fire, collected at the ceiling level, gradually mixing with air until within the flammable range. At this point, ignition would occur, suddenly and rapidly; hence, the descriptive term flashover. It is currently held that, while this ignition of combustible gases may occur, it precedes the flashover. Flashover is now believed to be caused by thermal radiation feedback from the ceiling and upper walls, which have been heated by the fire. This radiation feedback gradually heats the contents of the fire area. When all the combustibles in the space have become heated to their ignition temperatures, simultaneous ignition occurs. 18/

The California Public Utilities Commission representative testified that:

> ... tests [on BART cars] demonstrated that in the event that the car floor is breached by fire near a seat, there would be flames at the ceiling within three to four minutes and full involvement (flashover) would occur within no more than a further two minutes. It would be imperative to evacuate people on the incident car and adjacent cars before flashover occurred. Such a fire would also produce enormous quantities of black, toxic smoke.

18/ 14th edition, Gordon P. McKinnon, editor, and Keith Tower, assistant editor, Boston, Mass., January 1976, Section 6, p. 89.

Figure 5.--Combustible and toxic materials in a BART car: carpet, seats, and well liners. (Photo courtesy of BART.)

The potential consequences of the exposure of synthetic materials to fire were indicated by several fires in buildings in the early 1970's. 19/ Several years later, synthetic materials were identified as a critical factor in the October 15, 1976 "Christie fire" in the Toronto Transit Commission's Christie Station. The fire originated on the surface of polyurethane-cushioned seats in the rear corner of the last car of a six-car train. The train was stopped as it was leaving Christie Station, with one and one-quarter cars protruding into a tunnel. The flames spread so rapidly that when firefighters arrived at the station, about 10 minutes after the fire was detected, the smoke and heat were so intense that they were unable to get to track level. The fire occurred shortly before 2 a.m., when there were only four passengers and two crewmembers on the train, and all were evacuated safely. Four 75-foot cars were damaged beyond repair, at a replacement cost of $2.2 million.

Investigation by the Ontario Fire Marshall indicated that the polyurethane seat cushion material was responsible for the severity of the fire. As a result of that investigation, the Toronto Transit Commission conducted fire tests of seat cushion materials to evaluate the suitability of alternative materials. Based on the results of the fire tests, Toronto retrofitted neoprene seat cushions in all of its cars. The Toronto Transit Commission representative testified that:

> . . . during 1980, there have been three incidents in which all of the basic ingredients of the great Christie fire were present except the [polyurethane] cushioning. It is considered that the cost of the seat cushioning retrofit have probably paid for itself.

According to the Washington, District of Columbia (D.C.), Fire Department representative, a single Washington Metropolitan Area Transit Authority (WMATA) car contains approximately 8,355 lbs. of combustible and toxic materials, including, in part:

Polyvinyl Chloride (PVC)	2,291 lbs.
Wool	425 lbs.
Latex Foam Rubber	265 lbs.
Melamine Faced Wood	175 lbs.
Polysulphide	115 lbs.
Chloro-Sulfanated Polyethylene (in car)	73 lbs.
Chloro-Sulfanated Polyethylene (under car)	343 lbs.
Metal Faced Wood	2,390 lbs.
Polyester Foam	307 lbs.
Synthetic Hydrocarbon Hydraulic Brake Fluid	35 lbs. (5 gals.)

The Chief Surgeon of the Board of Police and Fire Surgeons for the District of Columbia described in his testimony the toxicological hazards posed by the use of some of these materials. He observed that electrical arcing between wires coated with PVC insulation produced substantial quantities of phosgene gas and hydrogen chloride in tests conducted by the National Bureau of Standards. Both of these byproducts are strong corrosive gases. The doctor testified that two other chemicals used as insulation in rail rapid transit car electrical cables are even more hazardous: chloro-sulfanated polyethylene and ethylene polyethylene

19/ Natural Fire Protection Association, op. cit., Section 6, pp. 93-94.

tetrafluroethylene polymer. When subjected to electrical arcing, chloro-sulfanated polyethylene may produce phosgene gas and carbonyl sulfide. According to the doctor, "Both are highly toxic gases with a toxicity comparable to hydrogen cyanide on a part-per-million basis and can cause cellular asphyxia (as in a penitentiary gas chamber)." Polytetrafluroethylene (PTFE), the doctor said, may produce perfluoroisobutalene and hydrolizable fluoride, which are 1,000 times more toxic than other polymeric materials such as polyurethane, polystyrene, and PVC. In addition, the combustion products of PTFE are suggestive of neurotoxic action (neurotoxins attack the human nervous system).

The doctor testified that knowledge of the toxicological hazards of plastic and synthetic materials has lagged far behind knowledge of their physical properties, such as flame spread and melting point. However, he said, the toxicological knowledge that has been developed, and the vulnerability of transit car electrical systems to fire, indicate that:

> Plastic and synthetic materials should not be used in subway car construction because of the "flashover" potential and the rapid buildup of toxic gases in a fire situation. Again, it would appear that continued indiscriminate use of those materials in these situations will result ultimately in a tragic loss of life.

The BART fire of January 17, 1979, involved polyurethane seat cushions that burned to produce a dense, black smoke and hydrogen cyanide gas. The cause of the firefighter's death in that accident was attributed to smoke inhalation and cyanide poisoning.

The BART representative testified that when the BART system was designed, the combustibility and toxicity of plastic and synthetic materials was not fully understood. "There wasn't a set of accepted guidelines or performance criteria or standards" to aid the system's planners in evaluating the fire hazards of such materials, he said. Consequently, BART's planners relied on their own expertise and on test methods that were acceptable at that time. Those test methods, the BART representative said, were designed primarily to evaluate the conformity of materials to criteria that the materials be "self-extinguishing." The BART representative testified that its cars met those criteria, which are now obsolete and have been replaced by new criteria and testing methods.

The International Association of Fire Chiefs testified that fire safety guidelines for materials have existed for some time--for example, for auditorium and theater seats--which could be used by transit system planners. The Association said that:

> There [are] a whole series of criteria on these things and information is readily available if you go to the right source. What we're trying to say is, if you have to go through some amalgamated group or you have to go through some specific agency to identify what that information is or what those resources are, then we're saying please do so.

* * * * *

> What we're saying is, let's apply the standards that are available . . . .

The San Francisco Fire Chief testified that he warned BART about the hazards of polyurethane seats in 1976. The National Bureau of Standards began a "Fire Hazard Evaluation of BART Vehicles" in 1977, and in March 1978 issued a final report. One of the recommendations in that report was that BART replace the existing upholstered polyurethane seat material with a more fire-resistant material. After discussions with UMTA, BART selected an alternative material, a type of neoprene, to replace the polyurethane in its seats. Although UMTA approved BART's request for Federal assistance to change the seat cushions in 1978, no funds had been provided before the January 17, 1979, fire.

After the BART fire, the East Bay Chapter of the California Society of Professional Engineers formed an advisory committee to assist in the San Francisco Fire Department's investigation by examining the engineering implications of the accident. The committee found that:

> . . . within five minutes after ignition, a burning BART train in the Transbay Tube could be expected to be completely surrounded by lethal and extremely disabling concentrations of cyanide gas, carbon monoxide, acid aldehydes, nitriles, benzene, and others. These toxic gases, together with large proportions of heavy black soot, would continue to be evolved as long as the fire continued to spread to new fuel areas without development to clean burning conditions at very high temperatures. Aside from any panic resulting from smoke or crowding, the additive effects of these combined gases produce rapid incapacitation in many ways, with time of exposure limited to a minute or so before "knockdown." 20/

The advisory committee analyzed the risk of casualties over the range of possible passenger loadings in a Transbay Tube fire accident similar to the January 17, 1979, BART fire. The hypothetical accident was characterized as involving a disabled 10-car train in the Transbay Tube with an exterior, undercar fire evolving heavy smoke and toxic fire gases, and requiring: (1) immediate evacuation of passengers from the car on fire into adjacent cars; and (2) total evacuation of passengers from the train into the maintenance gallery. The advisory committee concluded that at the lower levels of occupant loading (up to 75 passengers per car, or 750 passengers on the train), successful evacuation without casualties could be achieved with proper emergency planning. As passenger loading increases, estimated casualties increase until, at a crushload of 2,000 passengers, "panic would certainly result under crowding conditions so severe that no survivors could be assured." The advisory committee summarized its findings in a graph which also shows, for comparison purposes, the risk levels for

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20/ Memo to File, "BART Train Fire--Outline of Testimony to be Presented at [California Public Utilities Commission] Hearing," from Edward Bennet, Chairman of the Advisory Committee on BART Train Fire in Trans-San Francisco Bay Tube, East Bay Chapter, California Society of Professional Engineers, March 31, 1979.

the January 17, 1979, BART fire and the May 28, 1977, Beverly Hills Supper Club fire in Covington, Kentucky, which resulted in more than 200 casualties, including 165 fatalities. (See figure 6.)

According to a study sponsored by UMTA:

> . . . manufacturers of transit vehicles and transit authorities have been tightening their specifications regarding flammability and smoke. Some transit authorities have conducted flammability tests on components, such as groups of seats. Others have plans to conduct full-scale tests on old vehicles fitted with a variety of new materials. As a rule, however, they rely on certificates of compliance, with their specifications, from the materials' manufacturers. 21/

In 1976, the Department of Transportation's Transportation Systems Center (TSC) developed preliminary guidelines for materials flammability as part of a project for UMTA. TSC also maintains a materials data bank which provides information on the fire characteristics of some specific materials, where those characteristics have been tested and identified.

Nevertheless, transit authorities have indicated that that they have encountered difficulties both in determining accurately the fire characteristics of specific materials and in developing adequate safety specifications. The representative of MARTA testified that:

> During the preparation of material procurement specifications by the car builder, extreme difficulty was experienced in obtaining accurate statements of these properties for the specific materials as produced by industry suppliers. A clear guideline to production material physical properties, including fire and smoke characteristics, would be invaluable to users and car builders.

One problem is that within certain classes of materials, fire characteristics can vary considerably from one type to another. Neoprene materials, for example, include all polymers of chloroprene, and different types of neoprene, although similar in composition, can differ considerably in such properties as toxicity, flame spread, and smoke generation when exposed to fire.

After the BART fire, the California Public Utilities Commission originally ordered BART to replace the polyurethane materials on the seat assemblies in its cars by the beginning of January 1980. 22/ BART subsequently developed a plan for a seat replacement program and reported to the Commission:

21/ W.T. Hathaway and I. Litant, "Assessment of Current U.S. Department of Transportation Fire Safety Efforts," Transportation Systems Center, Final Report No. UMTA-MA-06-0051-79-4, July 1979.
22/ California Public Utilities Commission, Decision No. 90144, April 4, 1979.

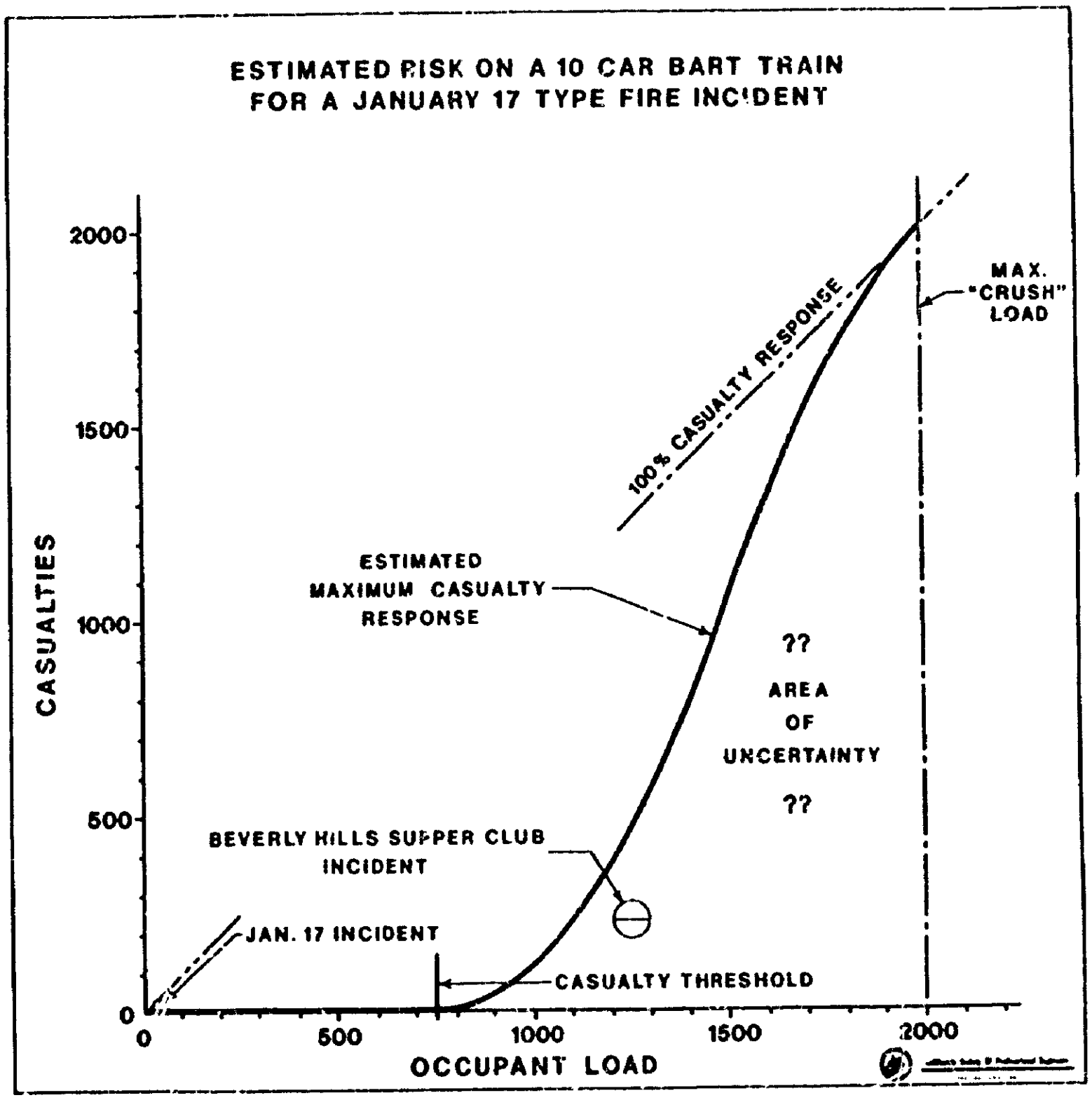

Figure 6.--Estimated risk of casualties relative to occupant load on a 10-car BART train for a fire in the Transbay Tube involving fire on exterior of train, producing smoke and toxic gases, and requiring evacuation on foot. (Graph courtesy of East Bay Chapter, California Society of Professional Engineers.)

> Prior to the issuance of this order BART was in the process of procuring new seats made of neoprene to replace the existing seats. The choice of neoprene was based upon recommendations by the National Bureau of Standards and [UMTA]. Neoprene provides better fire retardant properties under certain conditions. This selection was reevaluated in light of the Transbay Tube fire experience and further information on neoprene fire performance. The results indicated that the neoprene selected would not significantly improve the fire performance of the vehicle and the material was removed from immediate consideration. 23/

BART began to search for a more suitable replacement material, but found that the task was complicated by several factors. The seat replacement program plan explained some of the complexities involved:

> Acceptable standards and criteria for the selection of appropriate materials for use in a transit vehicle do not exist and it is incumbent upon [BART] to develop sufficient data to insure that any replacement material provides significant improvement without introducing additional hazards. . . .
>
> * * * *
>
> The problem of materials flammability and toxicity is not unique to the rail transit industry. A considerable amount of research for improved materials has been conducted for the commercial airlines, the furniture industry, and the seating industry in general. All of this research has not provided a material available in production quantities that will eliminate all of the problems associated with polyurethane foams.
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> * * * *
>
> There are several activities currently underway to develop ways to determine acceptability standards for materials in various applications. If one of the proposed methods for defining what is acceptable could obtain industry consensus, then some standards could be developed for particular applications. It appears that each organization involved in these activities is convinced that the method they have selected is the "only" viable method, and the chances of any standards being developed is remote.

23/ BART, "BART Seat Replacement Program Plan," submitted to the California Public Utilities Commission July 3, 1979.

> The problem of standards development is compounded by the diversity of test methods and techniques, which have been developed as laboratory tools to answer very specific questions. Characteristics of individual materials can be determined and verified by laboratory test. The synergistic effects of several materials used to form an upholstered seat cushion is very difficult to determine and there is very little agreement in the industry as to what are the best test methods. This situation is particularly critical in determining the toxicity aspects of a burning seat cushion.
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> * * * *
>
> Because of the wide variety of applications for non-metallic materials, producing organizations have found it necessary to develop a wide variety of very similar materials. Though there may be only a minor difference in the formulation of a material, this minor difference may drastically alter its flammability or toxicity characteristics. Consequently, neither the trade name or the generic name of a particular material is necessarily an accurate guide to performance in a fire situation. Some companies have elected to keep the precise formulation of a material as proprietary information, so one has to rely on supplied test data. It has been found that minor differences in production batches of the same material have resulted in significant differences in fire performance characteristics.

BART concluded in its program plan that "The lack of standards, criteria and the conflicting data presented by manufacturers has required [BART] to develop its own test plans to insure proper materials selection." That selection, the plan stated, would be made based upon "judgmental analysis" of test results.

BART devoted extensive efforts to searching for suitable seat materials, including considerable screening and testing of seat cushion and fabric materials. The Commission's deadline subsequently was extended several times because of the time required to test and evaluate alternative materials, problems with the workmanship of new seat cushions, and the business failure of a subcontractor on the project. 24/

In spite of the extensive efforts BART devoted to finding an acceptable seat material, the California Public Utilities Commission staff found the results inadequate. It reported that:

> The area of flammability and toxicity studies is a very complex subject because of:

24/ California Public Utilities Commission, Decision No. 91466, March 18, 1980, and Decision No. 92222, September 3, 1980.

1. The diversity of test methods and techniques.

2. Wide range of parameters involved.

3. Large number of material types and composition.

4. Difficulties in the interpretation of test data to the actual fire situation.

5. Lack of acceptable standards and criteria. 25/

The staff's report suggested that because of the complexities involved, adequate evaluation of the fire safety of materials would be a monumental task for a single transit authority. After analyzing BART's evaluation with the aid of a consultant, the Commission staff concluded that: the testing conducted was not sufficient to assess flammability and toxicity with confidence; more testing would be required to assess toxicity effects; the behavior of an actual fire could not be predicted from the testing; no long term toxicity or lethal dosage studies were conducted; potential damage from hydrogen chloride gas was not estimated; no attempts were made to test the relative contribution of various thicknesses and areas of seat material to fire and smoke hazards; the effects of a variety of parameters were not considered in BART's analysis; and no attempts were made to relate the laboratory behavior of seat materials to actual fire conditions.

The report of the Commission's staff also found that the material selected by BART as a result of its screening and testing program, a type of "low-smoke" neoprene, could pose serious toxicity hazards:

> Because of the large chlorine content of the neoprene under the influence of applied heat, hydrogen chloride gas will be liberated. Test data show a ten-fold increase in the concentration of hydrogen chloride gas in the case of neoprene foam over polyurethane foam. The hydrogen chloride is corrosive in the human airway. Inhalation of 50 parts per million for a short term is not fatal but it stops its victim in his tracks, restricting his capacity to escape. Impinging on the moist human eyeball, hydrogen chloride gas becomes hydrochloric acid. Pain and eye tearing are intense and even before smoke becomes thick enough to reduce visibility, the victim cannot see.

The alternative selected by BART was approved by the Commission over the objections of its staff, which recommended that BART be directed to install steel frame seats and to use thinner neoprene cushions than BART's alternative called for. 26/ After the delays encountered due to the screening and testing program

25/ Haji M. Jameel, Review of BART Vehicle Seat Replacement and Fire-Hardening Program, Transit Districts Safety Branch, California Public Utilities Commission, Case No. 9867, February 1980.

26/ Letter from Manager, California Public Utilities Commission Transit Districts Safety Branch, to General Manager, BART, January 3, 1980.

and problems in completing the project, the retrofit of new seat cushions in all BART cars was completed on November 1, 1980, more than 21 months after the BART fire.

Resistance to Fire Penetration.--Because of the large quantities of combustible and toxic materials in transit cars, it is critical that cars be designed to resist fire penetration for sufficient time to evacuate passengers safely. Fire officials testified that 90 percent of all transit car fires are electrical, and 65 percent of transit car fires originate under the floor of the car, where the car's heavy duty electrical equipment is located. The bodies of transit cars generally are constructed of aluminum, which burns at a lower temperature than that of the heat that can be induced by third rail electrical arcing. Aluminum also is used in the floors of transit cars on some systems.

The Washington, D.C., Fire Department representative testified that "there is an alarming potential for disaster in the [WMATA] system" because of the relative ease with which an under-car fire could penetrate the aluminum-faced plywood floor to reach the combustible and toxic materials in the car's interior. Currently, the car floors are constructed of plywood sandwiched between three separate layers of aluminum, which WMATA believes provides an adequate level of fire resistance. The Fire Department cited a National Academy of Sciences report which recommended that WMATA's car floors be faced with steel, rather than aluminum, to increase resistance to fire penetration. 27/

In reply to the recommendation, WMATA wrote to the National Academy of Sciences that:

> [WMATA] is in fact employing the very best electrical engineering design and taking particular care of floor design to prevent a fire from entering the car body. It is believed that the adequacy of the floor design will be verified by tests now being completed by the National Bureau of Standards. 28/

The National Bureau of Standards tests referred to by WMATA concluded that WMATA car floors are unlikely to allow rapid penetration of fire and smoke from a fire beneath the car. However, the tests were limited to a smoke penetration test on the floor of a car; small, laboratory fire tests on the carpet, wall liners and seating materials; and a series of fire tests on a full-scale mockup of a car interior. According to the National Bureau of Standards report, no fire tests were conducted on car floors:

> Since the car's floor assembly could not, for economic reasons, be exposed to an actual fire condition, these tests were designed to be non-destructive and to reveal the

27/ "Fire Safety and Fire Hazards Related to Polymeric Materials in Cars of the Washington Metropolitan Area Transit Authority," 1975.
28/ Letter from WMATA to the National Academy of Sciences.

> existence of any "holes" in the floor assembly as a result of construction procedures. 29/

The floors of BART cars are constructed of outer and inner 0.06-inch aluminum sheets, with the void between the sheets filled with a 2-inch core of polyurethane foam for rigidity and insulation. The California Public Utilities Commission representative testified that tests showed that a fire could burn through the floor of a BART car in as short a time as 2 or 3 minutes. One of the recommendations which resulted from the National Bureau of Standards' "Fire Hazard Evaluation of BART Vehicles" in March 1978 was that "BART develop a means for hardening the floor assembly against sub-car fire penetration at least in those areas most vulnerable to fire exposure."

After the BART fire, the Commission ordered BART to submit a plan by early January 1980 for fire hardening the floors of BART cars. The plan was to include a timetable for reduction of the fire hazards associated with the floors and other materials in at least 20 percent of the BART cars operating in the Transbay Tube and another long tunnel not later than April 4, 1980.

BART subsequently requested an extension of time to complete its fire hardening plan in order to undertake a more comprehensive fire hardening program. The Commission staff reviewed BART's request and found that:

> Fire hardening of BART's cars is a much more complex task than the replacement of seats. There are many more car components which are potentially flammable to identify. These components must be subjected to rigid and complete testing and analysis. In addition, each component of the car must be evaluated while keeping in mind the component's relationship to other flammable parts of the car. Once problem components are identified through experience and testing, they must be modified or replaced by other materials. Once again, these new materials must be thoroughly tested and analyzed in order to properly evaluate their fire resistance characteristics. 30/

According to the Commission staff, the complexity of the fire hardening program indicated that long-term planning and testing will be required. The Commission approved BART's request for an extension of time to January 15, 1981; later, BART requested a further extension. If the deadline currently proposed by BART is approved by the Commission, BART's fire hardening plan will be due at the Commission on March 2,1981, more than 2 years after the BART fire.

29/ Emil Braun, "A Fire Hazard Evaluation of the Interior of WMATA Metrorail Cars," National Bureau of Standards, October 1975, p. 4.
30/ Staff Counsel to the California Public Utilities Commission, "Staff's Recommendations Pertaining to Fire Hardening and Its Response to First Amended Petition of the San Francisco Bay Area Rapid Transit District to Extend Time for Compliance With California Public Utilities Commission Decision No. 90144," October 2, 1980.

According to fire officials, standards specifying minimum resistance of transit cars to fire penetration are needed to provide a reasonable level of safety to passengers. MARTA, the newest rail rapid transit system in operation, testified that its cars are designed to specifications which require that the floor resist fire penetration for 1 hour. However, MARTA is the first rail rapid transit system to use this type of time performance specification.

Emergency Exit from Cars

Currently, there are no uniform criteria for emergency exits in rail rapid transit cars. Because a single car may carry as many as 200 or more passengers, exit provisions for transit cars are just as important as exit provisions for buildings in which large numbers of people assemble (such as theaters and meeting halls). Such places of public assembly must meet exit criteria and limits on maximum occupancy set forth in State health and safety codes which apply to transit stations but not to transit vehicles.

Fire officials, citing the danger of large numbers of passengers being trapped in burning or smoke-filled transit cars, emphasized the importance of providing adequate means of emergency exit from cars. Their concerns include the design, marking, and emergency lighting of exits, as well as information for passengers on manual operation of exit doors and the location and use of exit ladders when they are provided.

Often the need for better provision for emergency exit from cars is not recognized until after a serious fire occurs. The San Francisco Fire Chief noted that emergency instruction signs and leaflets were added to BART cars after the BART fire. The Toronto Transit Commission testified that portable ladders were added to the system after a major fire in 1963, and after the Christie Fire in 1976, a public education program was established, on the recommendation of the Ontario Fire Marshall, to inform passengers of the action to be taken in the event of a fire emergency.

While fire accidents have resulted in some improvements and increased attention to emergency exit provisions, there are indications that serious problems remain. In the SEPTA fire on September 6, 1979, the train's automatic door controls were inoperable and car doors could not be opened manually by passengers because they were locked and had to be opened with a key. The train's motorman and conductor had door keys, but the conductor was at the rear of the train, and the motorman was not able to move through the crowded first car to reach the doors. Panic broke out and many passengers smashed windows to escape. A transit industry publication reported the reaction of some of the passengers involved in the incident:

> "I was never so scared in my life," said Connie Muraresku of Philadelphia's Olney section. "We almost got to Erie Avenue when we started seeing electric sparks and hearing explosions. Then the doors were locked and we were trapped.

> "We had to break windows. Everybody was breaking windows. I climbed out of one, grabbed hold of a pole and jumped down to the tracks," she added.
>
> * * * *
>
> "Granted, a lot of people panicked," said Roberta Holdsworth of North Philadelphia, another passenger on the ill-fated train. "But you can't condemn them for doing what they thought was necessary to survive." 31/

Most of the 178 people injured in the accident suffered from smoke inhalation and cuts received when the windows in the cars were broken.

NYCTA riders could face similar exit problems in an emergency. The Permanent Citizens Advisory Committee to the MTA contacted the Safety Board to express its concern about locked doors on NYCTA cars. The Committee reported that in its study of fire conditions on the New York system, it found that NYCTA had disconnected the emergency door switches which permitted passengers to exit from the newer transit cars during emergencies. "As a result," the Committee wrote, "riders may be trapped inside cars until help arrives, and riders in one car of a train have no effective means of informing train crews in other cars of their plight." The Committee said that NYCTA's action in disconnecting the switches was taken without consulting or informing the New York City Fire Department. 32/

The Washington, D.C., Fire Department has expressed concern about WMATA car exit provisions. In WMATA cars, a manual control for each side door is hidden behind a wall panel which must be unscrewed to reach it. There are no instructions or markings to tell passengers where the door control is located or how to operate it in an emergency. Fire Department officials told Safety Board representatives in an interview that they have asked WMATA repeatedly to mark the location of manual door controls and provide instructions to passengers on their operation. They say that WMATA has refused to do so because it does not want passengers exiting cars when it may not be safe to do so (for example, when third rail electrical power is on), and because juveniles or vandals might tamper with door controls. WMATA prefers to attempt to move a train in trouble to a station where passengers can be evacuated safely and to rely upon the motorman to provide emergency instructions to passengers via the train public address system when an evacuation is necessary. In November 1980, WMATA finished adding signs in all WMATA cars which inform passengers: "In emergency call train operator on intercom at either end of car." However, fire officials remain concerned that passengers could be trapped in cars, without knowing how to open the doors, if the train's public address system fails or if the train operator is incapacitated and cannot give emergency instructions. In any case, the necessity of locating

31/ David C. Hackney, "SEPTA's Getting Older Not Better," Mass Transit, Vol. VII, No. 10, October 1980.
32/ Letter to the Safety Board from the Chairman of the Permanent Citizen's Advisory Committee to the MTA, August 7, 1930.

and unscrewing the proper wall panels could pose problems under conditions of darkness, fire, smoke, and possibly panic.

Washington, D.C., fire officials also expressed concern that emergency ladders for use in exiting the ends of trains are enclosed under certain seat assemblies in each car, and the cars contain no information about the location, or even the existence, of the ladders.

On other transit systems, manual door controls generally are readily accessible to passengers and placards, or signs, give their location and instructions for their use -- although the manner of presenting the information varies. A representative of PATH testified that ". . . we do acquaint people with exit doors and exit means in various walks of life, so I see no particular problem with doing it on a transit system, either. It depends upon the nature of the particular information."

The BART representative testified that emergency and evacuation information is now provided in brochures available in stations and is disseminated through marketing techniques and other public information activities (such as visits to schools) to get the information to the public. According to the BART representative, ". . . essentially we tell [the public] what to do in case an evacuation is necessary, where fire extinguishers are, how to open the doors with the emergency door release, where to evacuate to a safe place of refuge." This type of information was not provided to BART passengers until after the BART fire.

Emergency Tunnel Ventilation

Fire officials consider emergency ventilation a fundamental safeguard in rail rapid transit tunnels. Emergency ventilation systems must be capable of rapidly removing smoke and heated gases, and procedures for control of air flow must be carefully preplanned to direct smoke away from routes of passenger escape and fire service access. Each transit system determines its own emergency ventilation requirements and establishes procedures for operation in a fire emergency. In some cases, however, ventilation systems or procedures have been found to be inadequate in actual fire conditions. Fire officials are concerned that some tunnels still have inadequate emergency ventilation systems, or in some cases, no emergency ventilation system at all.

When a train crashed and caused a major fire on Montreal's transit system in 1971, 5 years after the system began operating, the tunnel emergency ventilation system failed to operate properly. As a result, the emergency ventilation system was upgraded to increase its reliability, and emergency fans of larger capacity were included in new tunnels as the system was expanded. Montreal's representative testified that when another train fire occurred in 1974, the upgraded emergency ventilation system performed reliably, permitting the rapid evacuation of passengers from the train and the tunnel. However, fan operation was not coordinated effectively with the fire service, and when firefighters arrived to combat the fire, they were driven back when smoke was drawn in the wrong direction.

In the January 1979 BART fire, emergency procedures for ventilation in the Transbay Tube proved to be inadequate. When BART central control initially opened an emergency ventilation exhaust damper in front of the stranded train, dense, black smoke from the burning cars at the rear of the train was pulled forward and engulfed the lead car, where passengers were trapped. When the train operator reported that the smoke was increasing, BART central control closed the damper in front of the train and opened a damper behind the train. These actions cleared the smoke from the front of the train but pulled smoke directly into a rescue party of firefighters and BART personnel who had just arrived at the scene on another train. The heavy smoke caused the group to become separated in the tunnel; part of the group returned to the train they had left, while the majority retreated to the maintenance gallery and then moved through the gallery to assist passengers in evacuating the burning train. 33/

In Boston, MBTA currently has only one fan in the system that is reversible and can be operated remotely from central control. All other fans are exhaust only, and according to MBTA, many are obsolete. MBTA has requested UMTA funding for a 10-year, multiphase, systemwide tunnel ventilation program to upgrade its emergency ventilation capability. However, MBTA is not sure when it will get the money to undertake some portions of the improvement program and has informed the Safety Board that "The completion of the program is dependent upon the annual availability of UMTA funding, as well as other Authority demands on Federal funding." 34/

Evacuation from Tunnels

Transit systems generally plan to evacuate passengers from tunnels on foot only as a last resort. When a fire occurs in a tunnel or on a train, they prefer to attempt to move the train to a station, uncoupling cars on fire first, if necessary (after moving the passengers into other cars), or to evacuate passengers to another train. However, circumstances may require an evacuation on foot. The train may be disabled and conditions may make it impossible to uncouple burning or disabled cars (as in the BART fire); the train may be too full to transfer passengers between cars; there may not be time to wait for a rescue train; or passengers may panic and begin exiting the train prematurely.

In spite of the possibility that a tunnel evacuation may become necessary, transit tunnels have not been designed to provide adequate means of escape for the large numbers of passengers that could be involved in a fire emergency. In most cases, if safety features have not been built in during tunnel construction, they cannot be added later. Where retroactive installation (retrofit) of safety measures is feasible, fire officials state that they often are frustrated by inaction or delayed action by transit systems to implement them because of the cost of retrofitting safety equipment. Consequently, fire officials have called for more effective application of emergency evacuation design requirements in the construction of new transit tunnels, and for corrective action to alleviate safety problems in

33/ "Railroad Accident Investigation Report--Bay Area Rapid Transit District Fire on Train No. 117 and Evacuation of Passengers While in the Transbay Tube, San Francisco, California," January 17, 1979 (NTSB-RAR-79-5, July 17, 1979).
34/ MBTA letter to the Safety Board, July 15, 1980.

existing tunnels. Major concerns are the design and capacity of tunnel walkways, emergency lighting, the location, marking, and directions to exits, and the operation and maintenance of emergency exit doors.

Walkways.--Most transit system tunnels have a safety walkway along one wall. When a tunnel evacuation is necessary, many transit systems prefer, where possible, to evacuate passengers from the side doors of cars onto the walkway, rather than onto the trackway where the third rail can pose a serious electrical hazard. Walkways vary in width among transit systems, as well as within a single system. A walkway width of about 20 to 30 inches is fairly typical of most tunnels, with a dropoff of about 2 1/2 to 3 1/2 feet to the trackbed below. (See figure 7.) A handrail may or may not be available, and pipes or equipment protruding from the tunnel wall, or the curvature of the wall itself, may further limit the effective space available on the walkway.

The narrowness of walkways can pose a significant obstacle to successful evacuation, particularly if a full trainload of 1,500 to 2,000 passengers is involved. According to NFPA's Fire Protection Handbook, "Crowding of people into spaces where 3 sq ft or less per person is available under nonemergency conditions has resulted in panic situations and injuries."

The Handbook notes that studies have shown that in level walkways, crowding significantly reduces the rate of flow even under nonemergency conditions, and that "the problem becomes urgent under fire conditions when concentrations approach one person every 3 sq ft." 35/

The walkway surface also requires careful consideration in tunnel planning. On the BART system, the Berkeley Hills Tunnel was constructed with a grated walkway which could pose problems with narrow and high heel shoes. UMTA recently awarded a grant to BART to modify the walkway to eliminate the potential for safety problems.

Emergency Lighting.--Normal lighting in transit tunnels is extremely limited, and most lighting fixtures are located near the top of the tunnel where visibility can be reduced to near zero when smoke is present. One of the passengers in the BART fire testified before the California Public Utilities Commission at its hearings on the BART fire:

> . . . we had a very narrow walkway to walk on, and a handrail, and we walked about 20 yards, and the handrail gave out, it ended, and there was -- it looked like an opening in the cement wall, and the walkway started to go down at an angle, and then there was a pipe, on the other side of the gap of about four feet, that was a handrail again. At that point, the smoke was incredibly dense. I could not see the walkway. I did not have anything to hold onto. And I could just barely hear the firemen in front of me yelling, "This

35/ Op. cit., Section 6, p. 89.

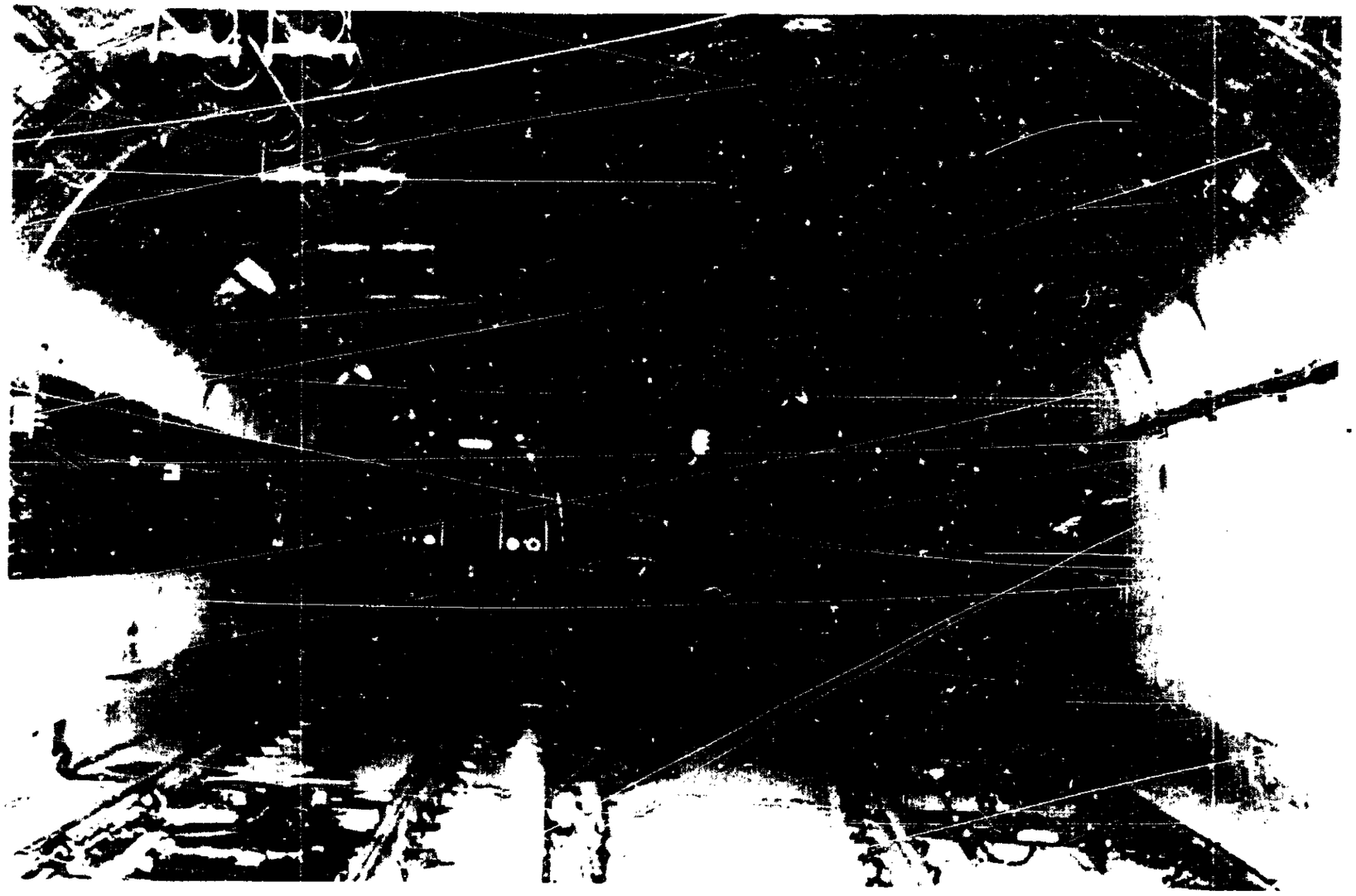

Figure 7.--In an emergency tunnel evacuation, passengers may have to exit train from sided doors onto a narrow walkway and proceed single-file to a station or emergency exit. Walkways shown are 20 inches wide and elevated more than 2 1/2 feet above the adjacent trackbed. (Photo courtesy of WMATA.)

way out." And I got really panicked, because I thought that, "This is it." I had no idea where I was. I was completely disoriented as to where I was supposed to go, because the walkway started to dip down.

* * *

. . .you couldn't see or feel anything. You had no way of knowing where you were going. The only thing that kept me going was I wanted to get out of the smoke and I couldn't breathe. . . . there was someone in front of me yelling, "This way out." So, I kept moving toward that voice. . . . it was so dark from the smoke and you couldn't see anything. 36/

The difficulty of negotiating a narrow walkway with a 3 1/2-foot dropoff at one side may be exacerbated if passengers are unable to see where they are going. For this reason, fire officials testified that emergency lighting must be included in the design of transit tunnels and should be arranged for maximum effectiveness in smoke conditions.

Directions to Tunnel Exits.--Directional signs to exits are a familiar sight in certain types of buildings, such as high-rise and commercial buildings and places of public assembly. These signs are required by local fire codes and are designed to standard criteria. All rail rapid transit systems use signs located at intervals throughout tunnels to give directions to exits as well as to provide one means of identifying locations within tunnels. These signs, called "chain markers," generally bear arrows and numbers to indicate the direction and the distance in feet to the nearest stations and/or emergency exits in either direction.

There are no standard criteria in use by rail rapid transit systems for chain markers; chain markers vary from one transit system to another, and in some cases within a single system, in the amount of information, the way it is displayed, the interval between markers, etc. For example, some transit systems include the word "exit" on chain markers and some do not; and some chain markers do not clearly indicate that the numbers displayed represent the distance in feet to the nearest exits. These types of chain markers may be understood by persons who are familiar with them, but they could be meaningless to passengers in the event they have to evacuate a tunnel on foot.

Since there is no standard distance for the interval between chain markers, each transit system must determine the interval, which may be included in agreements with local jurisdictions. The interval between chain markers in CTA tunnels varies from 200 feet in the State Street and Dearborn Subways to greater intervals in its Kimball Subway. WMATA, by agreement with one local jurisdiction, has chain markers located at intervals of 160 feet in tunnels in that

36/ Public Utilities Commission, State of California, Reporter's Transcript: "Investigation on the Commission's Own Motion into the Safety Appliances and Procedures of the San Francisco Bay Area Rapid Transit District," Case No. 9867 v. 25, February 13, 1979.

jurisdiction. 37/ However, officials of the Washington, D.C., Fire Department told Safety Board representatives in an interview that they believe chain markers should be no farther apart than 100 feet. There appears to be a variety of opinion among transit authorities and fire officials as to what interval is adequate, and there are no objective criteria for measuring or evaluating the distance requirements.

Similarly, there are no uniform criteria in use by transit systems to determine performance requirements for chain markers in terms of visibility, although the markers' effectiveness depends upon the ability to be seen and to communicate information. An objective method of measuring performance also is important because accumulation of dirt and grime can cause performance to deteriorate over time. For example, the CTA representative testified that the chain markers in one older tunnel had become "dingy and dull." He testified that CTA is considering designs for new chain markers, possibly using a highly reflective material, for improved visibility. The representative said that the existing chain markers are flush with the tunnel wall, and "until you are almost in front of them, you cannot tell that they are there." Consequently, CTA is considering having the new chain markers stand out from the tunnel wall so they can be seen at a greater distance.

Exits.--Some transit tunnels have trackways which are separated from each other by concrete walls with fire doors, permitting evacuation from one trackway to an adjacent trackway in the tunnel. Between the two trackways in BART's Transbay Tube, an enclosed maintenance gallery also serves as a route for evacuation and emergency services access. In systems where there is no gallery separating the trackways, crossover passages where passengers and firefighters can cross from one trackway to another may be 1,000 feet apart. Other tunnels have two, three, or four trackways in a single train bore, providing no alternative for stranded passengers but to exit toward one end of the tunnel or the other, where evacuation may be effected through stations or, in some cases, through vertical vent shafts equipped with stairways or ladders.

According to the NFPA's Handbook, where conventional stairways are constructed in vent shafts, "Unless the stairway is completely separated from the vent shaft by 2-hr fire resistant construction and adequate control of air currents within the bore is maintained, this concept is extremely risky, since smoke and heat may contaminate the vertical exitway." Vertical exits, in effect, can act as chimneys. The Handbook goes on to state that "Under no circumstances should required exitways contain straight vertical ladders." CTA and WMATA are two systems which use vertical ladders in vent shafts as one means of emergency exit from tunnels. In some cases, passengers may have to climb straight up a ladder as high as 160 feet to reach an exit.

Passengers who have managed to exit from a train on fire, negotiate a narrow walkway and climb a high vertical ladder have only to open an exit door to evacuate to safety--if the door can be opened. Transit systems have experienced

37/ Prince Georges County, Maryland, "Fire Protection, Equipment and Life Safety Agreement for the [WMATA] Rapid Rail Transit System" Master Agreement No. MA-024, August 1, 1972, Supplement dated August 1976.

problems with the operation of exit doors, particularly horizontal doors which must be pushed open from below. Washington, D.C., Fire Department officials told Safety Board representatives in an interview that some emergency exit doors in the WMATA system have horizontal doors as heavy as 2,000 pounds which were designed to support the weight of service vehicles driving over them. The doors are assisted by springs designed to permit a person to open them by applying 30 pounds of pressure; however, fire officials said that the springs weaken over time and may actually require 100 pounds of pressure to open. The fire officials said that doors of this type should be subject to more frequent maintenance, inspection, and testing to assure that they are kept in operable condition.

In his testimony, the CTA representative also emphasized the importance of testing and inspecting emergency exit doors. He described a problem which was encountered when CTA staff guided Safety Board representatives on a tour of an area which included an emergency exit, on July 31, 1980. Attempts to open the emergency door from within failed, although it was opened readily from outside. The CTA representative testified that subsequent investigation by the transit authority revealed that the internal door latch mechanism had been jammed as a result of trucks illegally driving over the door, which was flush with a sidewalk, as they entered and left an adjacent building construction site.

Under the exit conditions prevalent in rail rapid transit systems today, passengers may not have time to exit safely under fire and smoke conditions. In his testimony, the NFPA representative suggested that an enclosed passageway, similar to the one in BART's Transbay Tube, might offer the best means of providing a safe exit passageway for passengers, if properly designed for smoke control.

In the BART fire, however, the maintenance gallery filled with smoke which entered through an emergency door that had been left open as firefighters and BART personnel retreated from the smoke-filled tunnel into the gallery. Firefighters attempting to reach the stranded train through the gallery were turned back by heavy smoke, and one firefighter, overcome by smoke and toxic gases, died after collapsing in the gallery. The NFPA representative, citing the problems identified as a result of the BART fire, testified that "Tunnels and tubes in other locations or in other rapid transit systems may provide even less chance of survival during a major fire."

Emergency Procedures - Training, Drilling, and Testing

All rapid transit systems have established procedures to be followed in various types of emergencies. Procedures are specified in such areas as notification of fire services, clearing emergency areas of passenger trains, shutdown and restoration of third rail power, the intake and exhaust operation of emergency ventilation fans and dampers, evacuation of passengers, onscene coordination with fire services, and actions to be taken by train motormen and other employees, as well as by emergency response personnel. In some cases, however, emergency procedures have proved to be ineffective in actual emergencies for which they were designed. Failures of emergency procedures generally have been attributed to inadequacy of the procedures themselves or insufficient training and drilling of transit employees and emergency response personnel. Another problem is the general lack of testing of emergency procedures

under crushload conditions in simulated emergencies to verify their effectiveness before an actual emergency occurs.

One problem identified as a result of the BART fire was that the San Francisco Fire Department was not notified immediately because BART's emergency procedures did not cover notification of both the San Francisco and Oakland Fire Departments in the event of a fire in the Transbay Tube, part of which lies in one jurisdiction, and part in the other. In their testimony, fire officials also observed that transit systems often will not notify fire services of a fire unless the fire is considered serious and cannot be extinguished by transit system employees. Fire officials questioned the competence of transit employees to judge the seriousness of a fire and testified that fire services should be notified immediately anytime a fire is suspected. The International Association of Fire Chiefs testified that from the time a fire station receives an alarm, it can take up to 2 minutes to get fire trucks rolling on the street and a national average of about 4 minutes more to arrive at the scene - and in those 6 minutes a fire in a confined area can reach temperatures of 600° to 800°. The Association expressed concern that:

> . . .right away, we are getting fire conditions that could easily approach that temperature within an amount of time of 6 minutes, and here we are without anybody coming to help. . . in a definitive fashion with all the forces necessary. They do not even know yet that there is a fire.

Another problem identified in the BART fire was that, in spite of the hazardous conditions created by fire, smoke, and toxic gases in the Transbay Tube, BART sent two trains carrying passengers into the tube as rescue trains. One train carrying more than 1,000 passengers waited in the tunnel for about 30 minutes to pick up passengers evacuated from the train on fire. As a result of its investigation, the Safety Board recommended that BART revise its emergency procedures to prevent trains carrying persons other than emergency response personnel from being dispatched to fire or accident areas. 38/

BART subsequently revised its emergency procedures; however, more than a year after the Transbay Tube fire BART dispatched a train into a fire area, notwithstanding its new emergency procedures. 39/ Consequently, the Safety Board issued another recommendation urging that BART establish procedures to prevent its trains from being operated into an area where an emergency exists until it is known that it is safe to do so. 40/

38/ Safety Recommendation R-79-42, issued August 2, 1979.
39/ The fire occurred when a railroad train derailed next to BART's tracks and locomotive fuel, which had spilled in the derailment, was ignited. The case is reported in the Safety Board's Railroad Accident Report, "Derailment of Western Pacific Railroad Company Freight Train Extra UP 3734 West (Sealand 6), Hayward, California, April 9, 1980," NTSB-RAR-80-10, September 30, 1980.
40/ Safety Recommendation R-80-47, issued October 24, 1980.

Fifteen months after the BART fire, fire officials in the Washington, D.C., area identified the same problem in WMATA's emergency procedures and subsequently made an almost-identical recommendation to WMATA officials. 41/ The recommendation was based on an investigation of a fire that occurred in the 1.2-mile tunnel under the Potomac River between Arlington, Virginia, and Washington, D.C., on April 16, 1980. The Arlington Fire Chief and Safety Board representatives in an interview that a WMATA supervisor rode through the tunnel several times on trains carrying passengers in order to verify a reported smoke condition in the tunnel. When fire department personnel arrived, they found that trains were still operating in the tunnel although there was smoke in the tunnel and in a station. The fire turned out to be minor, involving oily rags burning in a sump in a tunnel pumproom. However, WMATA officials did not know at the time that the fire was not serious, and the actions taken raise the possibility that passengers could be needlessly exposed to hazards if a suspected fire or smoke emergency should prove to be serious.

Other emergency procedures problems were identified by Arlington County and Washington, D.C., fire officials as a result of the WMATA fire. WMATA did not notify fire officials promptly of the exact location of the fire when it was detected (fire officials first heard the location identified precisely by a local radio station, but they assumed the information WMATA had given them was correct); and WMATA's central control center told the D.C. Fire Department that Arlington was on the scene and could handle the emergency. According to Arlington fire officials, the D.C. fire units then left, although the Arlington County Fire Department units actually had just begun to walk into the tunnel toward the fire and were not yet on the scene. Fire officials also reported that they were unable to use the "blue light" (emergency) phone system in the tunnel because too many WMATA employees were using the system.

Inadequate training in emergency procedures was identified in the Safety Board's investigations of the fires which occurred on BART and NYCTA, as well as in the Arlington County Fire Department's investigation of the WMATA fire. Witnesses representing two Canadian systems also noted serious training and coordination problems in their testimony about the train fires they have experienced. In the BART fire, for example, the Safety Board found that BART employees who responded to the emergency were neither trained nor equipped to manage a smoke or fire environment. BART employees involved in the tunnel rescue effort went in without breathing equipment or knowledge of how to protect themselves in a smoke environment, and a number of them suffered from smoke inhalation. After the WMATA accident, Arlington recommended improved training for WMATA personnel in fire service notification procedures and the timely reporting of relevant information to fire services.

One emergency problem area involves procedures which call for coupling or uncoupling cars to evacuate passengers during an emergency. By uncoupling cars, the operable portion of a train can be freed from cars which are on fire or disabled. However, normal uncoupling of cars generally requires electrical power, which may not be available in an emergency. The Montreal representative testified that "uncoupling cars during a fire usually complicates the situation." U.S. transit

41/ Letter from Chief, Arlington County Fire Department to General Manager, WMATA, June 12, 1980.

systems generally specify uncoupling cars as a preferred procedure under certain emergency conditions. For example, the PATH representative testified that uncoupling is a primary means of evacuation on PATH. Another commonly preferred procedure, which requires straight, level track, is to couple another train to a disabled train to push or pull it to safety. Emergency procedures which call for uncoupling or coupling cars have proven difficult or impossible to carry out in actual emergencies on three different transit systems. In the BART fire, the operator of the stranded train attempted repeatedly to uncouple the cars, but he was not able to do so because of a short circuit in the uncoupling system due to the fire and 1,000-volt electrical arcing. As a result of its investigation, the Safety Board concluded that the efforts to escape by uncoupling cars prevented the expeditious evacuation of passengers to the gallery before heavy smoke conditions developed.

Similar difficulties were encountered on WMATA on October 15, 1980, when a train stalled on an elevated, curved section of track. WMATA personnel attempted to couple the train to another train to push or pull it off the elevated track. However, the trains could not be coupled on the curved track. An empty train was moved up to the stalled train to evacuate at least 1,000 passengers, who had to walk single-file through the cars from one train to the other. It took 69 minutes to complete the evacuation. 42/ In the NYCTA fire, the Safety Board found that, although the emergency procedures provided for the uncoupling of cars under certain circumstances to evacuate passengers in a fire emergency, some train personnel were not trained in methods of uncoupling cars.

Recognition of the need for effective, regular training in emergency procedures has increased within the transit industry as a result of the accidents and incidents that have occurred. The NYCTA representative testified that:

> The success of any operation depends upon the skilled, trained people that we have. The best developed procedures are just so much paper if the personnel that must apply them do not do it effectively.

APTA publishes and periodically updates a booklet, Moving People Safely, which contains a chapter on general emergency procedures. In response to safety recommendations resulting from Safety Board investigations, UMTA and APTA currently are developing an emergency procedures document for use by transit systems. Additionally, UMTA is collecting information from transit systems concerning employee training in emergency uncoupling procedures, which the agency intends to review and evaluate, and to request improvements where necessary.

Although some improvements in emergency procedures training have been made, some witnesses testified that training has not been adequate. The Amalgamated Transit Union, an AFL-CIO affiliate representing transit employees, testified that many employees complain that they are not adequately trained to

42/ Douglas B. Feaver, "Metro Emergency Woes; Response is Questioned After New Incidents," The Washington Post, October 17, 1980.

deal with emergencies, and that "We want some basic training to overcome our lack of knowledge [of] what to do in the event of a catastrophe. . . ." The union testified that employees should be given "hands-on" training, or training in which employees — and firefighters — actually practice procedures using emergency equipment as they would in a true emergency.

The Montreal representative described training improvements that were made after the system experienced two major train fires in just over 3 years. Training for train operators was increased from 2 to 5 weeks and was expanded to include hands-on training in simulated fire emergency conditions because ". . .some time during his life [the employee] is going to run into a special incident and he should be able to react properly." The simulations are conducted by fire prevention specialists in a training center located in the end of a tunnel that was abandoned when a new line was built. Three damaged transit cars that were salvaged after Montreal's 1974 train fire are used in the training. Several types of fire emergencies are simulated under realistic conditions which include a smoke generator and a noise machine (to recreate the loud noise of short circuit). The trainee must go through each procedure -- identify his location, notify a simulated central control center of the emergency, open doors, break out and attach emergency ladders to cars, shut down electrical power, and use fire extinguishers and hoses. The Montreal representative testified that this type of realistic simulation is necessary because:

> . . . people are frightened and don't react properly during an emergency. Training them in an environment like this --you know, for firemen it's normal to use a hose, but for an employee who never has used a hose before, he can't do it.

Fire officials testified that the same kind of hands-on training in rail rapid transit environments is needed for emergency response personnel, and that realistic, full-scale joint drills involving transit employees and emergency response personnel are needed to rehearse emergency procedures and the extensive coordination that is required in an emergency. The San Francisco Fire Chief testified that such training and drilling is critical for firefighters because the environment of a rail rapid transit system "is truly foreign to the average firefighter."

A professional firefighters' journal reported that at the time of the BART fire:

> BART provided procedural guides for train operators and the Central Control operator, but did not anticipate the unforeseen events, numerous demands, and on-the-scene decisions that a major emergency requires. Certainly BART procedures should have prevented the dispatching of rescue trains with passengers on board into the tube during a fire emergency. 43/

43/ "Rapid Transit Train Fire" (from a report by Richard Best, Fire Analysis Specialist, National Fire Protection Association Fire Investigations Department), Fire Command, August 1979.

The BART representative also testified to the importance of regular, joint drilling and stated that "Emergency plans must be tested under conditions simulating actual events to insure their effectiveness."

While the value of hands-on emergency training, drills, and testing appears to be widely recognized in principle, it is not done very extensively. In some cases, emergency training consists primarily of classroom instruction and training films. Drills may be conducted, on a limited scale, before a new system begins passenger service but not afterward, and full-scale tests may never be conducted. The NYCTA representative testified that it has never conducted time trials for emergency evacuation. Without such tests, a transit system can only estimate the time required to evacuate a heavily loaded train.

Some transit systems say that they find it difficult to conduct extensive emergency training, drilling, and testing because of limitations on money, personnel, and time, and because of scheduling difficulties. For example, WMATA officials testified that they consider themselves fortunate to be able to conduct emergency drills on a new line before it goes into operation. Afterward, they said, costs in personnel, time, and money to take employees away from their normal duties for training, drilling, and testing are prohibitive. WMATA, which recently was awarded a Federal grant for operational training and for emergency drills, testified that:

> The real problem is . . .finding the funding and the manpower to run some of the drills, at least. We have concluded it would be more effective to produce an audio-visual [emergency evacuation training] program. . . This is an inexpensive way to do it.
>
> I can't sit here and commit myself to large amounts of money. The older jurisdictions — and it's not just the older properties in New York and Philadelphia. The District [of Columbia] is now in some financial distress. Funding for these types of activities is difficult to get.

MARTA's problem is primarily scheduling. Since the system halts operations for only 3 hours each day (between 1:30 a.m. and 4:30 a.m.), that is the only time drills can be conducted. But that is also the time when contractors work on construction projects, so drilling must compete with construction for track time. Consequently, drills are normally conducted about 2 a.m. Sunday morning and "It's a bit difficult to get volunteers to participate" at that hour.

The representative of MARTA, which began operations in 1979, testified that in spite of scheduling constraints, it has conducted 10 emergency drills and has programs for regular training and drilling.

The CTA representative testified that it has no program for emergency drill but conducts familiarization tours and slide presentations for fire service personnel.

The PATH representative's testimony included presentation of a training film developed after the BART fire. The film portrays a simulated fire and evacuation, and demonstrates the proper application of emergency procedures by employees.

An official of the International Transport Workers' Union, who also is an NYCTA motorman, testified that NYCTA has never provided adequate emergency training for employees. He cited the NYCTA representative's testimony that a preferred method of evacuation is through the side doors of cars onto tunnel walkways and observed that much of the system is four-track operation, express, and elevated tracks, where there are no walkways, or tracks that are not located next to a walkway. He further testified that, as a motorman, he would like to receive hands-on training in evacuation of passengers, both onto walkways and, where walkways are not available, from the train to the ground. He testified that the NYCTA has emergency procedures on paper, but that employees do not receive hands-on training.

The Administrator of the United States Fire Administration, which operates the National Fire Academy at Emmitsburg, Maryland, testified that its training resources offer "a means of accomplishing some of the things that. . .have been neglected over the years as they address the problem of fire and life safety in [rail rapid transit] fires." The Administrator suggested that persons concerned with fire safety on rail rapid transit systems might consider participating in the development of the Fire Academy's curriculum.

Even when emergency drills are conducted, they are seldom conducted as tests in the sense that they may be monitored by observers and followed by a critique session in which observers and participants discuss the performance and attempt to identify problem areas. Moreover, testing the performance of the system in a simulated emergency under crushload conditions is extremely rare, so the effectiveness of the emergency procedures (for example, the time it takes to evacuate all passengers on a fully loaded train to safety) may not be known until a real emergency (such as the BART fire) develops.

Emergency Communications, Equipment, and Mobility

Conventional equipment normally used by fire departments and other emergency response agencies serving metropolitan areas often is inadequate in a rail rapid transit environment. Tunnel fires pose particularly serious equipment problems in the areas of communications, breathing apparatus, and mobility. Yet, in many cases, transit systems have not been responsive to special communications and equipment needs necessary to overcome these problems.

Communications.—Fire and rescue operations in tunnels cannot be conducted effectively without extensive communications and coordination among the large number of people involved in the emergency. In addition to normal requirements for communications between en route and onscene fire units, command posts, headquarters, and possibly among the various elements of fire services from two or more jurisdictions, extensive communications are required for coordination with transit central control and other transit personnel, as well as with police and emergency medical services. Critical decisions and actions -- such as removal and restoration of third rail power, rescue and evacuation actions, the operation of

emergency ventilation, and the movement of personnel and equipment — must be coordinated carefully among all participants. Although normal communications needs are increased enormously, communications capability is considerably reduced because fire service radios cannot work effectively underground without special equipment in place, and other means of communications may be unavailable or extremely limited in capability.

Fire officials testified that special emergency communications systems must be built into a transit system when it is constructed, or added to older systems which lack them. The San Francisco Fire Chief testified that:

> . . .[communications] always seems to be an afterthought and is not given top priority. When fire departments bring this need to the attention of transit authorities, any reliable, satisfactory system is usually termed to be overly expensive and sufficient funding not available.
>
> The transit industry must realize that their radio systems may be adequate for daily train service, but this is not so for emergencies. Transit system authorities must be convinced that adequate communications in the form of a dedicated emergency network are the first concept of underground fire combat operations and should be in place before revenue service starts.
>
> The direct opposite has been the rule rather than the exception, making it more difficult for the fire service to persuade mass transit management of the dangerous condition that they have created. And the reasons for this difficulty is monetary; saving dollars against the assurance of life safety.

According to the representative of the International Association of Fire Chiefs:

> You just cannot realize the frustration in dealing with a major incident and not knowing what the hell is going on... the [firefighter] who's down there at the burning car or... who's in charge of the instrument, the guy down here at the hose line can't get help because he can't communicate. The incident commander doesn't know what resources he needs to deal with the problem because he can't communicate, and yet in spite of all the efforts of a variety of our officials, . . . it's like . . . beating your head against a wall sometimes . . . .

Transit system representatives point out that generally, emergency communications and procedures and other safety issues are the subject of formal written agreements between each system and local fire departments. However, the existence of such agreements does not necessarily mean that fire officials are satisfied with the emergency equipment and procedures agreed upon in the documents, or that agreed-upon provisions will be carried out. For example, according to the Chief of the Washington, D.C., Fire Department:

> During the planning stages of the system, the District of Columbia and WMATA entered into a series of good faith agreements intended to regulate the design and operation of the Metro system. These agreements were necessary because of the absence of nationally recognized good practices and [the] lack of experience in regulating subways on the part of the local authorities. These agreements contain only that which WMATA chose to agree to. Not only are the agreements limited, but they contain no provisions for enforcement.
>
> At this point in time, it is obvious that the agreement system has outlived its usefulness. The time has come for the local jurisidictions to [enact] laws designed to maintain the safety of the passengers and employees of the Metro system. 44/

Fire officials consider it essential that tunnels be equipped with a dedicated emergency communications system (currently, this requires an antenna and relay system which permits fire services to use their own portable radios) and a telephone system or capability for use of portable telephones. This equipment was not built into most transit systems originally and has been retrofitted on some systems but not on others. The NYCTA representative testified that it was the first to install a VHF (very high frequency) radio system throughout its 125 route miles underground, with two channels for use by its operations personnel and transit system police. NYCTA received recommendations from New York City Fire and Police Department officials that a means of emergency communications be provided, and transit officials considered the possibility of doing so by adding a third, emergency radio channel, but testified that:

> At the time, the price was about $2 to $3 million. Today it would cost about $15 million to do it throughout our whole property. For the number of instances it is used in, we opted to provide for the continuing operating capability, that is, our operating people and our [NYCTA] police people.
>
> We've worked with our police and fire departments so that we provide capability to talk from their street command post down to the subway over sound-powered telephone where we bring a cable reel and we talk over sound-powered telephones from their on-site fire post or command post for joint action up to the street where they can talk to their central dispatcher, get additional aid, and communicate on a regular basis.

44/ Written statement submitted for the record by the Washington, D.C., Fire Department, July 14, 1980.

> This is a good example of coordination between departments and it provides for something that's workable rather than something that's the total ultimate. We are saving a good deal of money that [we] could spend other places, and it is certainly more cost-effective for us.

However, fire officials testified that such an arrangement is not adequate in an emergency. The International Association of Fire Chiefs representative testified that:

> I would tend to disagree with [NYCTA's method] as being the best way, because frankly that means requiring much more equipment to carry in. Now, you're talking about sound-powered telephones and reels of cable and so forth plus bringing the officer's own fire department communications devices to the scene of the incident.
>
> Why should we duplicate this equipment? Why not just crank into the tunnel construction, either retrofit or under new construction, the ability to utilize our existing communications equipment?
>
> Why do we have to have another system and have to put a third party, an intervenor in there. . .who is going to have to translate and relay and interpret . . .?
>
> What we are looking at in just this one specific [case] is utilizing our existing facilities, our existing equipment, our existing frequencies. We don't need to piggyback on the facilities provided by the transit system, [but to] utilize our existing frequencies with some equipment that will make them usable under that environment. That's all.

Inadequate communications have been identified as a serious problem in many of the fires that have occurred on rail rapid transit systems, and some transit systems have taken or are taking action to upgrade existing communications systems or to retrofit new equipment. Montreal and Toronto transit officials testified that they experienced problems with both operational and emergency communications in train fires, and both systems have implemented major improvements. Some of the improvements in Toronto resulted from the Christie fire. Toronto officials observed that "Critical time was lost at the outset of this fire as a result of communications difficulties between transit control and trains." Other improvements resulted from the Ontario Fire Marshall's recommendation that the Toronto Transit Commission and the Toronto Fire Department "review the suitability of communications equipment currently in use providing surface to below ground contact for fire command and control purposes."

At the time of the BART fire, BART had what was perhaps one of the most sophisticated communications systems, including a dedicated emergency system and capability for use of portable telephones. Yet firefighters still encountered

serious communications difficulties during the BART fire, including unavailability of communications equipment when it was needed and lack of discipline among transit employees in using the equipment.

Washington, D.C., and Arlington County, Virginia, fire officials told Safety Board representatives in interviews that the lack of a dedicated emergency communications system hampered their efforts to respond to the April 16, 1980, fire in a WMATA tunnel. Firefighters were unable to use their own equipment in the tunnel, and units of the two fire departments could not talk to each other. The problem was compounded by a radio malfunction at Arlington County Fire Department Headquarters and by the inability of firefighters to use the "blue light" (emergency) tunnel phone system because too many WMATA personnel were trying to use the phones at the same time. When WMATA officials told D.C. fire units that Arlington was on the scene and the D.C. units were no longer needed, the D.C. firefighters had no way of knowing that Arlington units, in fact, were not yet onscene, but had just begun to enter the tunnel on foot more than one-half mile from the fire. According to D.C. fire officials, because of the lack of a dedicated emergency network in WMATA tunnels, "When we get down there, we're almost blind." WMATA, which began operations in 1976, recently agreed to retrofit the tunnel under the Potomac River with emergency communications equipment, including a dedicated emergency system that will enable fire services to use their own radios, and an additional telephone system. However, local fire officials are concerned that WMATA is not acting fast enough to install the equipment and that other tunnels in the system pose the same problems but are not slated for improvements. Fire officials have urged that the current schedule, which calls for completion of the dedicated emergency system in the Potomac River tunnel in 1982, be accelerated and that emergency communications equipment also be added to other tunnels.

The Administrator of the United States Fire Administration testified that "The English and the Germans are experimenting . . . at the present time with some rather novel approaches" to emergency communications, but that the U.S. transit industry still is deficient in emergency radio capability. To correct existing problems, fire officials urged that communications improvements be given high priority for Federal grants to assist transit systems in retrofitting necessary equipment, and that emergency communications be included in all future tunnel construction on both existing and new rail rapid transit systems.

Breathing Equipment.—Conventional breathing equipment used by firefighters typically is of short duration and does not provide adequate breathing capability for the extended periods of time necessary to conduct rescue operations and fight underground rail rapid transit fires. Although the lives of hundreds of passengers may depend upon the rescue efforts of firefighters, the lack of adequate breathing equipment may not only jeopardize the safety of the firefighters themselves, but make it impossible to reach passengers in time. According to the Administrator of the United States Fire Administration, ". . .the ability of a fire department to function in the atmosphere that is created by a [rail rapid transit tunnel] fire is essentially that of a fire in a high-rise building lying on its side. The potential in this. . . for life loss is extreme."

Most fire departments have breathing equipment which has only a nominal 30-minute rating, and fire officials say that this is wholly inadequate for responding to rail rapid transit tunnel emergencies where firefighters may have to walk up to a mile or more in smoke conditions, carrying their equipment to locations far away from fresh air. Multihour breathing equipment is available, but users have experienced maintenance and flammability problems with some types, and equipment which firefighters find acceptable generally is expensive to purchase and maintain. The Administrator of the United States Fire Administration testified that:

> Currently the major portion of the fire service uses an open-circuit, self-contained breathing apparatus that was designed for use in industry and for mine safety and rescue, not for use in a hostile fire environment. This apparatus typically weighs 30-35 lbs., is uncomfortable to wear, and restricts the firefighter's movement. In addition, although it is rated for a 30-minute service life, the air supply typically lasts only 10-20 minutes, depending on the firefighter's work rate, physical condition, and size.
>
> To further complicate the problem, deficiencies in a particular breathing apparatus unit in the fire environment often are not discovered until it is actually used in the field. Within the past year serious malfunctions were observed in two types of breathing apparatus used during firefighting. In one instance, serious malfunctions in the regulator diaphragms of an unreasonably large number of one type of breathing apparatus were discovered during use in firefighting operations. In another case, failures in the high pressure hose assembly of another manufacturer's breathing apparatus were uncovered in the field. In both cases, even though the firefighters were using "approved" breathing apparatus, they did not provide the protection necessary for their safety.
>
> As a result of a NASA Technology Utilization Office project conducted in the early 1970's, an improved breathing system was developed and field-tested. Improvements included a 30 percent reduction in weight, redesign of the harness to increase comfort, and better visibility through the face mask -- all important advances. One industrialized version of this improved system is currently available. But the new system is rated for the same 30-minute service life as current gear and still typically does not last that long during firefighting operations. Although it is more comfortable to wear, the size and shape of the apparatus still hampers movement in cramped spaces and restricts movement necessary to conduct some firefighting tasks. In addition, although the new breathing apparatus costs only slightly more than those in use now, it requires installation of a totally new high-pressure system for efficiently filling the tanks, which is expensive. Few departments have been willing to pay the cost of conversions to the new system.

While some fire departments serving transit systems, such as CTA and WMATA, have purchased multihour breathing equipment, others say they cannot afford to buy the equipment and they look to transit authorities to provide the equipment as one of the costs of operating a mass transportation system. Before it began operations in 1979, MARTA purchased 1-hour breathing equipment and other special firefighting equipment for use by fire services in responding to MARTA emergencies. However, other systems have not been as responsive in meeting fire services' special equipment needs. Both the San Francisco and Oakland Fire Departments tried for several years to persuade BART to provide them with multihour breathing equipment. BART eventually agreed to buy the equipment shortly before the January 17, 1979, fire. However, the equipment was not provided in time to be used in the fire. According to the United States Fire Administration, the San Francisco Fire Department was able to fight the fire only because the Department had 20- or 30-year-old breathing equipment from Germany which it had modified.

Washington, D.C., and Arlington County, Virginia, fire officials told Safety Board representatives that they need better breathing equipment to fight WMATA fires but it is too expensive for them (some breathing equipment costs as much as $2,500 per unit). The Washington, D.C., Fire Department obtained twenty-five 1- hour oxygen masks (at a cost of $975 each) specifically for use in WMATA tunnels but was unable to use them because of problems which could cause the units to burn or explode when exposed to flame. One of the Department's rescue squads has a limited number of oxygen masks which are usable; however, as of this report date, the Washington, D.C., Fire Department still does not have a sufficient quantity of breathing equipment which provides adequate capability for responding to potential fires in WMATA tunnels without endangering firefighters' lives. Most fire officials called for provision of multihour breathing apparatus to fire services which may have to respond to tunnel fires and urged that Federal grants be provided directly to fire departments for their purchase.

The President of Local Division 1555 of the Amalgamated Transit Union in Oakland, California, testified that train operators also should be supplied with portable breathing apparatus to use in the event of fire. He observed that currently, "The people who are charged with the responsibility of evacuating the train are the least protected."

Fire officials testified that funding also is needed for research and development of better, more reliable breathing systems. According to the Administrator of the United States Fire Administration, the capabilities of breathing masks made in the United States are deficient, and currently very little money is allocated to research and development for such equipment.

Mobility.--The mobility of fire services is extremely limited in rail rapid transit tunnels. Normal means of transporting firefighters and their equipment to a fire cannot be used beyond tunnel access points, such as stations and vent openings, where equipment must be offloaded and hand-carried, in some cases while climbing down ladders in deep shafts and while moving on foot in underground trackways from access points which may be more than a mile from the location of the fire. Such exertion can further tax the capability of firefighters' breathing equipment, which often is already limited, delay rescue and firefighting operations,

and expose firefighters to the hazards of live electrical equipment and trains moving in the trackways.

Rail rapid transit trains can sometimes be used to transport firefighters and equipment to the scene of the emergency, but trains depend on third rail power, which may be shut down on some sections of track in an emergency, requiring personnel to offload their equipment and move on foot. If it is necessary for any fire service personnel to move on foot in the trackways, fire officials require that power first be removed from the third rail; coordination and confirmation of the status of track power can mean additional delay. The same problems of mobility can complicate passenger evacuation and the extrication of the trapped and injured.

To overcome these problems, fire officials have persuaded some rail rapid transit systems to provide special emergency vehicles, such as modified golf carts, which can be driven on top of the rails to transport firefighters and their equipment in tunnels and to remove injured passengers. But they also have encountered problems in using these vehicles. Washington, D.C., fire officials told Safety Board representatives that emergency vehicles provided by WMATA are difficult to place on the tracks, and in some incidents, such as the BART fire, the fire services have experienced lengthy delays in getting emergency vehicles into operation after they were requested.

THE CURRENT APPROACH TO SAFETY OVERSIGHT

The current approach to rail rapid transit safety is essentially ad hoc, based upon the voluntary safety activities of individual transit systems and the transit industry's association, APTA, with the assistance and guidance of UMTA, and the involvement, to a limited degree, of State or local oversight bodies. Fire officials, labor organizations, and other groups and individuals have suggested that the current, uncoordinated approach is not adequate to maintain a safe level of rail rapid transit, and they have called for a more vigorous approach to the identification and solution of safety problems. UMTA and the transit industry believe that the current approach is working and will continue to work to assure an acceptable level of rail rapid transit safety. The current safety approach and the various views of its adequacy are described below.

Government and Industry Safety Activities

UMTA.--In 1978, based on a study conducted by the Department of Transportation's Office of Environment and Safety, 45/ UMTA was delegated total responsibility for rail rapid transit safety within the Department. According to the study, the recommendation was based:

> . . . on extensive review and discussion of the issues within the Department and on the following specific considerations:

45/ "Rail Rapid Transit Safety Review: A Report to the Secretary of Transportation," op. cit.

a. Our present understanding of the nature of rail rapid transit and our knowledge of RRT [rail rapid transit] safety would not support the imposition of across-the-board Federal solutions; rather, DOT [the Department of Transportation] should continue to address specific, known safety problems on individual systems, serving as a catalyst for change and a clearinghouse for information.

b. A systems approach to RRT safety requires the ability to impact all aspects of RRT operations from design and development of rail components through operating practices and maintenance and repair; UMTA, through the management of its grant program, has that ability.

c. This review of current activities shows that UMTA is currently conducting a broader array [than FRA] of RRT safety activities, including research and development, training, and assistance in the development of safety and system assurance plans.

UMTA's current approach to safety oversight is in accord with the recommendations of the study, which were approved by the Secretary of Transportation in March 1978. The UMTA representative testified that when UMTA was assigned the responsibility for rail rapid transit safety:

> ... we undertook and continue to encourage and achieve voluntary cooperation between the accountable local operating agencies, industry peers, other interested local agencies, and the Federal government.
>
> The accountability for the operational viability of a system, including safety, ultimately rests with the local or regional decision-maker -- the general manager or senior executive officer of the transit organization -- who is locally or regionally accountable to the public for the safety and dependability of the system under his control within the established or changing local and regional social and political environment.

One of the recommendations of the 1978 study was the development of "a policy and management proposal outlining the appropriate Federal role in RRT safety, how UMTA should organize and staff for the RRT safety responsibility, what the areas of program emphasis should be, what supportive activities by other DOT agencies might be necessary, and what additional resources, if any, are required." This recommendation resulted in the development of a safety program plan which forms the basis for UMTA rail rapid transit safety activities. 46/

46/ "UMTA Rail Transit Safety Program Plan," issued September 12, 1978, as revised May 22, 1979.

Safety responsibility within UMTA is vested in the Office of Safety and Product Qualification, which is one of six offices under the Associate Administrator for Technology Development and Deployment. (See figure 8.) Since the safety office was established in 1976, its staff has increased from two to six full-time safety professionals (including two positions added in 1979 and another position added in November 1980). The six safety professionals are all assigned to the safety office in UMTA's Washington, D.C., headquarters; no safety professionals are assigned to UMTA's 10 regional offices which perform the initial review and processing of applications for grants. (See figure 9.) UMTA testified that:

> [Staff members] who are involved in the grant-making activities are primarily the individuals who would be working with the recipient of the resources, along with the staff who are overviewing them in carrying out those activities. . . .
>
> We try always to have our regional staff and the grant staff the contact point with the individual [transit systems]. We use our headquarters staff, particularly in the research area and the safety area, as policy and technical assistance staff. . . .

Since 1976, UMTA's annual budget for safety activities has grown from about $1 to $1.65 million for Fiscal Year (FY) 1981. UMTA's safety program plan originally projected a need for a professional safety staff level equivalent to 7 3/4 staff years 47/ and a budget of $1.7 million in FY 1980. However, in FY 1981, funding will be slightly less than the originally projected 1980 level, and the staffing level requested for 1980 will not be reached until 1982, when UMTA expects that the Congress will approve authorization of two or three additional positions to the safety office. This level of staffing and funding is not dedicated exclusively to rail rapid transit, as UMTA's safety office also has been vested with complete or partial responsibility for the Federal safety role in light rail, commuter rail, bus transit, and advanced transit technologies (such as automated guideway systems).

Under UMTA's safety program plan, dated April 1979, for rail transit, safety activities are organized into three elements: system safety, safety information, and safety research and development. Of these, UMTA considers system safety the most significant element.

System Safety.--The UMTA representative testified that its system safety activities include "unsafe condition" investigations under Section 107 of the National Mass Transportation Act of 1974, assisting transit systems to develop system safety plans, and conducting safety and system assurance reviews, safety and security education and training, and safety inquiries. Since Congress authorized the investigation of unsafe conditions in late 1974, UMTA has not developed procedures for the investigations and has conducted only one Section 107 investigation. That investigation was initiated in 1979 to examine safety problems involving the trucks, handbrakes, and power cables of NYCTA's R-46 transit cars.

47/ A staff year is the equivalent of one person working full time for 1 year.

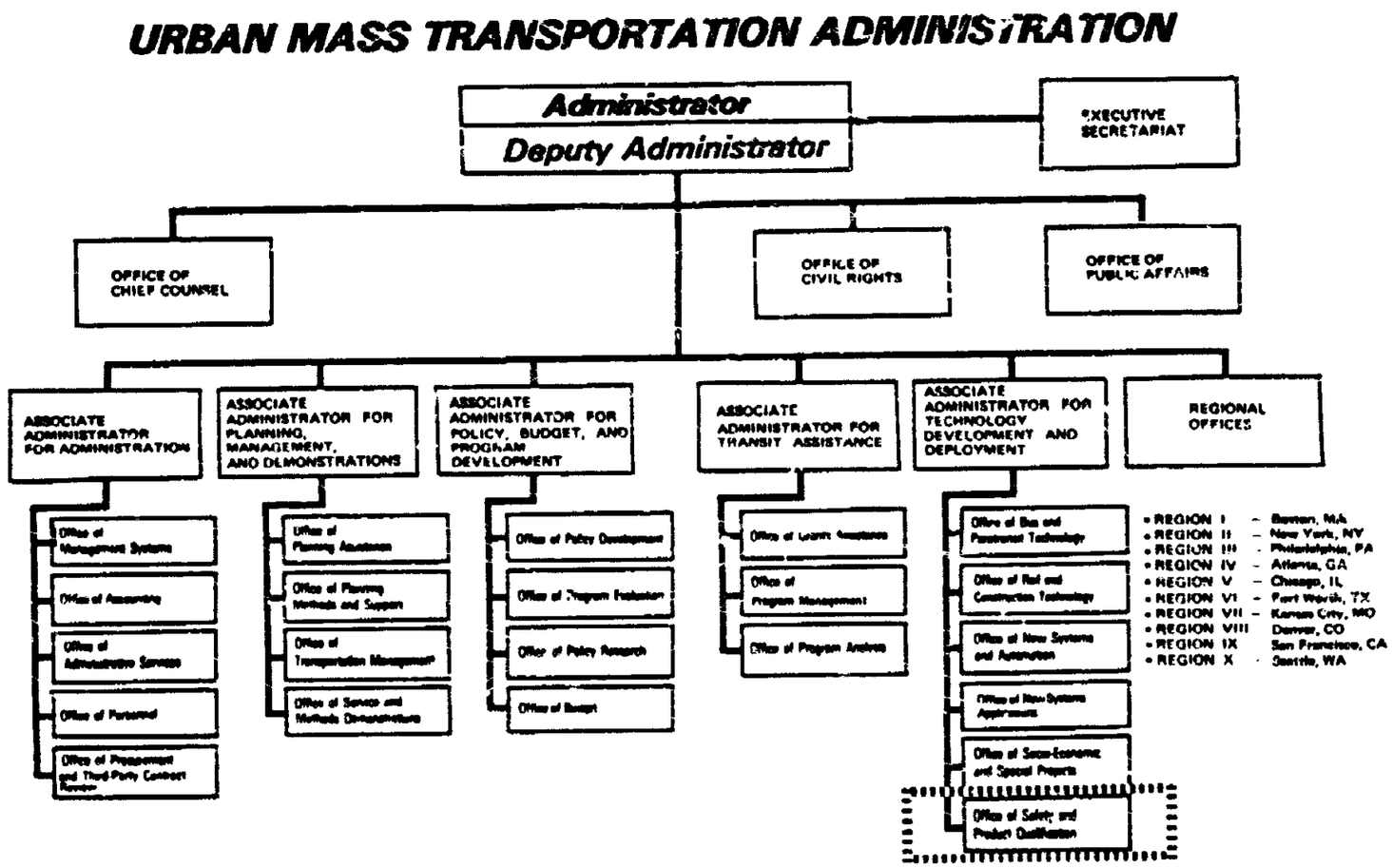

Figure 8.--UMTA organization chart showing location of safety office (outlined). (From U.S. Department of Transportation Directory, September 1980.)

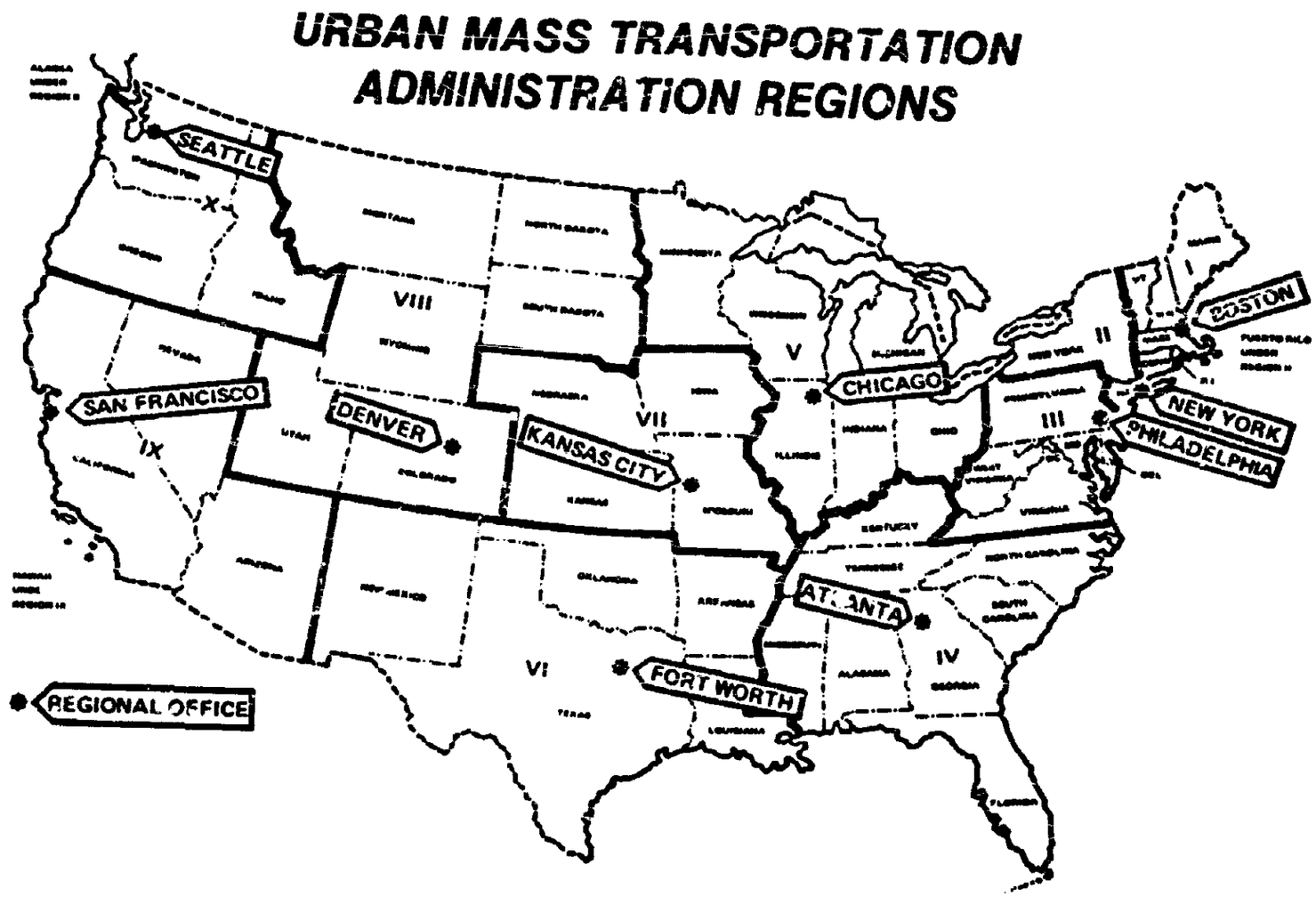

Figure 9.--UMTA regions and regional offices.
(From U.S. Department of Transportation Directory, September 1980.)

Federal action was requested by the Transport Workers Union of America after a series of derailments involving R-46 cars occurred in December 1978 and January, February, and March 1979. The Union testified that Federal action was delayed for months and that it experienced a great deal of trouble getting any action at all on its request. UMTA initiated its investigation in August 1979 after the union contacted the Safety Board, and the Safety Board asked UMTA to look into the problem.

UMTA's activities in assisting transit systems to develop system safety plans were the result of recommendations made by the Safety Board on June 16, 1971, in its Special Study of Rail Rapid Transit Safety. 48/ The study recommended that UMTA require transit systems to submit system safety plans as a condition of obtaining Federal grants, that formal requirements specifying the content of the plans be published, and that UMTA evaluate system safety plans and use its evaluation as a partial basis for approving release of Federal funds. The Safety Board also urged that UMTA develop a permanent system safety engineering capability to evaluate system safety plans.

In response to these recommendations, UMTA hired a system safety engineer in 1972 and indicated that informal evaluation was underway and that formal requirements would be developed. In 1973, the Safety Board issued its Special Study of Safety Methodology in Rail Rapid Transit System Development, based on examination of the BART system after a BART derailment occurred in October 1972, less than 1 month after the system began operating. Based on this study, on December 13, 1973, the Safety Board again recommended that UMTA publish formal requirements for the submission of system safety plans as a condition of releasing funds. 49/ UMTA initially replied that it intended to establish formal procedures by the end of 1974 and then reported in mid-1975 that a draft Notice of Proposed Rulemaking was under review by UMTA staff. To date, UMTA has not established formal requirements for system safety plans and has not developed a systematic plan for how safety plans will be evaluated and used to monitor and improve safety. After the Safety Board's initial recommendations, transit systems began developing system safety plans voluntarily, and UMTA informally requested that the plans be submitted to it. UMTA and APTA have indicated that all transit systems under development have completed safety plans, and that system safety plans for existing systems are in various stages of development, with completion of all plans expected in 1982.

According to UMTA's safety program plan:

> Assessment of adherence to [system safety] plans will be an important part of UMTA's on-going safety monitoring of the transit industry. Further, the planned on-site assessments will afford valuable experience and exposure to operating practices and knowledge of the equipment of the various properties for UMTA's safety staff. It may also serve as a means for unsafe condition determination and in assessing the effectiveness of corrective action(s).

48/ Safety Recommendation R-71-15 and R-71-16.
49/ Safety Recommendation R-73-33.

UMTA's safety program plan notes that UMTA considered establishing formal requirements for system safety plans as a condition of funding, but ". . .because of the large impact of such action on the properties and on UMTA, it is felt to be premature to recommend such an action without substantive justification of the benefits that would accrue. Future safety trends or events could indicate a need to change this stance." Currently, UMTA is sponsoring the development of guidelines for the content of system safety plans.

Since the safety office was established, UMTA's system safety activities have included limited onsite reviews of safety and system assurance of new rail rapid transit systems. In 1980, this activity was expanded to include limited reviews of existing rail rapid and light rail transit systems.

According to the UMTA representative's testimony, a system safety and assurance review:

> . . .generally consists of preliminary 1 or 2 day site visits or letters of correspondence followed by several days of in-depth presentations and discussions following an established agenda and ideally occurs at key times in system development.

Review participants generally include representatives from UMTA, the Department of Transportation's Transportation Systems Center (TSC), other transit systems, and APTA. Safety Board representatives observed several of the earliest reviews. Following a review, UMTA presents a report of its findings and recommendations; however, no requirements are imposed by UMTA. The UMTA representative testified that "Subsequent correspondence, meetings, and reviews establish the degree of acceptance and rejection of recommendations and reasons for these."

With a safety staff increase to 7 3/4 staff years, UMTA's safety plan estimated that three persons could be assigned to the review function in order to conduct one review of each rapid and light rail transit system each year. At the current level of staffing, UMTA is performing fewer than half the number of reviews projected. Since the review function was established, reviews of new rail rapid transit systems have been held at MARTA and WMATA, which were still being developed when the reviews were conducted, and the Mass Transportation Administration at Baltimore and the Metropolitan Dade County Transit System in Miami, where new systems currently are being designed or constructed. In FY 1980, UMTA conducted reviews of two existing systems — BART and SEPTA.

UMTA's education and training activities include sponsorship of several safety, security, and system assurance courses for transit industry management personnel at the Department of Transportation's Transportation Safety Institute (TSI) at Oklahoma City, and training seminars and workshops (primarily related to explosives management and system assurance) in various cities. These activities include training for personnel of rail rapid and light rail transit systems, bus transit, and Federal, State, and local government employees. The UMTA representative testified that more than 250 people have attended the TSI courses and 550 persons have attended the explosives management seminars. The funding

level for education and training is about $200,000, including tuition and transportation of attendees at training courses, and a safety staff commitment of one-half staff year annually is devoted to managing these activities. Under this program element, UMTA is planning a national workshop on rail transit safety for late FY 1981.

Safety inquiries have been a very small part of UMTA's safety activities, primarily involving the handling of safety complaints. The UMTA representative described this activity in her testimony:

> We receive a number of safety inquiries, some in the form of complaints from the public and Congress. Typical problems include bus operating equipment. . . improper maintenance and control of safety-related equipment, unsafe operating practices on buses, and malicious damage to transit operating equipment. Each inquiry is followed up to assure that legitimate safety problems are properly remedied by the affected property. This is usually done through written correspondence; however, numerous site visits have been made to get first-hand knowledge of the problems and to meet with the responsible transit officials.

Safety Information.--Safety information activities involve the collection, analysis, and dissemination of data about the safety of rail transit systems. Under this program element, UMTA issues annual rail rapid transit accident and incident reports; is developing a new rail transit accident and incident reporting system; and collects safety information from other sources.

Rail rapid transit systems currently are not subject to formal requirements for the reporting of accident and incident data. However, although a court decision overturned FRA's rail rapid transit safety authority in December 1977, FRA continued to collect data submitted voluntarily by transit systems to FRA's Railroad Accident/Incident Reporting System (RAIRS).

The Department of Transportation's 1978 study of rail rapid transit safety reviewed this system and found that it was tailored to railroad safety needs and was "not designed to obtain the most relevant information about the causes of rail rapid transit accidents, fatalities, and injuries." The study recommended that a new reporting system be designed for transit systems and that UMTA, in the interim, require transit systems to submit accident and incident reports to UMTA in the FRA reporting format as a condition of Federal grants.

As a result of the 1978 study, rail rapid transit systems are submitting accident and incident reports in FRA's format to UMTA voluntarily, at UMTA's request, and UMTA has used these reports to issue annual rail transit safety reports for 1978 and 1979. During the last 2 years, UMTA has been developing a rail transit "Safety Information Reporting and Analysis System" (SIRAS) and is now in the process of promulgating reporting requirements under the new system for both rail rapid and light rail transit systems. The UMTA representative testified that UMTA anticipated that rail rapid transit systems would begin reporting under SIRAS on January 1, 1981, with light rail systems to start reporting sometime later in the year.

Since 1972, UMTA also has collected information about rail rapid transit accidents by participating in the Safety Board's accident investigations and gathering information from transit systems through discussions, meetings, and correspondence. The UMTA representative's testimony and its safety program plan indicate that these activities have been receiving lower priority because of the emphasis on the SIRAS project, but are expected to increase when SIRAS is completed. According to the safety program plan:

> UMTA will have to play a much more active role in this area in the future. Either in support of [the Safety Board] or acting in its own interest, UMTA will have to furnish technical personnel at accident sites for investigatory efforts. Additionally, participation in public hearings and examination of investigatory data and findings will be required.

The plan states that "The workload will be very heavy when accident investigations are under way. At times, several members of UMTA and other organizations will be involved." However, UMTA would be able "to forego the need to have all the expertise in its own staff" for investigative activities by getting technical support from FRA and TSC. On that basis, it was estimated that the equivalent of one UMTA safety professional full-time would be able to cover both the investigative activities and the development of directives and procedures for Section 107 investigations.

Safety Research.--UMTA's safety program plan states that "The general safety research effort is the newest UMTA safety program activity and is least defined or formulated at this time." Currently, UMTA is sponsoring two ongoing safety research and development (R & D) projects, one which began in 1978 and another which began in 1979. Future safety R & D activities have not yet been identified.

The two current projects are the development of emergency preparedness guidelines for rail rapid transit systems and the development of flammability standards for materials used in the construction of rail transit cars.

According the to the UMTA representative, the emergency preparedness guidelines project "had its genesis as a result of the [BART] fire in early 1979 and the ensuing recommendations of several investigatory bodies, particularly the [Safety Board]." The UMTA representative gave the following description of how the project's results will be used:

> Since there are many site-specific differences among the properties, it is not reasonable to set absolute standards and procedures for emergencies. Instead, by assembling all of the best means used for coping with these problems, individual properties will be able to review their own emergency programs, identify areas where improvement is needed, and take action to make these improvements.

In 1980, two workshops were held on the emergency procedures project, and APTA and the individual rail rapid transit systems have established committees to prepare individual sections of the document. Plans call for a workshop and training session at one of the rail rapid transit systems in early 1981 as the document is completed, and UMTA plans to use the emergency procedures document "as a reference" in future safety and system assurance reviews.

The second safety R & D project, the development of materials flammability standards for rail rapid transit cars, is described in UMTA's safety program plan:

> TSC has been active in developing materials flammability guidelines for several years. In 1976, a preliminary set of guidelines were produced, and several rail properties have used some of the guidelines in new car specifications. Because of the informality of this process, and limited coverage of the guidelines, a full-scale standards development program was started at TSC in FY 1978. This is a multi-year project which will culminate in a set of standards which will be available for promulgation during FY 1980.

The UMTA representative testified that the fire safety standards for materials will be formally imposed on transit systems in early calendar year 1981, making their use mandatory as a condition for grants for rail rapid transit cars. The safety program plan originally projected the FY 1930 level of UMTA staff effort on the fire safety standards project at a one-quarter staff year level, with $250,000 in contract support from TSC and $25,000 for technical support from rail transportation systems.

Other fire safety R & D activities which UMTA has supported have included TSC's development of a materials data bank on the fire characteristics and physical and chemical properties of nonmetallic materials used in transit cars; an evaluation of the fire, smoke, and toxicity hazards of the electrical insulation of wires and cables used in transit cars (the "smokeless cable" project, scheduled for testing in late calendar year 1981); and the evaluations by the National Bureau of Standards of the fire hazards of BART and WMATA vehicles. UMTA also is supporting BART with a grant to conduct full-scale fire testing of BART cars.

UMTA intends to develop its safety R & D program and to identify future safety R & D projects. According to the safety program plan:

> Although the general safety level of rail transit is considered good, there are problem areas evidenced by existing data. Research should be conducted towards eliminating or ameliorating these problems or other problems. No such organized effort currently exists within the rail transit community since in general the individual properties are pursuing their own problems. Further, no mechanism has previously been available for evaluating safety problems in a general or generic sense. The safety information system under development [SIRAS] will afford

> this means of comparative and causal analysis to aid in conducting a meaningful research program. Existing data from the FRA [RAIRS] system and other sources should be sufficient to establish a program structure and possibly address some problems in the immediate future.

The safety program plan states that "Industry advice on the research program will be obtained to insure the practicality and reality of the research to be carried out."

The UMTA representative testified that UMTA's safety research program will be aimed "at the more nationally significant and critical safety problems of a generic nature. Site-specific problems are of concern also, but the particular property involved is expected to remedy this class of safety problem."

To identify and set priorities for R & D, including safety R & D, UMTA has conducted four national R & D priorities conferences in the last 4 years. According to the UMTA representative:

> Suggested safety research projects are to be discussed in detail for prioritizing at the UMTA National Workshop on Rail Transit Safety in late FY 1981. The transit industry will have an opportunity at this workshop to present their safety research needs and clarify the approach to high priority projects.

UMTA's safety program plan projects the use of one safety professional full-time to establish and direct safety R & D activities. Budget estimates submitted to the Congress by UMTA in March 1980 projected the following funding levels for safety R & D: 50/

Potential future safety R & D projects identified by UMTA include the development of rail car crashworthiness design standards, study of human factors-related causes of collisions and accidents, and research on slips and falls in stations and on platforms.

FUNDING LEVELS Fiscal year:	(Thousands of Dollars) Amount:
1978 and prior	0
1979	130
1980	570
1981	350
Future	600/yr.
Total Cost	600/yr.

50/ "Fiscal Year 1981 Budget Estimates for Research and Training," submission to Congress.

The UMTA representative testified that it conducts a Federal assistance program "first and foremost," and that in addition to its safety program activities, it has awarded to transit systems grants in which safety improvements are both explicit and implicit features. In her testimony, the UMTA representative listed the following of safety-related grants:

- A $10.8 million capital grant to the Massachusetts Bay Transportation Authority (MBTA) in 1973 to assist in the improvement of subway fire-fighting capability, lighting, and ventilation.

- A $500,000 technical study grant to BART in 1973 to assist in the resolution of safety and system availability issues. In March 1980, a capital grant for $1.3 million was given to BART to assist in replacement of the polyurethane seats in its rapid transit vehicles. In addition, UMTA is supporting BART with a grant to conduct a full-scale fire test on its vehicles.

- In 1976 a $275,000 technical study grant to CTA to evaluate CTA's technical management practices pertaining to safety, equipment reliability and maintainability, quality assurance and system availability/dependability of the rail system. As a result of this study, two additional grants have recently been given: $50,000 to develop improved accident analysis techniques and $68,000 to develop an improved motorman refresher training program.

- A $282,000 grant to WMATA was awarded recently to develop improvements in safety training programs and activities.

UMTA's representative testified that the agency also has sponsored research which is not classified as safety research but which does have a relationship to safety. These research activities include: the development of a National Design Practices Manual for rail transit systems, which will include a chapter on safety; a rail car standardization project with car and subsystem specifications, which will include the materials flammability standards now under development; the incorporation of subway fire simulation into a subway environmental simulation computer model which is used in the design of new rail transit systems; and participation in the development of voluntary standards for safety headways (the minimum operational spacing between trains) by the Institute of Electrical and Electronics Engineers.

State/Local Oversight Bodies.—According to the Office of Technology Assessment:

> Regulation of a transit system by an external agency is not an easy matter. It requires establishing an organization, staffed by technically competent and experienced personnel, to write standards, review plans and designs, and conduct tests and inspections. Even if the necessary personnel could be found, it might not be practical at the State or local level to create such an agency. Typically, a State contains only one rail rapid transit system; and to establish a special authority to oversee a single operating agency might be a governmental extravagance.
>
> For this reason, most publicly owned transit agencies are self-regulated, both for safety and economic matters such as fares and the level of service. As public or quasi-public bodies, they respond to the influences of the political system by which they are created and to the economic constraints imposed by the use of public funds. 51/

WMATA, which does not have a specific oversight body, testified that its location in the Nation's Capital subjects it to occasional oversight by the U.S. Congress. For example, the April 16, 1980, fire in a WMATA tunnel resulted in a hearing on the incident by the Metropolitan Affairs Subcommittee of the House Committee on the District of Columbia. However, that subcommittee is concerned with metropolitan affairs generally. It has no full-time, professional safety staff and is not regularly concerned with WMATA safety; it acts only when a particular problem or issue comes to its attention.

The California Public Utilities Commission is the only oversight body at the State or local level which oversees rail transit safety on a continuous daily basis. The safety oversight function of the California Public Utilities Commission has evolved in piecemeal fashion, in response to specific accidents and incidents, into a Transit Districts Safety Branch, including a BART Safety Section, staffed by eight safety professionals. The Commission began overseeing preoperational testing of BART in 1971 with two people assigned part-time. After a BART train accident in which a train failed to stop at a terminal station and crashed into a parking lot, the California Legislature authorized two full-time Commission staff positions for monitoring BART safety. After three more BART accidents and incidents, including one in January 1975 which resulted in a fatality, the Legislature authorized a Commission staff increase of four positions for transit safety oversight.

In spite of the growth of its safety staff, the Commission testified that its oversight capability remains limited, and its approach to BART safety has been reactive rather than preventive.

51/ Op. cit., p. 167.

> The Commission, with its limited base information and its limited resources, does not provide BART with guidelines for operating a safe system and preventing accidents. Instead, the Commission reacts to BART incidents, reviews problems retrospectively, and then orders corrective measures.

The Commission noted that its staff has participated actively with BART in the design of new equipment and development of new procedures, but that it has intervened in BART management and operation only in response to serious accidents or incidents on the BART system. For example, after the BART fire, the Commission ordered the Transbay Tube closed pending correction of safety problems disclosed by investigation of the incident. The Tube remained closed for about 3 months until the Commission was satisfied that safety hazards had been reduced satisfactorily. The Commission testified that "Many of the unacceptable conditions had existed for several years before the January 1979 fire, yet it was only when an accident occurred that the Commisssion was able to address fire hazards."

After the BART fire, the Commission also ordered many other short-term and long-term safety improvements, including elimination of the toxic polyurethane materials in BART's transit car seats (completed November 1, 1980), fire-hardening of car floors, improved procedures for emergency tunnel ventilation and emergency evacuation from trains, and improved communications. While the Commission feels that these and other improvements have made BART safer, its representative testified that reactive safety regulation leaves many serious problems unsolved.

The Commission cited four problems created by a reactive approach: (1) postaccident intervention, such as the Transby Tube closure, entails a major disruption of service (with adverse social and economic consequences); (2) reactive regulation breeds friction between BART's Board of Directors, who are responsible for both safety and operations, and the Commission, which is responsible only to oversee safety; (3) "the current regulatory framework provides BART with scant guidance as to the level of safety" the Commission will find acceptable; and (4) "Finally, the current approach addresses and rectifies past problems, but does little to prevent future safety hazards that might arise in unrelated areas."

In his testimony, the BART representative agreed that regulation by the Commission has not been without problems, largely because in monitoring BART safety, the Commission often must make subjective judgments. The BART representative testifified that:

> There exists no one set of accepted guidelines, criteria or standards by which the State of California can measure or verify the various safety issues involving BART. Too often decisions are based on individual opinions and preferences which have brought into question the issue of who is ultimately responsible for the safety of the system.

The Commission believes that it needs to move from an approach which is exclusively reactive to one which enables it to act prospectively, but it needs "clear guidelines and performance standards for attaining levels of operating safety that are acceptable to both the transit property and the regulating agency." In the absence of comprehensive national performance standards or guidelines, the Commission is actively exploring the possibility of developing State performance standards. First, it has begun efforts to explore the feasibility of establishing safety standards for fixed guideway rapid transit systems. It also has applied for an UMTA grant to begin an investigation that would assess the current state of the art of fixed guideway rapid transit safety standards, guidelines, and regulations. The Commission's representative testified that this investigation would be undertaken as a prelude to the ultimate determination of whether realistic State safety standards can be developed for rail transit systems.

The Commission's representative testified that it is:

> ...all too aware of the difficulties presented by the current regulatory framework in which the Commission makes ultimately subjective determinations of "how safe is safe enough?"
>
> Safety standards will establish clear goals for the operating properties. Necessary safety improvemnts can be undertaken prospectively. With stated guidelines for attaining and maintaining transit safety, an operating property can plan future innovation without the threat of unexpected intervention by the regulatory authority.
>
> From the perspective of the oversight agency, enforcement of its safety obligations becomes more effective. When a standard is violated, the agency acts. The degree of subjective decision-making is reduced significantly, to the benefit of all.

Industry Safety Activities.--Safety activities in the rail rapid transit industry are carried out by individual transit systems and by APTA.

Each transit system has its own safety staff. The MARTA representative, for example, testified that it has five engineers working in safety--its Manager of Systems Assurance, two engineers dedicated to system safety and reliability, and two safety engineers, one for construction and one for operations. In addition, MARTA's consulting engineer has two system safety specialists. The CTA representative testified that it has a staff of 22 in its safety department, plus 5 or 6 people in maintenance who are dedicated specifically to safety work, and 2 principal safety coordinators in its transportation department. WMATA listed seven people in safety engineer, a safety inspector, and the safety officer.

Rail rapid transit systems testified that their safety activities include the exchange of safety information among systems, including information about accidents and incidents, the development of system safety plans, participation in safety meetings and workshops, and supporting and participating in the safety activities of APTA and UMTA.

The BART representative testified that it has:

> . . . set up some rather formalized programs in assessing the various safety aspects of the [system] by structuring in such a manner that you have separate projects governing the car, the wayside communications, passenger information and so on.
>
> Since the Transbay Tube fire, we have taken all of the recommendations that came from many agencies, including our own knowledge of the system, put it into that particular program format, and we are currently now assessing each one of those elements we prioritized to begin with, and going through each one of those on all aspects of the system.
>
> We do have formal processes for assessing the safety of any modification that may occur on the system. Those are available. They are provided to the Public Utilities Commission on a regular basis.
>
> We analyze all operating incidents that, while they may not have . . . resulted in an accident, if it looks like they may have, we analyze, investigate and determine what can be done to preclude those, and that is a part of the on-going safety evaluation process at BART.
>
> We also involve outside agencies in that. There is a fire committee that has members from all of the 14 [local fire departments], that we take input from them and we also provide input. We analyze each incident where the fire departments are called on a BART situation.
>
> So that there is total understanding by both BART and the fire departments as to how that response went, where were the weaknesses, what can be done to improve them. And a number of things have come out of that committee, and that committee is not a new committee . . . . It's been in existence in one form or another since 1964.

Representative of other systems testified that they also have committees which involve local fire departments, and transit systems have their own systems for compiling data on accidents and incidents as well as system and equipment performance and reliability.

APTA conducts a variety of safety activities which include research, publication or reports and safety documents, the collection and dissemination of safety information, sponsorship of workshops, conferences and safety meetings, and safety services and support to its membership and to UMTA. APTA described its activities in detail in its testimony and in a May 13, 1980, letter to the Safety Board.

APTA's representative testified that about 90 percent of its research is funded by UMTA. Its research projects include or have included:

- The development of an emergency procedures document for the UMTA under a safety and system assurance contract. A draft outline has been completed and six APTA committees composed of transit system personnel are working to complete the document and deliver it to UMTA early in 1981.

- The development of a National Design Practices Manual. APTA completed the first phase of the project for UMTA in October 1979, developing a detailed outline, format and scope of a series of volumes that will be written by another UMTA contractor to guide planning, design, development, and implementation and improvement of rail systems and system elements. A chapter of the manual is to address safety issues such as materials flammability and toxicity, safety design, operational safety, and emergency response requirements.

- The development of Guidelines for Design of Rapid Transit Facilities, published in January 1979, which includes safety subjects such as fire protection, materials, and life safety.

- The development of draft content guidelines for rail system safety program plans, which is to be completed by another UMTA contractor and published by UMTA to assist transit systems in revising and updating their system safety plans.

APTA also is involved in the smokeless cable research project, a materials criteria and testing program, and NFPA's committee to develop a fire and life safety standard for fixed guideway systems. In this smokeless cable project, APTA is supporting TSC's study with an advisory board of nine electrical cable experts.

For future research and development, APTA's Five Year R & D Program Planning Manual identifies safety and other subjects in which APTA has asked UMTA to fund R & D projects. Safety-related subjects are:

Fixed and Motor Stairs Safety Study
Physiological and Psychological Ramifications of Stalled Trains
Safety Training Film for Rapid Transit Systems
Fail Safe Design Manual
Fire Detection and Extinguishment
Optimum Car Design Features for Fire Safety
Guideway Intrusion Detection Device Development
Derailment Detection

In addition to the research documents prepared for UMTA, APTA also produces Moving People Safely as a general safety guideline for rail transit systems. According to APTA, Moving People Safely addresses areas of safety procedures common to most rail systems.

In connection with UMTA research projects or on its own, APTA has conducted or participated in workshops, conferences, and meetings which involve safety issues. A workshop on emergency procedures in Washington, D.C., included representatives from UMTA, APTA, TSC, the Washington, D.C., Fire Department, and safety and operations personnel from 15 rail rapid and light rail transit systems. At the workshop, participants identified six areas to be addressed by the emergency procedures document project. Another workshop is planned at MARTA to permit transit system personnel to review emergency drill. The APTA Rapid Transit Conference held in Montreal in June 1979 included a workshop on fire safety which included presentation of three papers on the BART fire. APTA's 1980 Rapid Transit Conference in San Francisco included workshops on emergency response capabilities, the state of the art in fire safety, and accident investigation techniques and analysis.

The APTA representative testified that one of its activities is the dissemination of safety information to its members. In its letter, APTA reported that it had sent to all rail transit safety officers copies of the Safety Board's accident investigation report and a report by a board of inquiry convened by BART to investigate the BART fire. In response to Safety Board recommendations, APTA also is collecting from its members information on their methods, practices, and procedures for uncoupling transit cars in case of emergency, and on the training of employees to carry out such procedures where they are used.

Other activity is carried out by APTA's Technical and Research Services Department, which provides staff resources to manage industrywide safety programs, to support APTA's Rail Transit Safety Committee, and to furnish staff assistance and industry experts to support UMTA's safety activities.

APTA has established a Rail Safety Service and a Panel of Inquiry Service for rail transit systems. The Rail Safety Service, at the request of a transit system, sends a team of experts to assist in the development of a system safety plan, to review a system safety plan for conformance to the draft content guidelines for system safety plans, or to provide onsite inspection of a system's safety program for adherence to its system safety plan. After a major accident, when requested by the chief executive officer of the transit system, APTA will convene a three-member Panel of Inquiry composed of chief executive officers of rail transit

systems. The panel will investigate the accident, determine its cause, make recommendations, and issue an independent report.

Views on the Adequacy of the Current Approach

There are differing views as to whether the current approach to safety is adequate. According to the Office of Technology Assessment:

> The opinion within the transit industry is that self-regulation is a workable solution. The excellent safety record of rail rapid transit is cited as proof that a self-regulating body can manage its affairs in a responsible manner, with the public interest as a foremost concern. The opponents of self-regulation, while not questioning the integrity and sense of responsibility of the local transit system officials, point out the inherent danger of vesting a single agency with the authority to conduct transit operations and oversee the results. Both sides of the argument have merit, and one of the basic issues in the area of public policy for rail rapid transit is to find a proper balance between external regulation by a State or Federal agency (or some combination thereof) and responsible management by the local operating authority. 52/

During the Safety Board's public hearing, witnesses discussed the adequacy of the current approach and whether or not there is a need for increased oversight or regulation of the safety of rail rapid transit systems or minimum Federal safety standards. The views expressed by the transit industry, UMTA, fire and labor officials, and others are described below.

Transit Industry Views.--Transit industry witnesses testified that the current approach is effective and that the imposition of mandatory Federal safety standards would not improve safety and could even be detrimental to safety. Transit officials testified that uniform safety standards would be unworkable or impossible to develop because each system is different in its design and operation and safety problems are, therefore, "site-specific" to each system. Transit officials also contended that formal safety standards could hamper their safety efforts by limiting their flexibility to deal with problems; by leaving them with the responsibility but not the authority for safety; and by causing them to devote their time, effort, and resources to increased paperwork and administration.

Rail rapid transit system officials also believe that increased safety oversight and national minimum safety standards are not necessary. The good safety record of the industry, they say, shows that the voluntary approach to safety has been effective. For example, the NYCTA representative testified that:

52/ Op. cit., p.167.

> First, regarding the need for safety standards for rail rapid transit vehicles, we believe that they are not necessary. We think it important to realize that, since the inception of rail rapid transit service 75 years ago in New York City, the Transit Authority and its predecessors have prepared their own specifications for the purchase of cars. We have always recognized the need for safety awareness and have applied it to minimize the risk of fire or accident on our vehicles.
>
> Industry groups, such as the Institute of Rapid Transit and its successor, the American Public Transit Association, have disseminated a continuous flow of information within the industry. Numerous publications and guidelines have been put forward. With this exchange of information, with review of guidelines, with tailoring vehicle specifications to our own individual properties, we have been able to, through an evolutionary process, achieve reliable and safe vehicles.
>
> Efforts are now underway by APTA, in coordination with UMTA, to attempt to standardize those portions of the specifications which can be standardized. This is a worthwhile effort endorsed by the industry.
>
> We do not believe that the establishment of another set of minimal [sic] safety standards by any Federal, State, or other governmental agency would aid us in improving safety in rail rapid transit.
>
> The safety record for rail rapid transit is excellent. In our view, the record could not be improved by the establishment of a Federal safety standard for rail rapid transit cars.
>
> The approach that has historically been taken has kept accountability for vehicle design at the local level. The management of each property has had to act with imagination and initiative in implementing those programs that are necessary to achieve an adequate level of safety.
>
> What has happened over the years is that this local initiative, in trying to assure an adequate level of safety, has actually provided a superlative level of safety.

Transit officials also feel that they have learned a great deal from the accidents and incidents that have occurred and that this has improved safety. The NYCTA respresentative noted that each incident is followed by a review of its procedures to see where improvements can be made. The Montreal representative testified that its experience with major train fires led to action to correct the specific safety problems that were revealed by that experience and resulted in increased attention to safety. Montreal officials feel that the improvements have

greatly increased the system's safety. At the same time, the Montreal representative stated that:

> If in this presentation I gave the impression that we have solved all the problems related to fire safety, this is not so. We still have a lot to learn and a lot to do in this field.
>
> * * * * *
>
> In the operation of a rapid transit system, we must be humble and safety must remain our first concern, as we are all subject to circumstances and fate.

The transit industry's major objection to Federal safety standards is that because each system is unique and has different physical design and operating characteristics, it would be difficult if not impossible to apply meaningful, uniform safety standards to all rail rapid transit systems. According to the BART representative, the physical differences among transit systems alone require the more flexible, guideline approach that is being taken by the industry and UMTA. In emergency communications, for example, the BART representative testified that:

> . . .it is difficult to make general assessments as each property must be evaluated in light of its own operating considerations. For instance, a property entirely aboveground differs radically in communications aspects than one partially or totally underground.
>
> Likewise, an operation like BART in dealing with 14 separate fire departments will have needs different from an operator dealing with only one fire department. One can state, however, that reliable communications must exist between the property's control center and the command personnel of the local emergency response agencies.

In presenting a description of some of the safety features of its system, the CTA representative testified that:

> . . . comments relating to emergency evacuation procedures and training are site-specific to, for and about the CTA rapid transit system. As such, the details . . . may not, nor are they intended to be, directly applicable to all other transit properties.
>
> The numerous differences in equipment, conditions, situations, and so on, clearly indicates the need for and importance of dealing with matters at the local site level.

In general, the transit industry is greatly concerned that safety standards would dictate in detail exactly how a transit system would have to meet a particular requirement. For example, the NYCTA representative testified that it

has fiberglass seats in cars, with no padding, but if a Federal standard specified that seats must be padded with certain materials (for fire resistance), NYCTA would have to add padding to its seats. The MARTA representative testified that it does not need ladders to evacuate passengers from cars, but ". . . if there was a rule which said, 'Thou shalt carry a ladder, and it shall be four or five feet long,' " MARTA would have to have ladders it would never use. "Each property is site-specific with respect to its design. If you attempt to mandate, 'Thou shalt perform this function in this fashion,' . . .it can create many, many problems," the MARTA representative said.

While all of the transit systems believe that they are "site-specific," or unique, they acknowledged that they do have elements in common. Although the BART representative believes that it would be difficult to establish safety standards which would be applicable to all transit systems, he noted that:

> . . .there are commodities between the properties. There are certain elements that are common, like the ability to. . . evacuate effectively, to have the planning in place and the training and drilling to insure that, when you need to evacuate, that those things can occur and can occur effectively.

Transit officials also are concerned about issues of authority, responsibility, and accountability. They believe that they are ultimately accountable and responsible for the safety of their systems, and that external safety authority would reduce their ability to provide for safety. The BART representative, for example, testified that:

> The current approach places the responsibility and authority for safe operations squarely upon the [transit system] operator. Additional regulation could well serve to diminish the effectiveness of the operator by placing authority in the hands of another body but still holding the operator responsible.

The BART representative said that it has had those kinds of problems with regulation at the State level by the California Public Utilities Commission. According to the BART representative, if issues of authority, responsibility, and accountability are difficult to manage at the State or local level, Federal regulation would worsen the situation.

Transit systems testified that they need the flexibility to address safety problems at the local level. Because their resources are limited, they have to be able to set their own safety priorities. The APTA representative testified that:

> In the area of fire protection, the high costs of adding, modifying, or replacing existing facilities generally requires that there be a very high benefit to justify such large expenditures. Local responsibility is the most effective means of ensuring fire safety in transit.

The NYCTA representative testified that:

> Safety items such as special fire equipment, improvements that can mitigate serious fires, smoke and other emergency conditions are necessary and should be included in our ongoing program, and to a large extent they are.
>
> But it should be noted that the relatively simple installations that we're talking about are costly because of the magnitude of the system that we are involved in. For example, a wet fire line throughout our 125 miles of subway system would cost some $40 million and take more than 5 years to install and put into service. While this would be a safety asset, it must be weighed against the other needs of the system.
>
> * * * * *
>
> We are all aware that we will not, in the foreseeable future, get anywhere near the amount of money that we deem necessary. So in establishing our improvement program, we must constantly weigh the system's needs against the resources available.
>
> And in doing that, we at the New York City transit system are providing what is necessary for our ridership and for the continuing successful operation of our plant, and we are providing what is needed for safety improvements.

One of the objections transit officials have to Federal regulation is their assertion that it could actually harm safety by imposing paperwork and administrative requirements that would strain their limited resources.

The APTA representative testified that:

> Rigid standards that do not reflect the many and necessary differences in design, construction and operation of the existing transit systems will not serve any purpose and can only result in dissipation and waste of fire safety-related efforts within the transit organization. The [Occupational Safety and Health Administration] lesson need not be repeated. Countless hours and funds were spent in applying, revising and changing inconsequential details to conform to, in many cases, arbitrary, inappropriate [occupational safety and health] standards.
>
> What is needed and what is being developed are guidelines for many areas of equipment and facility design and operation. Such guidelines will permit and encourage rapid deployment of the benefits of the guidelines.

The WMATA representative testified that:

> We believe that additional oversight or regulatory authorities can only impede [the safety] process and thereby decrease safety. Any additional oversight or regulatory authority that requires us to divert resources from identification and correction of problems to providing additional information or responding to inquiries by oversight or regulatory authorities may degrade safety.

All of the transit industry witnesses agreed that the current safety approach of developing voluntary safety guidelines is the most effective way to maintain a high level of rail rapid transit safety.

UMTA Views.--UMTA believes that the current safety approach is effective, although it intends to make some improvements in its activities. For example, UMTA has asked Congress to authorize certain changes in its Section 107 authority, primarily to make its investigative authority applicable to all transit systems which receive or have received grant assistance and to permit UMTA to ascertain whether an unsafe condition exists. UMTA also has asked that it be allowed to set "safety criteria and standards" to be used as tools in investigations of unsafe conditions. The UMTA representative testified that Section 107 currently does not explicitly grant this authority.

UMTA believes that it may be necessary to "establish standards in a particular investigation" since there are no national standards. UMTA emphasized, however, that "this is not intended to be authority for setting overall national standards or regulations for application to rail operations."

The UMTA representative indicated that one of its most urgent needs is to formalize and codify its safety program, which for some time "has run on an informal basis." The agency intends to document and publish its safety program early in calendar year 1981.

According to the UMTA representative, its role as a financial assistance agency primarily means that:

> . . . our safety responsibility must focus on the planning of safety features and procedures in new or rehabilitated systems, vehicles, or services. We have accomplished this through the planning and guidance and valuable products of R & D made available to grantees.

UMTA testified that it does not currently have the authority to impose formal safety regulations on rail rapid transit systems, and it does not believe formal safety regulation would be beneficial. The UMTA representative testified that the current, voluntary approach is the only way to provide for the safety of transit systems:

> The best we can do is to assure that Federal processes and resources are in place and are maintained, to produce informed decision making at the local level leading to transit and related public sector investments which assure operational safety.

UMTA rejects the idea that Federal safety standards are needed and would improve safety, based on the site-specific characteristics of transit systems and on the view that serious authority and accountability problems would result. The UMTA representative testified that:

> By statute we cannot regulate the operating practices of our grantees, nor do we wish to, since we believe that formal regulations would be close to unworkable due to the unique nature of each system. The fact that regulations would need to be "minimum" standards and quite likely could impede creativity and flexibility helped us to arrive at this posture.

However, UMTA distinguishes between safety requirements imposed on a system before it receives a grant and the application of mandatory safety requirements after the fact. For example, UMTA intends to place safety conditions (for materials flammability) on grants for new transit vehicles, but does not intend to impose any safety requirements retroactively on existing vehicles.

Federal intervention through formal safety regulation, according to the UMTA representative, is to be avoided. She testified that:

> The accountability for the operational viability of a system, including safety, ultimately rests with the local or regional decision-maker--the general manager or senior executive officer of the transit organization--who is locally or regionally accountable to the public for the safety and dependability of the system under his control within the established or changing local and regional, social and political environment.
>
> UMTA action to preempt local or regional accountability for one or more safety-related decisions could implicitly generate UMTA accountability for all such decisions. This is a situation to be avoided, for we cannot acquire the detailed system and environment knowledge necessary to make informed decisions for the safety of systems we do not manage.

Fire Officials' Views.—Fire officials believe that the current approach to safety is not adequate. They testified that basic fire and life safety principles have not been applied in the design and operation of transit systems, and that there consequently are numerous safety problems which the current safety approach has not been adequate in correcting.

The NFPA representative testified that:

> Considering the prevalent use of combustible materials in modern subway cars, inadequate means of egress, and the lack of automatic fire detection and fire extinguishing systems in many rapid transit systems, the passengers on a fully loaded train may not have time to exit to safety in the event of a fire. Until those problems are corrected, the possibility of a major life loss from a rapid transit system fire continues.

Fire officials believe that many of the existing safety problems have developed and persisted because neither UMTA nor the transit industry have involved the fire services effectively in their safety activities or in the development of transit systems. When fire officials attempt to become involved or to make recommendations, they often are unsuccessful. In many cases, they find that their safety recommendations are rejected for economic reasons, and even when they are accepted, action on safety improvements often is delayed. A major problem, they say, is the lack of minimum safety guidelines or standards for rail rapid transit systems.

The Administrator of the United States Fire Administration said he disagreed with the statements of transit officials that the fire services have been included in industry safety activities. "The most common complaint I hear from the fire service," he said, "is that they have not been included at UMTA meetings or at APTA meetings." The San Francisco Fire Chief testified that at APTA's Rail Rapid Transit Conference in San Francisco in June 1980, ". . . there wasn't one person from the fire world, from the fire service, that was invited, that was part of a panel. We didn't know anything about it. We read about it in the newspaper in San Francisco." A list of 410 participants at one UMTA research and development priorities conference included no fire service representatives. 53/ Other testimony indicated that the emergency procedures workshop sponsored by UMTA and APTA in Washington, D.C., included transit system representatives from all over the United States and Canada, but the only fire service involved was the fire department of the host city.

Fire services have been involved to some extent in the development of the newer rail rapid transit systems, but they feel they often are not involved early enough when the system is actually planned and designed. If safety requirements are not included while a system is on the drawing board and built in during construction, fire officials indicated, they may be difficult or impossible, as well as costly, to make later. And fire officials noted their frustration in attempting to persuade transit authorities to add safety improvements. According to San Francisco's Fire Chief:

53/ American Public Transit Association, "Proceedings of the Third UMTA R & D Priorities Conference, November [illegible] and 17, 1978," Report No. UMTA-DC-06-0157-79-1, November 1978, pp. 51-67.

> When life safety requirements follow completion of construction, then. . . response to firefighting professional recommendations is delayed and bottlenecked.
>
> Management excuses, generally, are attuned to the lack of funds. Here is where foresight and advice from fire departments should have been utilized. Too often, rail rapid mass transit sacrifices life safety for comfort and other factors of engineering thought to be more essential.

The Administrator of the United States Fire Administration testified that:

> I can't express more forcefully here my disappointment at the lack of input that the fire service has had into the planning for life safety and rescue and suppression in case of fires in [rail rapid transit] systems.

Fire officials also observed that when their safety recommendations are accepted, delays in implementing them can be critical. The testimony of both the BART representative and the San Francisco Fire Chief supports a commentary on the BART fire which appeared in a firefighters' journal:

> Both the Oakland and San Francisco Fire Departments had had liaison officers working with BART for a number of years. Both departments, as well as other agencies, had submitted warnings and recommendations to BART concerning the combustibility of BART cars, the need for four-hour breathing apparatus [for firefighters], and the desirability of conducting drills more than once a year. BART had initiated action on the purchase of four-hour breathing apparatus, but none of the concerns had been resolved prior to the fatal fire. 54/

Fire officials uniformly stated that rail rapid transit systems need more effective external safety oversight. They asserted that all too often, needed safety improvements are not made until an accident or incident occurs. Some fire officials believe that mandatory safety standards for rail rapid transit systems should be developed and enforced, while others appear not to be concerned with the manner in which safety criteria are expressed, as long as they are developed and applied. The San Francisco Fire Chief testified that the death of a firefighter and injuries to passengers, employees, and firefighters in the BART fire:

> . . .opened the eyes of many to hard, cold facts. And these are that there are no national rail mass transit fire safety standards, no means of citing non-compliance, and Federal and State regulatory agencies that do not come on stage until after the disaster. These regulatory agencies must

54/ "Rapid Transit Train Fire," op. cit.

> move in before a serious fire claims lives and causes respiratory and burn injuries.

The NFPA representative testified that 5 years ago it formed a committee to develop a fire safety standard for rail rapid transit and other fixed guideway transit systems. The project was undertaken because:

> The element of need for fire safety standards for rail rapid transit systems has been demonstrated by several unfortunate incidents occurring in transit systems, both new and old, and most importantly because of the extreme potential for entrapment, injury and asphyxiation of large numbers of people who routinely utilize these mass transportation facilities.

The Association said that its standard will address the common safety needs of transit systems and is intended as a minimum standard, but its use by the industry will be voluntary. UMTA's safety program plan stated that at one point the Association's project was "dormant for more than a year (partially because of disagreement on content and criteria)." The standard is now scheduled for completion in 1982.

The Administrator of the United States Fire Administration testified that safety standards are badly needed. He testified that:

> . . .we're planning for human safety in metro tunnels and transit systems based on trial and error. I guess if we've killed enough people, or expose enough people to some sort of danger, we then adopt a standard or help a fire department to combat that sort of thing. I think that's rather shocking.

Labor and Other Views.—Labor unions testified that formal regulation of rail rapid transit safety is needed to fill what one union called the "vacuum in safety oversight." The unions indicated that they are most concerned about equipment maintenance, emergency training for their employees, and provision for emergency evacuation.

The Transport Workers Union of America representative testified that:

> Although rail rapid transit systems have been in operation for decades, the post-World War II transition from private to public ownership and operation was accompanied by a loosening and outright exemption from previously - existing regulation and surveillance of transit system preventive maintenance and operating practices.
>
> In their place came self-policing by underfunded and politically-motivated operating authorities, which has proved to be totally inadequate if not practically nonexistent.

The Union representative testified that the complexity of transit technology has increased considerably, but there has not been a corresponding increase in the recurrent skill training of maintenance and operating personnel. Training and maintenance, according to the Union representative, are among the first items sacrificed when budgets have to be trimmed. The Union believes that safety has deteriorated, particularly on the older systems such as NYCTA and SEPTA, as economic troubles have worsened. He expressed amazement that:

> . . . the Federal Government, which has gone to such lengths and such expense to help these rail systems by providing the greater part of the cost of this advanced-technology equipment, does such an inadequate job of making sure that it is maintained and operated properly.

The Union representative urged that one agency be made responsible for the safety and reliability of rail equipment on publicly-operated transit systems, and called for Federal safety standards in such areas as maintenance, training, security, passenger information, and emergency evacuation. Federal regulation, the Union representative testified, "would make these authorities responsible, in a legal sense, to someone," and would "enhance safety on a long-term and reliable basis, and that. . .is much more important than trying to deal with a catastrophe after it happens." Regulation, he testified, would provide checks and balances to assure that a transit system "does the things that it should be doing, regardless of political influence or the squeezing of budgets."

The Amalgamated Transit Union representative testified that formal safety standards are needed in a number of areas including flammability and toxicity of materials used in transit cars, emergency communications, and emergency procedures. The Union representative also stated that safety inspections of rail transit facilities by an independent party should be required.

According to the representative of the California Public Utilities Commission, in the absence of any safety standards it has no objective basis for assessing what is safe and what is not. The Commission's current effort to explore the possibility of developing State safety standards is being undertaken out of desperation since the Federal Government has not acted.

Regarding the voluntary approach to safety through self-regulation by transit authorities, the Commission representative testified that without the Commission's oversight of BART and its orders directing corrective action, many of the safety improvements that were made after the BART fire would not have been accomplished.

THE NEED FOR A NEW APPROACH TO SAFETY

Analysis of the information developed in this evaluation indicates that although design and operational differences exist among rail rapid transit systems, these systems face fundamental safety issues which are truly industrywide in scope. The current approach to rail rapid transit safety has not provided an effective process for addressing these issues on a nationwide basis. It has been

largely reactive rather than preventive, permitting the introduction of safety problems which often are recognized or resolved only in the wake of serious accidents and incidents. In fire safety alone, numerous serious safety problems continue to exist in such areas as the exposure of passengers to fire and toxicity hazards of materials used in transit car construction, inadequate provision for rapid evacuation or rescue of passengers who may be trapped in burning trains or smoke-filled tunnels, and insufficient training and drilling of transit employees and emergency service personnel in emergency procedures.

Consequently, in spite of the good safety record of rail rapid transit, there exists an enormous potential for a catastrophic accident involving major loss of life. The BART fire, the accidents and incidents that have occurred on other systems, and current safety problems indicate that passengers on a fully loaded train can be exposed to serious hazards which could result in hundreds of fatalities. Such an occurrence no doubt would be followed by public outrage, extensive public inquiries, and massive efforts to improve safety. Obviously, the public should not have to wait for a disaster to occur before the safety of its transit systems receives proper attention. It is imperative that systematic, effective, preventive safety action be taken now to reduce the potential for a future disaster.

The limitations of the current approach to rail rapid transit safety indicates the need for a new safety approach which provides the capability to prevent or identify and resolve nationwide safety problems and bring about safety improvements based upon the establishment of objective criteria for minimum safety performance.

Why the Current Approach is Inadequate

The current safety approach relies almost exclusively on independent action by essentially self-regulating transit authorities with minimal external safety oversight. This approach has resulted in fragmented efforts by individual transit authorities to address industrywide safety issues on a site-by-site and often reactive and ad hoc basis, without safety guidelines or safety standards for evaluating safety problems. Because of the lack of safety guidelines or safety standards and the currently limited capabilities of safety oversight bodies at the State, local and Federal levels, this approach has not provided adequate checks and balances to assure that safety issues are recognized and resolved.

Rail Rapid Transit Industry Self-Regulation.—Rail Rapid Transit authorities do want their systems to be safe, and in general, they try to assure that their systems are designed and operated safely. However, transit authorities operate under institutional and resource limitations which restrict their ability to assure that all safety issues are given proper recognition and are successfully resolved. Indeed, the increasing need for maintenance, with an implied reduction in safety inspection and surveillance of transit equipment and facilities may further impact the transit authorities' abilities to insure that minimal safety requirements are met.

Under the current safety approach, many common safety problems of rail rapid transit systems are being addressed in a fragmented way, often involving differing approaches to problems which have industrywide implications. Individual transit authorities lack the objectivity to evaluate the results of their safety decisions and are further limited by the lack of safety guidelines or safety standards by which to evaluate their safety programs.

The testimony of transit industry representatives indicates that, because the resources of transit systems are limited, safety needs must compete with operational needs for funding. However, transit systems constantly are faced with demands for more or better service while there may be few or no demands for safety action unless an accident or incident has occurred. Transit authorities must deal with operational needs every day, but encounter serious safety emergencies only rarely. And where operational problems often have tangible, predictable consequences in terms of deterioration or interruption of service, many safety problems can appear to be "abstract." When priorities are established, safety equipment or improvements, which may not be needed until some indefinite time in the future when the unexpected emergency occurs, may not be perceived as having the same level of immediacy as operational projects to keep the trains running smoothly tomorrow, next week, next month, or next year. At the same time, operating budgets for mass transit are limited even in the best times and can be squeezed even tighter when the cities or metropolitan areas they serve are under financial stress. During a budget crunch, the transit authority may find it almost impossible to justify spending a nickel on "abstract" safety issues when there has not been an accident.

Accidents and incidents have too often revealed safety problems which previously had been recognized but had been put aside because of funding priorities. In some cases, even when a safety problem had been recognized in advance, such as the hazards of polyurethane used in transit car seats or the lack of adequate breathing equipment for firefighters, corrective action is undertaken without a sense of urgency commensurate with the potential severity of the consequences. Transit authorities emphasize that their resources are limited, and that safety needs constantly must be weighed against operational needs in assigning funding priorities. NYCTA recognizes that the installation of a wet line water supply for firefighting in its tunnels would be a substantial safety asset, but indicates that need has to be compared against other system needs. MBTA recently indicated its uncertainty about whether the upgrading of its obsolete emergency tunnel ventilation system can be completed as planned in 10 years because some of the money for the project may have to be directed to meet operational needs. Even on the newer systems like WMATA, safety improvements, such as emergency communications equipment in tunnels, have to be added to the system now because they were not incorporated during system design and construction. The perspective of transit authorities on safety issues, particularly those which involve precautionary measures for potential emergency events, appears to be limited because of their limited resources and their primary function of managing the normal operations of their systems and dealing with the problems involved in those operations.

The current safety approach does not provide an efficient and effective mechanism for dealing with basic safety issues which affect all transit systems. On each safety issue, each system has had to devote substantial amounts of time, effort, and money to determine what safety criteria and objectives should be applied to guide safety decisionmaking. Each system has had to answer the question, "How safe is safe enough?" before determining the specific ways in which selected safety criteria and objectives will be met. This often requires extensive research, investigation, and testing. Each system has had to repeat this process to arrive at its own conclusions. Each system has had to "reinvent the wheel" to determine, for example, the general criteria to which emergency tunnel ventilation systems should be designed to adequately remove smoke and fire gases, how much emergency training, and how often, is adequate to prepare employees to deal effectively with emergencies, and what information passengers need to be able to exit cars and evacuate safely in the event of an emergency. Individual action by transit systems to address a safety concern which is common to other transit systems results in a needless waste of their limited resources without assurance that the resulting safety decisions will be disseminated or applied to other systems.

BART's experience with transit car fire safety problems provides an example of the limitations of transit industry self-regulation without safety standards or adequate safety oversight. The safety implications of transit vehicles constructed using new synthetic materials which had been made available by new technology were not fully explored before the introduction of these materials in transit cars. BART passengers had been exposed to these risks for more than 6 years before the Transbay Tube fire, although the hazards had been identified several years earlier. No safety guidelines or safety standards existed for transit vehicle fire safety peformance and no comprehensive research effort had been undertaken to resolve the complex, industrywide problem of transit vehicle fire safety. At each stage, BART had to develop or redefine its own safety performance criteria. BART was left to independently conduct extensive screening and testing of alternative materials, but in spite of its considerable efforts, the magnitude of the task proved to be beyond the capability of a single transit authority. In the end, BART selected alternative materials based upon subjective evaluation of the limited information and test data that had been obtained.

With no safety guidelines or safety standards available, the designers of BART cars had to rely on their expertise to evaluate potential safety problems, and fire hazards were not suspected; the cars were believed to be safe. The hazards were discovered as a result of fire incidents in the industry, warnings of fire officials, and formal study. However, no adequate criteria were available to evaluate the safety implications of alternative corrective actions. Even then, the urgency of the need to correct the "abstract, remote" safety problems was not fully recognized until a major fire occurred. After the BART fire, action that had been planned to reduce the fire hazards of the seating materials was recognized as inadequate.

Removal of polyurethane seat cushions from BART cars, which had been further delayed by the screening and testing of materials, was not completed until nearly 2 years after the BART fire -- more than 8 years after BART began

operating. It now appears that fire hardening of the floors of BART cars and other efforts to reduce the hazards that were identified as a result of the Transbay Tube fire may not be completed for several more years.

The need for a common approach to mutual safety issues has been recognized by the transit industry, which has identified some research needs for UMTA. However, the completion of research and implementation by UMTA of research findings through any formal mechanism (guidelines or standards) has been limited. Current activities, such as the development of fire safety standards and emergency procedures guidelines, were initiated in response to accidents and incidents which revealed problems in these areas, rather than based on the prior identification of safety areas where research was needed.

Safety improvements have been made by the industry through the safety programs of individual transit systems and APTA. However, these efforts have largely excluded participation by groups outside the industry, its suppliers, and manufacturers, and the municipal bodies and other organizations interested in mass transit service. The industry's safety activities could be improved and enhanced by actively seeking broader participation by groups and individuals which could make a substantial contribution to safety. For example, the resources and expertise of local fire and emergency response services and national safety organizations could be of invaluable assistance to the industry in its safety efforts. The United States Fire Administration, the International Association of Fire Chiefs, the National Fire Protection Association, and the International Association of Fire Fighters are just a few of the organizations which could be helpful in the area of fire safety. The United States Fire Administration has offered to assist in the development of emergency training requirements and has indicated its receptiveness to transit industry participation in the development of a curriculum for the United States Fire Academy. The Administration also has opened the possibility of including transit issues in its ongoing fire safety research program. UMTA and the transit industry should take advantage of such assistance.

Federal Safety Oversight.--By default, the largely passive Federal safety oversight posture has permitted individual transit systems to regulate themselves. UMTA lacks the authority and resources for comprehensive safety oversight, and UMTA construes its safety role narrowly. While UMTA is seeking amplification of its safety authority from the Congress, the agency has not used its existing authority effectively. UMTA, like the transit industry, has not achieved broad participation in the establishment of safety policy for urban mass transit. For these reasons, UMTA's safety program is reactive and poorly-defined, lacking the ability to identify and assure reduction of safety hazards before they become readily apparent or result in accidents.

Beyond the specific authority to attach safety conditions to grants, perform Section 107 investigations, and conduct such activities as research and training, UMTA's safety authority is expressed in general terms. While this general authority could be interpreted as authorizing a broad range of Federal safety activities, including formal safety regulation of rail rapid transit, such an interpretation might be challenged. Other safety oversight agencies, such as FRA, have their authority defined by statute in far more detail. FRA, for example, has been

granted specific powers under the Federal Railroad Safety Act of 1970 to establish safety standards for railroads, investigate accidents and incidents, and conduct safety inspections. UMTA's safety authority appears to be far more limited.

There does not appear to be a commitment by the UMTA to use its present authority to its maximum potential. For example, UMTA's safety function is a secondary activity to its financial assistance function. Of the $1 to $2 billion allocated to urban mass transportation each year, only $1.65 million is planned for safety oversight in FY 1981; and, of UMTA's total staff of over 500, only 6 professionals are assigned to conduct safety oversight (with a possible increase to 7 or 8 by FY 1982). Three other oversight agencies in the Department of Transportation (the Federal Railroad Administration, the Federal Highway Administration, and the National Highway Traffic Safety Administration) have established their safety functions at the level of associate administrator, a level which defines the major functions of the organization. UMTA's safety office is not at this level. It is one of six offices under an Associate Administrator for Technology Development and Deployment, who must divide his attention among responsibilities which are far broader than safety alone. In addition, UMTA's safety function is located in its Washington, D.C., headquarters and does not extend to its regional offices, which are the primary contact points for transit systems and the initial in the process of reviewing grant applications.

The safety function, with its limited staff and budget and its relatively low position in the organization's mission and structure, is further limited by UMTA's commitment to a largely passive, reactive safety approach. That UMTA believes it necessary to seek explicit authorization to establish procedures to carry out its statutory authority under Section 107 to investigate unsafe conditions indicates a narrow construction of its safety role.

While UMTA's safety authority is defined in far less detail than that of other safety agencies, UMTA has not effectively used the authority which it has been granted. UMTA is only now preparing to begin attaching safety conditions to grants, has not developed procedures for Section 107 investigations, and has conducted only one Section 107 investigation in the last 5 years. In addition, UMTA still has not developed a plan for how it will take advantage of the potential for use of system safety plans as tools to evaluate and monitor the safety of transit systems, as recommended by the Safety Board more than 9 years ago. Indeed, UMTA's existing safety plan is an informal internal document which has not been updated since April 1979 and covers a 2-year period or less. Its usefulness is further limited by the fact that the plan remains based on staffing levels which were projected 2 years ago, but which have not been attained.

UMTA has undertaken, as its primary safety activity, the development of safety guidelines. There is an unquestionable need for safety research and development in rail rapid transit; however, UMTA relies almost entirely upon voluntary action by transit systems to apply the guidelines developed. For example, the emergency preparedness guidelines now under development are to be used only as a reference in safety and system assurance reviews. In the absence of formal requirements, UMTA lacks the means to assure that even safety criteria which are considered necessary to achieve a minimum level of safety are, in fact, applied.

UMTA intends to attach safety criteria to new grants; however, UMTA does not believe it is necessary or appropriate to establish requirements that existing systems correct similar safety problems. Even if safety criteria are formally instituted in the grant procedures, UMTA has only two remedies available to insure that safety corrections are made--the withholding of further financial assistance, which UMTA has never done and is unlikely to do except in the most extreme circumstances, and the issuance of requirements for the correction of unsafe conditions. The withholding of funds is unrealistic since such action could have enormous economic and political consequences and is contrary to the Federal policy of fostering and assisting the development of mass transit. The authority to compel correction of unsafe conditions can be a difficult enforcement tool to use since it can be used only when an unsafe condition is of such a magnitude that it "creates a serious hazard of death or injury," and then only after a Section 107 investigation is conducted. For practical purposes, UMTA's enforcement powers are extremely limited. Therefore, a series of minor, technical maintenance or procedural safety concerns may not be addressed in a systematic effort until after a major catastrophic accident occurs.

Another problem is that UMTA's safety leadership has been lacking. From the testimony provided at the hearing, it is evident that UMTA has failed to expand its contacts beyond APTA, transit management, industry manufacturers and suppliers, and service-oriented interests. Such organizations as fire and emergency medical services, labor unions, and one State safety oversight body voiced their opinion that UMTA, as the agency responsible for Federal safety oversight, should be the national focal point where they can forward their safety concerns and receive appropriate attention. However, these safety interests have been neglected by UMTA.

While UMTA has neglected transit labor and public safety organizations, UMTA has been responsive to the interests of a single constituency--the rail rapid transit industry. UMTA's current safety programs appear to be strongly dominated by the industry whose safety UMTA is charged with overseeing. UMTA's process for identification of research and development needs and priorities is based almost entirely on industry participation, to the virtual exclusion of outside safety interests. UMTA relies on the industry "to present their research needs and clarify the approach to high priority projects," and much of UMTA's research work is carried out in whole or in part by APTA. According to APTA, research projects funded by UMTA account for about 90 percent of APTA's safety research activities. The relationship between APTA and UMTA, in terms of safety decisionmaking and leadership, raises serious concern that UMTA has abdicated its responsibility to maintain its independence and objectivity. While cooperation is necessary, if carried to extremes it can result, in effect, in the delegation of oversight responsibility to the industry.

In order to provide an opportunity for broader public participation in the development of Federal safety policies and plans concerning rail rapid transit, UMTA should consider the procedures used by other agencies. For example, FHWA and NHTSA provide for public participation in the development of their 5-year research plans through public meetings and by making these documents available to the public. Since UMTA's safety program plan and its research plan impact the

transit industry and the public, have substantial impact on safety, and are supported by public funds, these safety decisions which affect others outside the agency should be subject to review and comment by those who may be affected.

State and Local Oversight.—Currently, there is virtually no State or local oversight of rail rapid transit safety except in the wake of serious accidents and incidents. Some transit systems operate with no State or local body to oversee them. Others are overseen only on a part-time, intermittent basis. BART is the only rail rapid transit system that is monitored by a body (the California Public Utilities Commission) which exercises oversight on a full-time, continuous basis Yet, the problems which were identified as a result of the BART fire had existed in spite of the Commission's oversight.

The Commission appears to have the most active oversight function at the State or local level (and has a larger safety staff than UMTA), yet even it is able to do little more than react to accidents and incidents after they occur. Because there are no comprehensive, objective criteria which it can use to measure BART safety, the Commission has had to use subjective judgment. Without safety criteria in effect, the Commission must deal with each safety issue as it arises. For example, BART recently approved closer headways between trains in the Transbay Tube, but the Commission has little or no means of evaluating the safety impact of this change. It needs research to provide a basis for safety decisions, but it has little or no research capability of its own.

Other State and local oversight bodies, where they exist, are in an even more difficult predicament. They are not in a position to undertake the massive research efforts necessary to determine the safety of the systems within their jurisdictions, or to determine what safety criteria should be applied to each system. They face the problem of substantially delaying safety improvements if they must sponsor research or testing on a case-by-case basis and wait for the results. The California Public Utilities Commission and other oversight bodies at the State or local level should be able to look to the Federal Government for safety research and standards development. So far, Federal research in rail rapid transit safety has largely been limited to research needs identified as a result of accidents or incidents and has not been comprehensive. And because the Federal Government is not developing national safety standards, the Commission has taken the responsibility for developing its own standards, beginning with efforts to determine the feasibility of such an undertaking. Ironically, the Commission testified that if it is successful in developing safety standards, "then the Federal Government can use whatever work comes out of the State of California for whatever purpose they deem appropriate for the rest of the country."

The Need for Federal Safety Standards

While the Safety Board believes UMTA could exercise far more oversight utilizing its present safety authority, we do not see the present UMTA safety program as having the capability to bring to bear the internal and external resources and expertise necessary to address national rail rapid transit safety issues on a broad scale in a coordinated and comprehensive manner.

The limitations of the voluntary approach have been demonstrated in all of the serious accidents that have occurred. These accidents have revealed a host of serious safety problems in transit car design, emergency evacuation capability and procedures, training, and other areas where reliance on voluntary action by transit systems has been ineffective in resolving the safety issues involved before the occurrence of an emergency. Continued reliance on a haphazard approach to safety is an invitation to a catastrophic disaster.

Safety standards are needed not only in fire safety, but in other areas which affect the ability of transit systems to operate safely. Safety Board investigations of train collisions and derailments have disclosed deficiencies in areas, such as rules for safe train operations, lack of consistent enforcement of operating rules, inadequate train communications, lack of an effective operator training program, ineffective protective devices and procedures to minimize the risk of train collisions, and inadequate inspection of equipment. (See appendix C.)

As a result of its investigation of a collision on the GCRTA system, the Safety Board recommended in 1978 that the Department of Transportation (DOT) develop the capability for safety oversight and safety regulation of rail rapid transit. At that time, DOT was reviewing alternative arrangements for rail rapid transit safety oversight since FRA's broad interpretation of its authority had been struck down by a Federal court. Following that review, complete responsibility for rail rapid transit safety was assigned to UMTA.

UMTA testified that it currently does not have the authority for formal regulation of rail rapid transit safety and does not believe that formal safety regulation is necessary. However, the Safety Board believes that nationally uniform safety standards for elements common to all transit systems can be extremely advantageous and beneficial to transit systems. The establishment of safety standards on a national level would substantially reduce the burden on each transit system of conducting the site-by-site research, testing, and evaluation necessary to identify safety criteria and objectives for the system in safety issue areas which are common to all systems. Much of the duplication of effort devoted within the industry to "inventing the wheel" could be eliminated, permitting individual rail rapid transit systems to better focus their resources on "site-specific" problems.

A major argument leveled against Federal safety regulation of rail rapid transit is that uniform safety standards would be unworkable due to the "site-specific" nature of each system. Both UMTA and the industry stated that national standards cannot fit all systems because of the uniqueness of each system. The Safety Board recognizes that each rail rapid transit system is unique in its design and operating conditions. There are site-specific problems which can only be treated at the local level. However, these systems face many common safety issues, such as the need to prevent or minimize fire and toxicity hazards in the construction of rail rapid transit vehicles; to provide adequate emergency ventilation capability in tunnels; to provide adequate means of safe egress from transit cars and from tunnels; to maintain effective emergency communications capability; and to train personnel effectively in the handling of emergencies. There are

many other safety issues in which fundamental principles would be applicable to every transit system, regardless of its design or operating conditions.

UMTA and the transit industry acknowledge that there are commonalities among transit systems. UMTA testified, for example, that its safety research program will be aimed "at the more nationally significant and critical safety problems of a generic nature." In fact, UMTA, the transit industry, and NFPA are all involved in the development of national safety guidelines in certain areas for all rail rapid transit systems. Even UMTA's safety program suggests a creeping evolution toward Federal safety standards. For example, UMTA sponsored research at TSC to develop voluntary fire safety guidelines for the testing and selection of materials used in the construction of transit cars. Preliminary guidelines were developed and made available for voluntary use in 1976, but UMTA testified that, "In 1978, we decided that the severity of the hazard presented by the extensive use of synthetic materials justified setting standards which grantees must follow." UMTA intends to issue these "standards" in 1981, making their use mandatory as a condition of grants for the purchase of new transit cars. However, UMTA considers this a "determining condition" activity rather than a regulatory activity.

UMTA testified that it is seeking authority to establish "standards" in a particular Section 107 investigation. However, the term "standards" implies that some broad areas of uniformity apply. It appears that UMTA intends to decide what safety criteria it will apply on a case-by-case basis, after the detection of an unsafe condition. The transit industry would be better served by a safety standards process which puts transit authorities on notice in advance of what Federal safety criteria will be applied, rather than a "second-guessing" approach which informs them after the fact.

Another concern voiced by both UMTA and the transit industry is that Federal safety standards would impede transit systems' creativity and flexibility in solving safety problems. Transit systems and APTA indicated their apprehensiveness that Federal safety standards would dictate exactly how they must meet safety criteria, supplanting local decisionmaking with Federal authority. However, Federal safety regulations, in most cases, can be expressed in terms of the level of safety performance that must be met. This would allow the transit system to determine the details of how it would meet the performance criteria. For emergency evacuation, for example, it is not necessary to require that transit systems carry ladders of a specified size in transit cars. A Federal aviation safety standard requires commercial air carriers designed to carry 44 passengers or more to be able to evacuate all passengers from the aircraft in 90 seconds in the event of an emergency. 55/ It requires that the 90-second evacuation be demonstrated in a test conducted under simulated emergency conditions. This standard applies to a variety of aircraft which are dissimilar in their design configurations and operated by a variety of airlines having different emergency procedures. The standard does not specify how many exits there must be, how large they must be, or how the aircraft interior must be designed. It simply prescribes the result and lets the

55/ Title 14, Code of Federal Regulations, Section 25.803, "Emergency Evacuation."

aircraft designer and the airline make the decisions as to how to achieve that result. This is one of the ways in which emergency evacuation requirements for rail rapid transit cars might be applied. However, the use of design standards should not be ruled out entirely. In some cases, it may not be possible to express requirements in performance terms only.

Existing transit systems are particularly concerned about how Federal regulations might affect them. Many of these systems were designed many years ago, when many of the safety considerations that are part of modern transit design were not employed. It is an accepted practice in other modes of transportation that standards for safety performance differentiate between new systems which can be designed to meet the standards, and existing systems where it may not be possible or practicable to meet the same criteria as new systems. This practice can be applied to rail rapid transit. Safety standards for existing systems can recognize these differences and provide the flexibility to achieve levels of safety performance which are developed with an understanding of the practical problems involved.

Flexibility also is needed to treat exceptional cases. For example, where compliance would be unduly burdensome in the case of a particular system, or physically impossible, or it could be shown that the system had achieved an equivalent or higher level of safety through alternative action, an exception may need to be made. The Federal regulatory process commonly provides for treatment of exceptional cases, where justified, through exemption and waiver procedures.

Another transit industry objection concerns flexibility in a slightly different sense. Both APTA and NYCTA believe that mandatory safety requirements can restrict the ability of a transit system to set priorities among safety and operational needs. At the same time, the enormous risk of endangering large numbers of people in an emergency requires that unreasonable risks to the public be reduced. The application of safety requirements should recognize the need for flexibility, without neglecting the need to achieve a minimum level of safety. Where corrective action may be long-term, interim or substitute safety improvements may be used to compensate for conditions which do not provide the desired level of safety. For example, the California Public Utilities Commission ordered BART, pending completion of the replacement of polyurethane in BART's seats, to take interim measures (such as providing an additional employee on trains operating in the Transbay Tube to assist in evacuating passengers in the event of an emergency).

Both the transit industry and UMTA contend that Federal regulation will leave transit systems with the accountability and responsibility for safety, but not the authority. This simply is not the case. Safety standards can establish a minimum level of safety performance that must be maintained. The transit system will decide how to maintain the level of safety specified and may exceed that level.

Finally, the industry and UMTA assert that the imposition of Federal safety standards will actually degrade safety by causing transit authorities to divert resources from safety activities to deal with Federal regulations--responding to

inquiries, doing paperwork, contesting asserted violations, etc. This objection appears to be related to the industry's experience with Federal regulations on occupational safety and health. One transit official reported that the regulations required detailed forms and reports and that minor changes in detail created additional paperwork for the transit system. Safety guidelines which are properly developed and effectively implemented should never degrade safety or require an unjustified expenditure of resources. Actually, Federal safety standards for rail transit safety could make it possible to relieve transit systems of much of the workload generated by the need for each system to identify safety criteria for common safety issues for which no national criteria exist. Transit systems already are reporting accident information to UMTA and have helped to develop the SIRAS system, so it is unlikely that safety standards will entail substantial new reporting requirements.

Further, the Safety Board believes that any nationwide deterioration in the budgetary climate for public works activities will only heighten the pressure for reduced funding of safety related activities. As budgetary pressures continue to mount, UMTA should be in a position to insure that safety maintenance levels and procedures of rail rapid transit systems are not derogated.

In conclusion, the Safety Board supports a substantially increased effort by UMTA to improve its safety standards and oversight of rail rapid transit systems. With the cooperation and support of the individual transit authorities, meaningful and essential improvements can be achieved through the development by UMTA of safety guidelines and standards. Compliance could then be the responsibility of the individual authorities with UMTA monitoring implementation.

The past record does not give strong encouragement that such guidance will be produced by UMTA or that compliance can be achieved. If this is the case then the public's safety will require that mandatory authority be given to and exercised by UMTA.

Therefore, UMTA should continue and bolster the creation of voluntary guidelines or standards and concurrently seek standby authority from Congress to establish and enforce mandatory standards if voluntary support by all the rail rapid transit authorities is not forthcoming.

CONCLUSIONS

1. Many design, equipment, and operational differences exist among rail rapid transit systems; however, there are many fundamental safety problems which are common to all rail rapid transit systems.

2. Notwithstanding the rail rapid transit industry's historically good safety record, numerous serious safety problems exist which, if not corrected, could lead to a catastrophic accident involving hundreds of fatalities.

3. The current, self-regulating approach to rail rapid transit safety has been largely reactive rather than preventive, permitting the introduction of safety problems which often are recognized or resolved only in the wake of serious accidents and incidents.

4. The use of new technology and synthetic materials to improve passenger comfort have resulted in a generation of rail rapid transit cars which pose substantial risks to passengers in the event of fire.

5. The current safety approach has failed to provide an effective process for the development of safety performance standards or safety guidelines.

6. The current safety approach has not provided effective safety oversight to monitor and evaluate the safety of rail rapid transit systems and assure that a minimum level of safety is maintained.

7. The current safety approach has relied almost exclusively on self-regulation of the rail rapid transit industry through voluntary action by individual transit systems which often lack the resources to identify adequate solutions to provide a reasonable level of safety.

8. In the absence of established safety guidelines or safety standards, safety problems have had to be addressed by individual rail rapid transit systems on a site-by-site, ad hoc basis as they arise--a process which frequently involves redundant work and is wasteful of the limited resources that are available.

9. The current safety approach has not provided a systematic process for applying safety lessons learned from an accident or incident on one rail rapid transit system to other rail rapid transit systems throughout the industry.

10. Rail rapid transit industry safety activities have largely excluded participation by public safety organizations, such as fire and emergency medical services, and these organizations have not been included adequately in the design and development of rail rapid transit systems.

11. Safety oversight capability at the State and local levels is virtually nonexistent. Where it does exist, the lack of safety guidelines or safety standards to measure and evaluate safety performance allows oversight agencies to do little more than react to accidents and incidents as they occur.

12. UMTA, the agency having the primary Federal responsibility for rail rapid transit safety, does not have complete authority and resources to exercise a dynamic and effective safety role.

13. Under existing authority, UMTA's future effectiveness in substantially improving rail rapid transit safety will rely heavily on the support and cooperation of the individual rail rapid transit systems.

14. The rail rapid transit systems do not collectively agree that national standards and Federal oversight are either needed or desirable.

15. UMTA should have the necessary authority to promulgate safety standards and perform oversight in the event cooperation is not forthcoming from the rail rapid transit systems.

16. In funding, staffing, organization, and its mission, UMTA's safety functions have been accorded a relatively low position within the agency.

17. UMTA has not developed a comprehensive safety program plan for improving rail rapid transit safety and for overseeing the safety of new systems as they are being developed.

18. UMTA's safety program is largely reactive and poorly-defined and lacks any mechanism to actively identify and prevent the introduction of safety hazards or to eliminate existing hazards before they become readily apparent or result in accidents or incidents.

19. UMTA plans to issue guidelines for emergency preparedness and for fire safety of new rail rapid transit cars, but UMTA has little or no practical means of assuring that the guidelines are followed by transit systems.

20. UMTA has not developed a plan for short-range and long-range safety research and development for rail rapid transit.

21. UMTA has not developed criteria by which to assess the adequacy of system safety plans submitted by rail rapid transit systems.

22. UMTA has not effectively involved public safety agencies, such as fire and emergency medical services, in its safety activities, such as on-site reviews and planning for safety research and development related to rail rapid transit.

23. The current relationship between UMTA and APTA raises serious questions about UMTA's ability to maintain its independence and objectivity in terms of safety leadership and decisionmaking.

24. Rail rapid transit authorities have expressed concern about difficulties encountered in obtaining Federal financial assistance for certain categories of safety activities, such as acquisition of safety equipment, training and drilling of employees in emergency procedures, and periodic inspection, maintenance, and testing of emergency equipment after it is installed.

25. Active review and evaluation of existing hazards on rail rapid transit systems and action to reduce the potential for a catastrophic accident are urgently needed.

RECOMMENDATIONS

Based on the findings of this evaluation, the National Transportation Safety Board made the following recommendations:

-- to the Secretary of Transportation:

Propose legislation to explicitly authorize the Secretary of Transportation to regulate the safety of rail rapid transit systems which receive Federal financial assistance. Such legislation should include the authority to establish Federal minimum safety standards, to enforce compliance, to conduct inspections, to conduct investigations of accidents and incidents, and such other general powers and duties as are necessary to provide for effective safety oversight. (Class II, Priority Action) (R-81-1)

Pending the enactment of legislation conferring direct regulatory authority, require the Urban Mass Transportation Administration to establish Federal guidelines for equipment and operations, to aggressively utilize existing grant programs and investigative authority to promote conformance with Federal guidelines, and to conduct a program of substantially increased safety oversight of Federal assisted rail rapid transit systems. (Class II, Priority Action) (R-81-2)

-- to the Urban Mass Transportation Administration:

In cooperation with rail rapid transit authorities and local fire officials, immediately survey the facilities, communication systems, fire safety and other emergency equipment, and emergency plans of existing rail rapid transit systems to determine their capability for evacuation of passengers under various operational and passenger load conditions. (Class I, Urgent Action) (R-81-3)

Establish procedures to consult organizations, such as the United States Fire Administration, the International Association of Fire Chiefs, the International Association of Fire Fighters, the National Fire Protection Association, and employee unions, as appropriate, in addition to the American Public Transit Association and individual transit properties, in developing Federal guidelines for car and tunnel design, safety equipment requirements, training programs (including emergency response) and other appropriate safety areas. (Class II, Priority Action) (R-81-4)

Make appropriate organizational changes to provide for more direct consideration of safety issues in the formulation of the Administration's rail rapid transit policies and priorities. (Class II, Priority Action) (R-81-5)

Establish, on a priority basis, Federal guidelines for the elimination or minimization of combustible and toxic gas and smoke-generating materials in existing rail rapid transit cars. Wherever possible, adherence to these guidelines should be made mandatory as a condition of Federal financial assistance. (Class I, Urgent Action) (R-81-6)

In cooperation with rail rapid transit authorities and local fire officials, assess the need for modification or retrofit of existing rail rapid transit cars to reduce the potential for the exposure of combustible or toxic materials to fire. (Class II, Priority Action) (R-81-7)

Include in Federal financial assistance to rail rapid transit systems an ability to provide funding for acquisition of emergency equipment and for periodic inspection, maintenance, and testing of such equipment after it is installed (Class II, Priority Action) (R-81-8)

Develop and publish for public comment a comprehensive, 5-year safety program plan for increased safety oversight of new rail rapid transit systems as they are developed and for improving the safety of existing systems. (Class II, Priority Action) (R-81-9)

Develop and publish for public comment a comprehensive, 5-year plan for rail rapid transit safety research and development. (Class II, Priority Action) (R-81-10)

Establish a process, based upon testing and evaluation in accordance with such criteria as the Administration shall establish, for the certification or identification of specific products and materials used in the construction of rail rapid transit cars as meeting minimum safety standards or guidelines, and provide this information to rail rapid transit authorities on a regular basis. (Class II, Priority Action) (R-81-11)

Develop and publish for public comment a formal plan for the review, evaluation, and certification of rail rapid transit system safety plans. (Class II, Priority Action) (R-81-12)

Establish a fire safety research and testing program to assess the combustibility and toxic gas and smoke generation of materials used in the construction of rail rapid transit cars and to evaluate the fire safety of rail rapid transit cars through full-scale testing (Class II, Priority Action) (R-81-13)

Offer to assist and cooperate with the United States Fire Administration in its development of a national training curriculum for fire service personnel involved in the administration of fire protection on rail rapid transit systems. (Class II, Priority Action) (R-81-14)

Develop Federal guidelines for training programs for rail rapid transit employees, to include actual performance, under simulated conditions, of the duties they may be required to perform in the event of a fire or other emergency. (Class II, Priority Action) (R-81-15)

Conduct research to determine the most effective means of informing rail rapid transit passengers of the actions to be taken in the event of an emergency, the location of emergency equipment, and the means of operating vehicle exit doors, and promulgate Federal guidelines. (Class II, Priority Action) (R-81-16)

Study and evaluate the need for fire suppression systems on new rail rapid transit vehicles and conduct research and development, and develop and promulgate Federal guidelines if so indicated. (Class II, Priority Action) (R-81-17)

Require rail rapid transit authorities to have a formal, continuing process for including local fire and emergency medical service officials in reviews of fire and life safety considerations during system planning, design, construction, and operation. (Class II, Priority Action) (R-81-18)

Include local fire and emergency response services in onsite reviews performed by the Administration of new and existing rail rapid transit systems. (Class II, Priority Action) (R-81-19)

Until such time as comprehensive, formal safety standards have been established for rail rapid transit, publish an annual report assessing the degree of conformance or nonconformance of rail rapid transit systems with each Federal safety guideline established by the Administration. (Class II, Priority Action) (R-81-20)

— to the United States Fire Administration:

Offer to assist and cooperate with the Urban Mass Transportation Administration in its development of rail rapid transit system training program guidelines which address fire safety concerns, such as tunnel rescue in a smoke and/or fire environment. (Class II, Priority Action) (R-81-21)

In consultation with the Urban Mass Transportation Administration, develop a national training curriculum for fire service personnel involved in the administration of fire protection on rail rapid transit systems. (Class II, Priority Action) (R-31-22)

— to the International Association of Fire Chiefs:

Offer to assist and cooperate with the Urban Mass Transportation Administration in its development of rail rapid transit system training program guidelines which address fire safety concerns, such as tunnel rescue in a smoke and/or fire environment. (Class II, Priority Action) (R-81-23)

Offer to assist and cooperate with the United States Fire Administration in its development of a national training curriculum for fire service personnel involved in the administration of fire protection on rail rapid transit systems. (Class II, Priority Action) (R-81-24)

Offer to assist and cooperate with the Urban Mass Transportation Administration in its determination of minimum fire safety equipment needs of rail rapid transit systems. (Class II, Priority Action) (R-81-25)

— to the International Association of Fire Fighters:

Offer to assist and cooperate with the Urban Mass Transportation Administration in its development of rail rapid transit system training program guidelines which address fire safety concerns, such as tunnel rescue in a smoke and/or fire environment. (Class II, Priority Action) (R-81-26)

Offer to assist and cooperate with the United States Fire Administration in its development of a national training curriculum for fire service personnel involved in the administration of fire protection on rail rapid transit systems. (Class II, Priority Action) (R-81-27)

-- to the National Fire Protection Association:

Offer to assist and cooperate with the Urban Mass Transportation Administration in its determination of minimum fire safety equipment needs of rail rapid transit systems. (Class II, Priority Action) (R-81-28)

— to the International Transport Workers Union of America, AFL- CIO:

> Offer to assist and cooperate with the Urban Mass Transportation Administration in its determination of minimum training and equipment needs to improve the ability of rail rapid transit employees to respond to emergencies (including smoke and/or fire conditions) in transit environments. (Class II, Priority Action) (R-81-29)

— to the Amalgamated Transit Union:

> Offer to assist and cooperate with the Urban Mass Transportation Administration in its determination of minimum training and equipment needs to improve the ability of rail rapid transit employees to respond to emergencies (including smoke and/or fire conditions) in transit environments. (Class II, Priority Action) (R-81-30)

-- to the American Public Transit Association:

> Encourage and facilitate participation by organizations having related safety interests in safety meetings and other safety activities of the Association. (Class II, Priority Action) (R-81-31)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ G. H. PATRICK BURSLEY
Member

PATRICIA A. GOLDMAN, Member, filed the following concurring and dissenting statement:

I concur with the analysis, conclusions, and recommendations contained in this report with the following exceptions. Although I am fully supportive of increased safety oversight of rail rapid transit operations, I do not share the majority's opinion in several regards.

First, I am not convinced that mandatory Federal standards or regulations are essential to achieve the desired level of safety. Some regulations may be needed. However, regulations are not a panacea and much improvement can be achieved without them. For example, a "system safety" program based on minimum safety guidelines, and which is developed and implemented with adequate input from the various parties might be sufficient.

Secondly, I am not convinced that increased safety oversight should be entirely a Federal responsibility. Increased State and local oversight in certain cases might be appropriate and more effective.

Thirdly, I am not convinced that the historical lack of effective Federal safety oversight is based on deficient legal authority. Rather, I believe it has been based more on philosophy and lack of resources. Therefore, I do not believe recommendation R-81-1 is justified at this time.

Finally, I do not believe it appropriate, in this instance, for the Safety Board to make the 10 recommendations to the U.S. Fire Administration, the International Association of Fire Chiefs, the International Association of Fire Fighters, the National Fire Protection Association, the International Transport Workers of America, and the Amalgamated Transit Union since they are redundant of other recommendations. Also, the record from our national hearing clearly indicates that these organizations have already pledged their support.

/s/ PATRICIA A. GOLDMAN
Member

January 23, 1981

APPENDIXES

APPENDIX A

WITNESSES BEFORE THE NATIONAL TRANSPORTATION SAFETY BOARD'S PUBLIC HEARING ON RAIL RAPID TRANSIT SAFETY JULY 28 AND 29, 1980

(In order of appearance)

1. Mr. George Donato, Director of Engineering, Montreal Urban Community Transportation Commission.

2. Mr. James J. Kirk, Deputy Director of Rail Transportation, Port Authority of New York and New Jersey.

3. Mr. Andrew C. Casper, Chief, San Francisco Fire Department.

4. Mr. Donald D. Flinn, General Manager, International Association of Fire Chiefs.

5. Mr. John R. Anderson, Manager of General Engineering, National Fire Protection Association.

6. Mr. Richard L. Best, Fire Analysis Specialist, National Fire Protection Association.

7. Mr. Charles Kalkhof, General Superintendent, New York City Transit Authority.

8. Mr. Jack W. Townsend, Director of Safety and Security, Toronto Transit Commission.

9. Mr. Walter J. Bierwagon, Vice President, Amalgamated Transit Union.

10. Mr. Ralph S. Veule, Director of Safety, Bay Area Rapid Transit District.

11. Mr. Thomas D. Boyle, Manager of Safety, Chicago Transit Authority.

12. Mr. Nicholas J. Roll, Assistant General Manager for Transit Services, Washington Metropolitan Area Transit Authority.

13. Mr. John J. Flynn, Safety Officer, Washington Metropolitan Area Transit Authority.

14. Mr. Albert M. Lock, Manager of Systems Assurance, Metropolitan Atlanta Rapid Transit Authority.

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15. Deputy Fire Chief Theodore R. Coleman, Washington, D.C. Fire Department.

16. Mr. William G. Lindner, International President, Transport Workers Union of America.

17. Honorable Gordon Vickery, Administrator, United States Fire Administration.

18. Mr. Alex E. Lutkus, Manager, BART Safety Section of Transit Districts Safety Branch, State of California Public Utilities Commission.

19. Mr. Frank J. Cihak, Director of Technical and Research Services, American Public Transit Association.

20. Ms. Lilian Liburdi, Deputy Administrator, Urban Mass Transportation Administration.

21. Mr. William J. Rhine, Director, Office of Safety and Product Qualification, Urban Mass Transportation Administration.

22. Mr. Charles Falding, International Vice President, Transport Workers Union of America.

23. Mr. James S. Danzy, President and Business Agent, Amalgamated Transit Union Local 1555.

24. Mr. Stephen D. Robinson, Chief Steward, Services Employees International Union Local 390.

25. Dr. Victor H. Esch, Chief Surgeon for the District of Columbia Board of Police and Fire Surgeons.

APPENDIX B

WRITTEN COMMENTS SUBMITTED FOR THE RECORD OF THE PUBLIC HEARING ON RAIL RAPID TRANSIT SAFETY JULY 28 AND 29, 1980

1. Mr. Walter G. Wells, Senior Standards Engineer, American Iron and Steel Institute.

2. Mr. Paul Lennon, Director of Safety, Massachusetts Bay Transportation Authority.

3. Mr. Michael Gerrard, Chairman, Permanent Citizens Advisory Committee to the MTA.

4. Mr. Henry Miranda, Safety Officer, Amalgamated Transit Union Local 1555.

5. Mr. L.A. Kimball, Administrator, State of Maryland Mass Transit Administration.

6. Fire Chief A.H. Estepp, Prince Georges County Fire Department.

7. Mr. Guy Wright, Assistant Director of System Safety and Assurance, San Francisco Municipal Railway.

8. Mr. Brian R. Woodcock, Manager of Offsite Operations and Safety, Surface Transportation Systems, The Boeing Company.

9. Dr. Robert L. Eisner, Manager of Product Assurance Services, Basic Technology Incorporated.

10. Ms. Sheryl Yount, Emergency Medical Service, Department of Public Health, City and County of San Francisco, California.

11. Fire Chief William L. Moore (retired), City of Oakland, California Fire Department.

12. Ms. Christina M. Baxter, Citizen's Task Force on BART, San Francisco Fire Department.

13. Mr. Robert B. Johnston, General Manager, Port Authority Transit Corporation of Pennsylvania and New Jersey.

14. Mr. Jonathan H. Klein, Chief Mechanical Officer, Rail Equipment Department, Southeastern Pennsylvania Transportation Authority.

15. Dr. Edward J. Farkas, Associate Professor, Department of Man-Environment Studies, University of Waterloo.

APPENDIX B

16. Chief R. E. Chamlee, City of Atlanta, Georgia, Bureau of Fire Services.

17. Honorable James W. Tysinger, Senator, State of Georgia Legislature, MARTA Technical Overview Committee.

APPENDIX C

RAIL RAPID TRANSIT COLLISIONS AND DERAILMENTS INVESTIGATED BY THE SAFETY BOARD

Rear End Collision of Three [MBTA] Trains, Boston, Massachusetts, August 1, 1975 (NTSB-RAR-76-5)

Synopsis:

On August 1, 1975, during the evening rush hour, southbound traffic on the Red Line of the Massachusetts Bay Transportation Authority in Boston backed up because of a train standing at a stop signal in the tunnel south of Charles Street Station. Train 1402, a four-car "Bluebird" train, stopped at signal 236 because of the backup. Train 1604, a four-car "Silverbird" train, was keyed by signal 234 and crashed into 1402 about 4:58 p.m. About 3 minutes later, a four-car "Bluebird" train, 1431, crashed into the rear of train 1604. One hundred and fifty-four persons were injured; total damage to equipment was estimated to be $425,000.

Probable Cause:

The National Transportation Safety Board determines that the probable cause of this accident was the malfunction of the train-stop tripper and the subsequent operation of trains 1604 and 1431 in violation of the rules and in excess of the speed at which they could stop short of collisions in the available sight distances.

[CTA] Collision of Trains No. 104 and No. 315 at Addison Street Station, Chicago Illinois, January 9, 1976 (NTSB-RAR-76-9)

Synopsis:

On January 9, 1976, at 8:06 a.m., Chicago Transit Authority (CTA) train No. 315 struck the rear end of train No. 104 while it was standing at the Addision Street Station platform in Chicago, Illinois. The impact forces extensively damaged the lead car of the moving train and the rear car of the standing train, and slightly damaged the other cars in both trains. Of the 381 passengers who were injured in the collision, 1 died. Damage to the equipment and track was estimated to be $267,000.

Probable Cause:

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the motorman of train No. 315 to perceive standing train No. 104 at a sufficient distance to permit him to stop his train before striking No. 104. Contributing to the collision were the rule that permitted the operation of the train with the automatic train control and the cab signals inoperative, the lack of consistent enforcement of operating rules, the absence of flag protection against following trains, the failure of

the train phone system to provide reliable communications, and the violation of the 25-mph speed limit required by Rule 178B.

Rear End Collision of Two [GCRTA] Trains, Cleveland, Ohio, August 18, 1976 (NTSB-RAR-77-5)

Synopsis:

About 11:35 a.m., on August 18, 1976, Greater Cleveland Regional Transit Authority train No. 461 struck the rear of train No. 409, which was standing near the East 79th Street Station in Cleveland, Ohio. Twenty persons were injured and property damage was estimated to be $61,000.

Probable Cause:

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the operator of train No. 461 to comply with the mandatory stop signal indication and to apply the brakes in emergency promptly after the train ahead had been sighted, and operation of the train at an excessive speed. Contributing to the probable cause was the lack of an effective operator training program and the ineffectiveness of the protective devices and procedures to prevent a following train from entering an occupied block.

Rear End Collision of Two [CTA] Trains, Chicago, Illinois, February 4, 1977 (NTSB-RAR-77-10)

Synopsis:

About 5:27 p.m., c.s.t., on February 4, 1977, Chicago Transit Authority Lake-Dan Ryan train No. 930 struck the rear of Ravenswood train No. 415, which was standing on the elevated rail structure at the intersection of Wabash Avenue and Lake Street. The four lead cars of the eight-car Lake-Dan Ryan train overturned and fell from the elevated structure to the street. One end of each of the two rear cars of the Ravenswood train derailed. Eleven persons were killed and 266 persons were injured. Property damage was estimated to be $1.2 million.

Probable Cause:

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the motorman to exercise due care in meeting his responsibilities and the unauthorized operation of the Lake-Dan Ryan train into a signal block occupied by the standing Ravenswood train, at a speed that was too fast to stop after the operator sighted the standing train.

Head-On Collision of Two [GCRTA] Trains, Cleveland, Ohio, July 8, 1977 (NTSB-RAR-78-2)

Synopsis:

About 10:05 a.m., e.d.t., on July 8, 1977, two trains of the Greater Cleveland Regional Transit Authority collided head-on on the eastbound track of the Shaker Heights Line, near 92nd and Holton Streets in Cleveland, Ohio. Sixty persons were injured and property damage was estimated to be $100,000.

Probable Cause:

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the Greater Cleveland Regional Transit Authority to have established rules and procedures, and special instructions to assure safe train operations. Contributing to this accident were the failure of both supervisors to establish and coordinate adequate local procedures for operating trains in both directions on a single track and, further, the vegetation along the curve which was allowed to grow to the extent that the view was blocked.

Derailment of [NYCTA] Subway Train, New York, New York, December 12, 1978 (NTSB-RAR-79-8)

Synopsis:

About 4:38 p.m., on December 12, 1978, the sixth and seventh cars of a New York City Transit Authority subway train designated "CC" 4:06 p.m. derailed within moments after departing 59th Street station. Twenty-two persons were injured, and property damage was estimated to be $667,500.

While the Safety Board was investigating this accident, three other trains derailed from what appeared to be similar causes. Therefore, the investigation was expanded to include all four accidents. The other derailments were: (1) At 8:08 a.m. on January 15, 1979, when the fourth car of an "A" train derailed north of Rockaway Avenue; (2) at 7:23 p.m. on February 14, 1979, when the seventh car of an "E" train derailed at 53rd Street; and (3) at 7:04 a.m. on March 21, 1979, when the first car of a "CC" train derailed at 14th Street.

Probable Cause:

The National Transportation Safety Board determines that the probable cause of each of the four accidents was a cracked wheel which had resulted from extensive overheating. Contributing to the cause of the overheating of the wheels was the partial application of a handbrake. Because of a lack of adequate inspection procedures, the New York City Transit Authority employees failed to detect the partially applied handbrake and the thermally damaged wheels before they cracked.

ACRONYMS USED IN THIS EVALUATION

APTA - American Public Transit Association

BART - Bay Area Rapid Transit District

CTA - Chicago Transit Authority

DOT - Department of Transportation

FRA - Federal Railroad Administration, U.S. Department of Transportation

GCRTA - Greater Cleveland Regional Transit Authority

MARTA - Metropolitan Atlanta Rapid Transit Authority

MBTA - Massachusetts Bay Transportation Authority

MTA New York - Metropolitan Transportation Authority of New York

NFPA - National Fire Protection Association

NYCTA - New York City Transit Authority

PATCO - Port Authority Transit Corporation of Pennsylvania and New Jersey

PATH - Port Authority Trans-Hudson Corporation

RAIRS - Railroad Accident/Incident Reporting System

SEPTA - Southeastern Pennsylvania Transportation Authority

SIRAS - Safety Information Reporting and Analysis System

TSC - Transportation Systems Center, U.S. Department of Transportation

TSI - Transportation Safety Institute, U.S. Department of Transportation

UMTA - Urban Mass Transportation Administration, U.S. Department of Transporation

WMATA - Washington Metropolitan Area Transit Authority

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