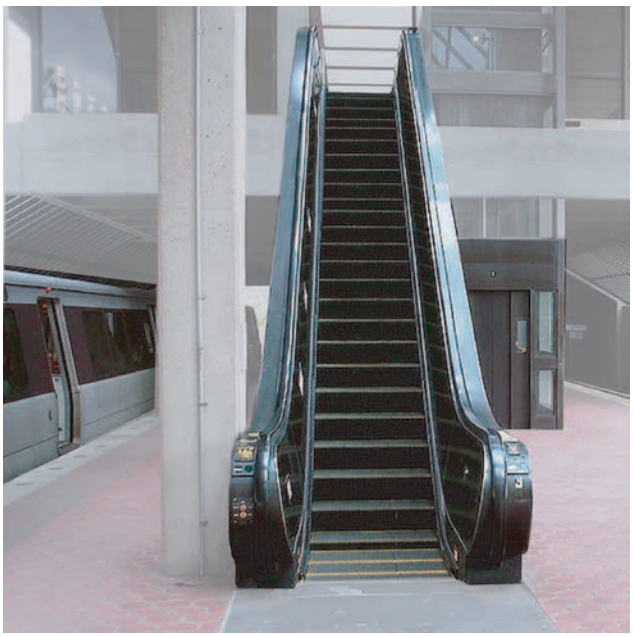
TCRP
SYNTHESIS 100

TRANSIT
COOPERATIVE
RESEARCH
PROGRAM

Sponsored by
the Federal
Transit Administration

Elevator and Escalator Maintenance and Safety Practices



A Synthesis of Transit Practice

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP SYNTHESIS 100

Elevator and Escalator Maintenance and Safety Practices

A Synthesis of Transit Practice

CONSULTANT

JOHN J. SCHIAVONE
J. Schiavone Consulting
Guilford, Connecticut

SUBSCRIBER CATEGORIES
Public Transportation • Safety and Human Factors • Vehicles and Equipment

Research Sponsored by the Federal Transit Administration in Cooperation with the Transit Development Corporation

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2012
www.TRB.org

TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academy of Sciences, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by TRB. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

TCRP SYNTHESIS 100

Project J-7, Topic SE-06
ISSN 1073-4880
ISBN 978-0-309-22358-4
Library of Congress Control Number 20122932148

COPYRIGHT INFORMATION

NOTICE

The project that is the subject of this report was a part of the Transit Cooperative Research Program, conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council.

The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

The opinions and conclusions expressed or implied in this report are those of the researchers who performed the research and are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors.

The Transportation Research Board of the National Academies, the National Research Council, and the sponsors of the Transit Cooperative Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of the report.

Published reports of the

TRANSIT COOPERATIVE RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet at
http://www.national-academies.org/trb/bookstore

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

Cover figure: Transit escalator and elevator installation. *Credit:* The Transit Elevator/Escalator Training Consortium.

FOREWORD

Transit administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the transit industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire transit community, the Transit Cooperative Research Program Oversight and Project Selection (TOPS) Committee authorized the Transportation Research Board to undertake a continuing study. This study, TCRP Project J-7, "Synthesis of Information Related to Transit Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute a TCRP report series, *Synthesis of Transit Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Donna L. Vlasak
Senior Program Officer
Transportation
Research Board

The purpose of this synthesis is to document highly specialized elevator/escalator (El/Es) maintenance, safety practices, and passenger communication efforts at five U.S. transit agencies: MARTA (Atlanta, Georgia), NYCTA (New York City), SEPTA (Philadelphia, Pennsylvania), CTA (Chicago, Illinois), and BART (San Francisco, California). These five agencies together operate 1,418 elevators and escalators throughout 850 rail stations. Together, they are part of an FTA-sponsored consortium with APTA, Amalgamated Transit Union, and the Learning Center, engaged in developing a Transit Elevator/Escalator Maintenance Training and Apprenticeship Program.

The Topic Panel directed the consultant to survey and conduct in-depth telephone interviews with these transit agencies' staffs to provide a comprehensive look at how representative agencies provide El/Es services, the specific challenges they face in doing so, and the steps taken to provide safe and reliable access to all their customers and, particularly, the disabled community. The goal is to allow others to benefit from the successful experiences of their peers in providing safe and reliable access to users and lessen unnecessary expenditures.

A review of the relevant literature was conducted for this effort. Collected literature was useful, but somewhat limited. It was determined that in-depth case studies would provide more thorough synthesis reporting of El/Es subject areas at select agencies and be more beneficial and useful to other transit agencies than cursory synthesis survey reporting of numerous subject areas across a larger number of agencies.

John J. Schiavone, J. Schiavone Consulting, Guilford, Connecticut, collected and synthesized the information and wrote the report, under the guidance of a panel of experts in the subject area. The members of the Topic Panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

The following four appendixes are web-only and can be found at www.trb.org, search on "TCRP Synthesis 100."

BART Elevator PM, 59
BART Escalator PM, 254
BART El-Es Training 1, 507
BART El-Es Training 2, 556

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

ELEVATOR AND ESCALATOR MAINTENANCE AND SAFETY PRACTICES

SUMMARY

Elevators and escalators (El/Es) play important roles in public transportation, moving passengers vertically to train stations above and below grade levels. Keeping this equipment operational is essential, especially for persons with disabilities who rely on El/Es for their transportation needs and are inconvenienced the most when equipment breaks down. Active involvement by the disability community has helped agencies realize the importance of providing reliable El/Es service.

The task of keeping El/Es operational falls squarely on agency maintenance departments that must comply with legal requirements, equipment manufacturers' recommendations, and their own unique operating environments. This task, however, is fraught with significant challenges that include aging infrastructure, nearly continuous use in harsh conditions, lack of standard equipment, difficulty in obtaining spare parts, insufficient staffing levels, and customer abuse.

Despite the challenges, agencies have implemented several proactive maintenance approaches to overcome staffing shortages and put into place various communications strategies to inform the public when El/Es do fail and to provide them with alternative means of transport. Efforts by maintenance and communications departments, regardless of how diligent or efficient, must be supplemented by the entire transit agency, especially upper management. Because vertical transportation can receive less attention than the prime movers of rail cars and buses, agencies are better served if they treat El/Es with the same level of importance as rolling stock—integral agency assets that require active management to account for ongoing maintenance, modernization, and replacements.

The purpose of this synthesis is to document El/Es maintenance programs, safety practices and passenger communication efforts at five U.S. transit agencies:

- Metropolitan Atlanta Rapid Transit Authority (MARTA),
- Chicago Transit Authority (CTA),
- New York City Transit Authority (NYCTA),
- Southeastern Pennsylvania Transportation Authority (SEPTA) in Philadelphia, and
- Bay Area Rapid Transit (BART) in San Francisco.

The in-depth case studies provide a snapshot look at how representative agencies provide El/Es services, the specific challenges they face in doing so, and the steps taken to provide safe and reliable access to their customers. In particular, the synthesis brings attention to a segment of public transit that is often overlooked, and it allows other agencies to learn from the experiences of their peers as they work to improve their own El/Es programs in a time of shrinking budgets. This synthesis is intended to provide a better understanding of EI/Es to those who work with El/Es on a daily basis, as well as upper managers, other transit officials, and policy makers.

The approach to this project included a literature review, a comprehensive survey of the case study agencies, and follow-up telephone interviews to obtain additional information.

Collected literature, while useful, is somewhat limited. Therefore, the survey questionnaire administered to the case study agencies became the primary tool used to obtain detailed El/Es information. Collectively these five agencies operate 1,418 elevators and escalators throughout 850 rail stations.

Several conclusions were drawn from the study:

- El/Es are an important but often overlooked element of public transportation.
- Their application is unique to transit with increased use and environmental conditions being harsher than in typical building applications.
- Unlike rolling stock that benefits from having spare replacements, El/Es are fixed and must be repaired where passenger service is provided, which draws greater public attention when equipment becomes inoperable.
- Agencies use a variety of measures to make prompt repairs required by the ADA, inform passengers of downed El/Es equipment, and provide alternative transportation options.
- Regardless of the steps taken to inform passengers and make prompt repairs, the nature of downed El/Es is such that passengers are inevitably inconvenienced unless redundancy is built into the station design.
- Asset management, where agencies adequately plan and budget ongoing maintenance, repairs, equipment modernization, and replacements is absolutely essential for continued safe and reliable El/Es operation.
- Enhanced technology features have greatly improved passenger safety but also add to equipment shutdowns and inconvenienced passengers.
- Agencies understand their maintenance responsibilities and use a combination of fundamental and innovative procedures to improve efficiency and El/Es reliability.
- Agencies surveyed do the bulk of their maintenance and repairs in-house, while typically contracting for major refurbishments and replacements.
- When services are contracted out, strict oversight by the agency is essential to ensure satisfactory contractor performance.
- Not all agencies are required to have licensed and certified technicians.
- Agencies do not have, or may be reluctant to provide, information pertaining to unscheduled maintenance, making it difficult to gauge their performance.
- Agencies use a variety of definitions to classify El/Es being unavailable for service, which also makes performance comparisons between agencies difficult.

Suggestions for future study include developing standard definitions for monitoring and measuring El/Es availability nationally, expanding the ADA definition of "prompt repair" to provide additional agency guidance, developing a process that transit agencies could use to determine appropriate El/Es staffing levels, investigating the need for additional standards, and studying the feasibility of establishing an Internet forum where El/Es professionals could exchange information.

CHAPTER ONE

INTRODUCTION

PROJECT BACKGROUND AND CONTEXT

Elevators and escalators (El/Es) are highly specialized and provide an essential public transportation service. Despite this critical role, agencies tend to downplay the importance and understandably place their primary focus on traditional rolling stock. Activism by the disability community has played a key role in bringing El/Es to the forefront, resulting in agencies adopting a more positive approach to more aggressively and effectively maintaining El/Es equipment to improve reliability and availability.

Although El/Es are highly specialized, the core operational and maintenance requirements are very similar to those of buses and rail vehicles. Regarding maintenance, the basic tenets apply:

- Equipment needs to be inspected, maintained and repaired on a regular basis.
- Inspections and related maintenance activities need to comply with all legal requirements and take into consideration original equipment manufacturer (OEM) recommendations and local operating conditions.
- Inspections need to be performed according to detailed written procedures, at established time intervals, and by trained and skilled personnel.
- Maintenance needs to be conducted on a planned scheduled basis where activities are predicted and scheduled at times that least affect customers.
- Unscheduled repairs and breakdowns, although impossible to completely eliminate, must be kept to a bare minimum through a proactive preventive maintenance (PM) approach.
- Experience and data obtained from several sources must be analyzed and converted into scheduled maintenance activities.
- Most important, regardless of how repetitious maintenance becomes, it needs to be performed consistently, correctly, and without interruption over and over again.

On the operating side, passengers are not concerned about difficult maintenance challenges. Whether a bus, train, or escalator, they justifiably want all public transportation to function properly and safely when needed, day in and day out. When equipment does fail, customers expect replacement services that inconvenience them the least.

While customer expectations and the overall approach to maintenance may be similar to other forms of public transit on a broad level, El/Es are poles apart from revenue-producing rolling stock. Elevators and escalators are also physically very different from each other, despite being grouped in the same vertical transportation category, which requires technicians to have a wider array of knowledge and skills. Aging equipment, increased passenger use, complex technology applications, harsh and punishing environments, and extended use add to the adversity agencies face in keeping El/Es operational and providing quality service. Adding to these challenges, some customers are intent on purposely abusing and undermining the equipment simply to create a public nuisance.

The bottom line is that the exclusive nature of El/Es equipment requires specialized attention and skills, a more proactive approach to PM, and quicker response to failures. When El/Es do break down, public confidence is diminished and riders who rely on vertical transportation to access public transit are inconvenienced. Those with disabilities are affected the most. At the same time, accessibility regulations bring into focus that continual availability of vertical transportation equipment needs to be a core element of public transportation.

The need for this synthesis stems from the unique nature of El/Es, the inconvenience caused to customers when this equipment breaks down, and the general lack of information available regarding collective El/Es experiences. The purpose is to provide summary information through an in-depth examination of representative U.S. transit agencies. Doing so allows others to benefit from the experiences of their peers as they work to provide safe and reliable El/Es access to users and lessen unnecessary expenditures.

This synthesis is intended for a broad range of transit professionals, ranging from maintenance personnel to general managers and other stakeholders, to widen existing understanding and gain greater insight into this important but often unnoticed subject.

Specifically, the synthesis addresses the following:

- Equipment specifications,
- Safety and ADA compliance,
- Equipment availability,
- Customer communication and education,

TABLE 1
EL/ES EQUIPMENT AND STATION SUMMARY

Agency	No. of Elevators	No. of Escalators	Combined El/Es	No. of Rail Stations
Atlanta (MARTA)	109	149	258	38
Chicago (CTA)	159	161	320	144
New York City (NYCTA)	192	176	368	468
Philadelphia (SEPTA)	106	50	156	156
San Francisco (BART)	140	176	316	44
Totals	706	712	1,418	850

- Personnel allocation,
- Technician training and licensing,
- Maintenance programs and appropriate intervals,
- Spare parts and inventory, and
- Impact of new technology.

TECHNICAL APPROACH TO PROJECT

The approach to this synthesis began with a teleconference with Topic Panel members overseeing the synthesis project held on October 26, 2010, to discuss the project approach. Due to the extensive nature of the scope that includes numerous topic areas warranting a more comprehensive investigation, the panel decided that the consultant should focus on providing in-depth case studies of five transit agencies. It was determined that providing thorough analyses of several El/Es subject areas at a select number of agencies would be more beneficial and useful to the reader than would a more cursory examination of numerous subject areas made across several agencies. The five agencies used for the in-depth case studies were selected from a consortium currently engaged in developing a Transit Elevator/Escalator Maintenance Training and Apprenticeship Program.

During the October 26 teleconference, the panel also suggested beginning the report with overviews on how each of the five case study agencies individually addresses each of the El/Es subject areas. It was recommended that the following chapter would then take the various subject headings and collectively present the range of approaches used by the case study agencies with a focus on successful applications. The panel also recommended that the synthesis examine how each of the case study agencies uses different approaches to define El/Es maintenance and service, especially with regard to defining equipment availability. A work plan incorporating panel direction and comments was prepared, delivered, and then approved by panel members.

The synthesis approach also included the following:

1. A literature review. A Transportation Research Information Services (TRIS) search using several different keywords was conducted to aid the literature review.
2. A comprehensive survey of five transit agencies used as in-depth case studies: Metropolitan Atlanta Rapid Transit Authority (MARTA), Chicago Transit Authority (CTA), New York City Transit Authority (NYCTA), Southeastern Pennsylvania Transportation Authority (SEPTA), and Bay Area Rapid Transit (BART).

The survey consisted of a comprehensive questionnaire designed to elicit detailed El/Es information from several agency personnel. One person at each agency was responsible for coordinating responses from maintenance, public communication, data management, personnel and other agency departments. Table 1 shows the distribution of El/Es and rail

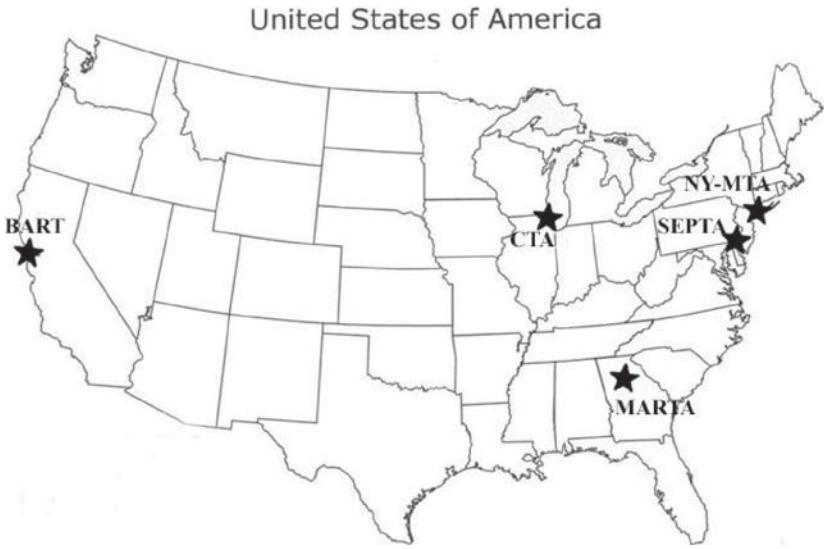


FIGURE 1 Case study agency locations.

stations among the five case study agencies. A copy of the survey questionnaire and compilation of agency responses is included as the appendix. Figure 1 shows the geographic locations of the five case study agencies.

REPORT ORGANIZATION

Following this introduction, chapter two reveals the findings of a literature review. Included are publications from ASME that addresses safety codes, APTA that provide specification guidelines, ADA of 1990 that present accessibility requirements, and other relevant El/Es-related publications. Chapter three offers an in-depth look at how each of the five case study agencies maintains its elevators and escalators, complies with safety regulations, classifies equipment availability, communicates with customers, provides alternative transportation during equipment outages, and handles the impact of new technology. Chapter four recaps noteworthy achievements of each of the five agencies organized under major heading groups. The report ends with chapter five, which summarizes the findings and lessons learned from this study.

CHAPTER TWO

LITERATURE REVIEW

This chapter summarizes findings from a literature review of elevator and escalators. TRIS was used to aid the literature search. Found references, however, were either outdated or limited due to the highly specialized nature of this subject. The most useful references reviewed for this study include the following:

- ADA of 1990;
- ASME A17.1-2010, Safety Code for Elevators and Escalators;
- Various materials published by APTA;
- 2008 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance, Report to Congress (CP Report); and
- Consortium documents to develop a Transit Elevator Escalator Maintenance Training and Apprenticeship program.

ADA

ADA was established to provide a clear and comprehensive national mandate for the elimination of discrimination against individuals with disabilities through enforceable standards, and to ensure that the federal government plays a central role in enforcing those standards. U.S. Department of Transportation regulations implementing ADA contain specific requirements meant to assist persons with disabilities in using fixed route transportation services. Specifically, §37.161 Maintenance of Accessible Features states:

> (a) Public and private entities providing transportation services shall maintain in operative condition those features of facilities and vehicles that are required to make the vehicles and facilities readily accessible to and usable by individuals with disabilities. These features include, but are not limited to, lifts and other means of access to vehicles, securement devices, elevators, signage and systems to facilitate communications with persons with impaired vision or hearing.
>
> (b) Accessibility features shall be repaired promptly if they are damaged or out of order. When an accessibility feature is out of order, the entity shall take reasonable steps to accommodate individuals with disabilities who would otherwise use the feature.
>
> (c) This section does not prohibit isolated or temporary interruptions in service or access due to maintenance or repairs.

Additional detailed information regarding ADA as it relates to public transportation can be found at the FTA website: http://www.fta.dot.gov/civilrights/civil_rights_2360.html.

As indicated above, ADA requires accessibility features to be repaired promptly. When an accessibility feature is out of order, the transit agency must take reasonable steps to accommodate individuals with disabilities who would otherwise use the feature. To prevent claims of discrimination, transit agencies are required to make consistent and diligent efforts to keep accessibility equipment, including El/Es, in working order. Compliance with the ADA requires transit agencies to make efforts in every phase of operations including design, policy, training, inspection, maintenance, repair, and monitoring.

The FTA website also contains a series of ADA compliance review reports that document findings at specific transit agencies, several of which pertain to El/Es (http://www.fta.dot.gov/civilrights/ada/civil_rights_3899.html).

ASME A17

The ASME A17 Safety Code for Elevators and Escalators was first published in 1921, establishing a U.S. standard for the design, construction, operation, inspection, testing, maintenance, alteration, and repair of elevators, escalators, dumbwaiters, moving walks, and similar equipment. The most recent addition, number 19, became effective June 30, 2011. Its purpose is to provide for the safety of life and limb and to promote the public welfare. The 400-plus-page code book also includes the Canadian Standards Association Code B44-10, which builds off of the ASME A17 code by adding requirements applicable only in Canadian jurisdictions.

After covering scope, purpose and definitions in Part 1, Parts 2 and 3 of the A17 code define requirements for electric and hydraulic elevators. Of particular interest are the maintenance, repair, inspection, and testing requirements identified in Part 8, which call for the following:

- A written maintenance control program to include examinations, cleaning, lubrication, testing and adjustments made at prescribed intervals to maintain El/Es equipment in compliance with established procedures (Part 8.6.1.2). This program must be made available to maintenance personnel.
- Maintaining detailed records of inspections, repairs, and callbacks (Part 8.6.1.4).

- General maintenance methods and procedures that prohibit making safety devices inoperative or ineffective and require parts to be properly lubricated and up-to-date wiring diagrams to be maintained (Part 8.6.1.6).
- General repair requirements that address parts usage and repair of specific El/Es equipment (Part 8.6.2).

Parts 8.10 and 8.11 detail El/Es requirements for acceptance and periodic inspections and testing. These sections address persons authorized to make the inspections and tests, unique or product-specific procedures and methods, inspection frequency, and several other topics. Requirements contained in ASME A17 are comprehensive and extremely detailed; all agencies operating El/Es need to have a copy and become familiar with all stated requirements.

APTA DOCUMENTS

APTA has published four known documents related to El/Es that are summarized below (there is also a guideline for moving walkways, which is not reviewed here). The objective of this work is to address the specific heavy-duty escalator needs of North American agencies to help them provide safe, reliable service in harsher, heavy usage and high-abuse transit environments. The APTA design guidelines are not intended to be a complete technical specification applicable for all transit agencies. Each agency may find it necessary to make changes to suit its specific needs. However, the more stringent provisions are the result of the members' combined experiences and reflect the need for improved safety and reliability for public transit El/Es applications.

Design guidelines developed by APTA are the result of the combined efforts of the members of the APTA Elevators and Escalators Technical Forum. Membership of this forum includes transit agencies, consultants, and elevator and escalator component manufacturers.

Authors of the guidelines readily note that some manufactures will claim that additional transit requirements will increase equipment costs, but state through past experience that paying "more up front" will be more than compensated for by the overall reduced life-cycle costs. Most important, the APTA guidelines claim that added transit escalator requirements will improve customer safety, satisfaction, and convenience, resulting in an increase in the public's confidence in a transportation system's ability to meet their needs, and thus, increase ridership.

Heavy-Duty Transportation System Escalator Design Guideline

This guideline specifies requirements for the design, fabrication, installation, and testing of escalators. Included are operational, structural, and environmental requirements; vibration levels; fire protection; job conditions; quality assurance; submittals including as-built drawings; training; and warranty. Part 2 addresses product requirements, including controls and safety devices; balustrades, skirt panels, and decking; electrical equipment and controllers, truss wiring, and conduit; materials and finishes; and various requirements for mechanical equipment.

Heavy-Duty Machine-Room-Less Elevator Design Guideline

This guidance document was prepared specifically for the machine-room-less elevator (MRL), a newer technology being developed by all major elevator manufacturers. As with other APTA design guidelines, agencies will need to make changes to suit their unique specification needs. The guideline has been established for traction elevators and can be used at any rise. As was done with other APTA heavy-duty elevator guidelines, the Working Group recommends increasing the capacity of MRL elevators above and beyond that of the ASME A17 code required minimums. Table 2 shows the APTA-rated minimum load recommendations that should be incorporated into the design decisions for all elevators used in transit applications.

Heavy-Duty Transportation System Elevator Design Guideline

This APTA document provides design guidelines for the fabrication, installation, and testing of low-rise (under 40 ft of travel) elevators intended for use in a public transit environment. The objective is to address the specific heavy-duty elevator needs of North American transportation systems. The guideline also

TABLE 2
ELEVATOR PLATFORM SIZE VERSUS RATE LOAD CHANGES

Platform Width (ft)	Platform Front to Back (ft)	Inside Net Platform Area (ft^2)	A17.1 Maximum Inside Net Platform Area (ft^2)	A17.1 Rated Min.	A17.1 Rated Nominal (lb)	APTA Rated (lb) @ 1.5 over A17.1 Minimum
6.00	5.00	24.08	24.2	1,993	2,000	3,000
7.00	5.00	28.33	29.1	2,425	2,500	3,750
7.00	5.50	31.67	33.7	2,781	3,000	4,500
7.00	6.17	36.11	38	3,278	3,500	5,250
8.00	6.17	41.53	42.2	3,920	4,000	6,000
6.00	8.83	45.81	46.2	4,455	4,500	6,750
6.00	9.38	48.88	50	4,853	5,000	7,500

TABLE 3
MAXIMUM RISE OF ELEVATORS PER TYPE

Elevator Type	Direct Plunger	Single-Stage Holeless	Roped Hydraulic	Rack and Pinion
Maximum rise	40 ft	16 ft	40 ft	40 ft

Note: Applicable for this document only.

establishes certain design parameters for elevators to be considered for transit applications, as shown in Table 3.

The guideline does not recommend the use of telescoping hydraulic elevators in transit applications. It also recommends increasing the capacity of the elevators above and beyond that of the ASME A17 code required minimums as shown in Table 2.

Mid- to High-Rise, Heavy-Duty Traction Elevator Design Guideline

Approved back in 2004, this document provides design guidelines specifically for the fabrication, installation, and testing of traction and rack-and-pinion elevators. Like the other elevator guidelines developed by APTA, this one also recommends increasing the capacity of the elevators above and beyond that of the ASME A17 code required minimums as shown in Table 2.

CP REPORT

The 2008 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance, Report to Congress, also known as the CP Report, provides decision makers with an objective appraisal of the physical conditions, operational performance, and financing mechanisms of highway, bridge, and transit systems. The report is based both on the current state and projected future state of these systems under a set of alternative future investment scenarios. The 2008 edition is the eighth in the series that combines information on the nation's highway and transit systems.

The transit investment analysis is based on the Transit Economic Requirements Model, which identifies the investments needed to replace and rehabilitate existing assets, improve operating performance, and expand transit systems to address the growth in travel demand. FTA uses this model to forecast estimates of total capital investment needs for the U.S. transit industry over a 20-year period.

The CP Report reveals that U.S. transit agencies spent $9.3 billion in 2006 to rehabilitate and replace antiquated and/or worn equipment. To maintain current average transit asset conditions into the future, however, providers of transit services would need to spend $11.4 billion annually on rehabilitation and replacement projects. Although El/Es are not specifically addressed, the study does highlight transit's financial shortfall in refurbishing and replacing physical assets, and parenthetically emphasizes the importance for agencies to include El/Es in their asset management planning process.

ELEVATORS AND ESCALATORS TRAINING CONSORTIUM

The Transit Elevator/Escalator Maintenance Training and Apprenticeship Program is a national consortium consisting of BART, MARTA, SEPTA, NYCTA, and the Washington Metropolitan Area Transit Authority (WMATA) along with their respective union partners to share resources and develop a uniform El/Es training program. The project is supported with matching funds from FTA and administered by the Transportation Learning Center with participation from APTA. The El/Es training program is being established on a joint labor–management basis where collective resources are pooled to develop training materials consistent with nationally established training standards. Once completed, courseware materials consisting of standard curriculum outlines, lesson plans, student textbooks, and instructor guides will be provided to each of these agencies.

Although documents are not yet complete, preliminary drafts have been reviewed. Once completed, a nationally standardized El/Es training program with input from both labor and management will greatly improve the skills and knowledge of El/Es workers and help improve equipment availability.

SUMMARY

The literature review supports the initial observation that while there is much information on safety compliance and equipment specifications available through ADA, ASME, and APTA, there is not a significant body of work documenting the repair and maintenance of El/Es in transit applications. Nor are there many materials regarding passenger communication strategies and providing alternative transportation when transit El/Es equipment becomes disabled. The reference materials identified in this chapter are, however, important resources to agencies operating El/Es and served as a useful starting point for this study.

The next two chapters present in-depth case studies and successful practices gleaned from those studies. Material taken from the survey collectively offers a snapshot view of what transit agencies face in providing vertical transportation services to their customers.

CHAPTER THREE

CASE STUDIES

ATLANTA, GEORGIA (MARTA)

The Metropolitan Atlanta Rapid Transit Authority (MARTA) operates 109 elevators and 149 escalators at 38 stations throughout the greater Atlanta, Georgia, area. El/Es operate 22 hours per day, 7 days a week, with over 63 million passenger trips annually. All stations are accessible. Table 4 shows a classification of MARTA's El/Es equipment. Unlike the other agencies surveyed for this study, MARTA contracts out all of its El/Es maintenance, repair, upgrades, and replacements.

Equipment Specifications

MARTA develops its own El/Es technical specifications by adhering to the APTA guidelines described in chapter two, but does not call for any unique specification requirements except for video surveillance cameras. Regarding useful life, most of the 117 Westinghouse Modular escalators were installed in the mid-1970s to early 1980s and are now more than 30 years old and have exceeded their useful life. As a result, MARTA is actively engaged in an escalator modernization program. The first phase of updating 30 units is now 50% completed, while the second phase of 30+ units is set to begin next fiscal year. MARTA is also planning to issue a contract to replace all of the agency's O&K (Orenstein & Koppel) escalators, now over 25 years old, because parts availability has become a critical issue. The modernization program is part of a capital improvement plan and illustrates MARTA's commitment to assessment management where proactive measures are taken to improve reliability and reduce maintenance costs.

Safety, Availability, and Customer Communication

Safety and Legal Compliance

Safety is MARTA's top priority. Because the agency uses 100% contract services for El/Es maintenance, repairs, and upgrades, it has four in-house inspectors on staff to ensure the contractor is complying with all applicable ASME and local safety code requirements. Each inspector is certified as a Qualified Elevator Inspector (QEI), which requires applicants to meet standards established by the ASME for elevator and escalator safety. The in-house inspectors routinely examine the contractor's maintenance activities and perform random equipment assessments to audit equipment condition. They also perform accident investigations, assist the police with investigations, and review video recordings. MARTA believes that its Test and Evaluation Department, developed specifically for El/Es, is one of the most stringent acceptance programs, utilizing both ASME and APTA code requirements when testing equipment. MARTA has also hired an outside consultant to supplement the Elevator and Escalator Department staff to provide ASME A17 inspections on selected elevators and escalators throughout the year.

A safety incident on one of MARTA's escalators caused the agency to change one of its scheduled maintenance intervals regarding brake inspections. Although MARTA's previous requirement for quarterly brake inspections had exceeded the ASME requirement, the inspection frequency was increased to monthly.

Equipment Availability

MARTA notes that although the availability of El/Es is paramount, providing safety is the number one priority. Any condition that denies the public access to El/Es equipment, including scheduled maintenance, classifies the equipment as being unavailable. The only exception is for equipment down for long-term modernization upgrades. MARTA currently uses a spreadsheet program to track El/Es availability, but the process does not provide timely status reporting. Monthly reports are not generated until the second week of the following month. The agency is currently working to track data electronically to provide real-time monitoring and reporting capability.

In MARTA's opinion, the leading cause of El/Es being unavailable for service is equipment age, which results in increased maintenance and failures. Its ongoing modernization program will improve equipment reliability and uptime availability. Additionally, MARTA's in-house inspectors play a critical role in making certain that contractors maintain El/Es availability.

To meet ADA requirements for prompt equipment repairs, MARTA's maintenance contract classifies El/Es as being either "critical" or "special." For "special" classification El/Es,

TABLE 4
CLASSIFICATION OF MARTA EL/ES EQUIPMENT

Elevators			
Manufacturer	Type	Age (years)	Quantity
Westinghouse	Traction–4 Hydraulic–44	30+; most installed in late 1970s and early 1980s	48
Dover	Traction–2 Hydraulic–30	15–30	32
Schindler	Traction–4 Hydraulic–9	6–10	13
KONE	Hydraulic	2–10	4
CEMCO	Hydraulic	9–30	4
US	Hydraulic	30+	2
Mowrey	Hydraulic	15	2
Montgomery	Hydraulic	30 & 13	2
Otis	Hydraulic	30+	1
Millar	Hydraulic	13	1 Total 109
Escalators			
Manufacturer	Type	Age (years)	Quantity
Westinghouse	Modular	30+ years	117
Montgomery	Conventional	15–23	10
O&K	Conventional	25+	17
Schindler	Conventional	7–11	5 Total 149

work to repair the unit must begin immediately and crews must work around the clock to return it to service. Stations with only one El/Es, such as the Atlanta Airport station and heavily traveled stations such as MARTA's central transfer station, are designated "special." All remaining El/Es are "critical" and carry the same requirements as those designated "special" with the exception that work can be deferred until the following day if approved by the Manager of Elevators and Escalators. When an El/Es is down for service, MARTA complies with the ADA requirement to accommodate individuals with disabilities by providing buses equipped with a wheelchair lift or ramp to transport passengers between rail stations.

Customer Communication and Education

MARTA uses several communication procedures to inform customers, especially those with disabilities, when El/Es are out of order. Equipment status is provided to MARTA patrons through public address (PA) announcements made at each station, as well as operator messages broadcast in trains and buses. MARTA's website also contains a listing of equipment out of service for extended periods. The listing shows the status of each station with green and red symbols. Green indicates the number of El/Es in service and red indicates the number out of service. Appropriate signage is also placed at station entrances to inform patrons about modernization projects and other long-term outages. Additionally, a scrolling message board located at most stations is used to post El/Es outage information as appropriate.

To educate passengers about El/Es usage MARTA plays recorded messages at regular intervals over the PA system that advise patrons to (1) hold handrails and (2) be careful entering and exiting the escalators. There are also several ways for customers to communicate El/Es issues, such as complaints, comments, and suggestions to MARTA. A community ADA committee external to MARTA also meets regularly throughout the year to address public accessibility issues, including MARTA's vertical transportation equipment. MARTA staff participate in these meetings to listen to public concerns and provide the group with information. Patrons can also provide feedback through Facebook, Twitter, MARTA's website, and the agency's Customer Service Hotline.

The type of El/Es issues communicated to MARTA by its customers in descending order based on frequency include

- Reports of equipment out of order,
- Escalators not running in a direction that is deemed convenient (i.e., one direction in the morning and the opposite in the afternoon), and
- Elevators not being located at every corner of the station.

When it comes to responding to communications made by its patrons, MARTA routes complaints from the Customer Service Department to the appropriate manager responsible for that area of concern. Issues are investigated and responses routed back to Customer Service for discussion with the patron or group issuing the communication. To improve passenger communication, MARTA recognizes that it needs to provide real-time web status of El/Es outages. Currently, only long-term outages are listed on MARTA's website.

Personnel

Staffing Levels

As mentioned, MARTA contracts all work on its vertical transportation equipment including preventive maintenance, repairs, and upgrades. Contracted technicians are generalists in that they work on both elevators and escalators. To service the combined fleet of 258 El/Es, the contractor assigns 21 workers to PM and inspections, two workers to perform quality assurance (QA) oversight, and one superintendent. Regarding repairs, a pool of 21 technicians (16 minimum) are assigned by the contractor when needed. Since the contractor has other technicians available, additional workers are brought in to meet workload requirements.

MARTA has a separate contract for its modernization project mentioned above. Currently, the contractor for MARTA's El/Es maintenance and repair work and its modernization project are the same (Schindler). About 14 technicians are dedicated to the modernization project, although more are brought in when needed.

MARTA is satisfied with its El/Es contractor. All liability is transferred to them. The agency, like the other agencies surveyed, feels it would benefit from additional contractor and in-house El/Es personnel.

Work Schedules

The contractor is required to have staff working within the system between the hours of 6:00 a.m. and 6:00 p.m., 5 days per week, Monday through Friday. Two overlapping shifts are used to provide 12 h/day coverage.

The contract is a full service agreement, requiring the contractor to provide a 90-min response time for all critical or special El/Es repair needs. Maintenance on all critical units must be done outside peak service hours, which is defined as 7:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:30 p.m. Maintenance on all special units must be done between the hours of 2:00 a.m. and 6:00 a.m. Workers split their hours to accommodate this schedule. Critical and special El/Es equipment distinctions are defined earlier.

Since the contract requires a 90-min response time on all El/Es, technicians must be on call during weekends. The contract states, however, that repair of certain El/Es can be deferred with MARTA manager approval.

Training

MARTA does not specify how much training contracted maintenance personnel should receive. Instead, their contract specifies that technicians must be competent to work on all El/Es equipment within the system. Because the contract is performance based, MARTA does not feel it necessary to dictate how technicians are to be trained. Instead, the responsibility falls on the contractor to provide a competent workforce. Training of technicians by the contractor is required to maintain their Georgia state license as indicated below.

Qualifications and Licensing

Although MARTA uses contracted maintenance personnel, the agency does employ four in-house equipment inspectors who audit contractor maintenance and equipment condition. These inspectors are all QEI certified, even though the Georgia Department of Labor does not require this certification for their own state inspectors. Regarding qualifications of its contracted workforce, the state of Georgia requires all El/Es technicians to be licensed through testing and recertification.

Maintenance

Written Maintenance Program

MARTA requires the contractor to have a written maintenance program. The contract specifies that OEM recommendations regarding inspections and appropriate service intervals be followed, as well as all ASME code and local requirements. Additionally, MARTA requires increased inspection frequency on all safety devices and brakes for escalators. The maintenance program was last modified in September 2010 when the most recent contract was bid.

Use of Job Procedures and Checklists

MARTA's contract calls for documentation that stipulates inspection, maintenance, and audit frequencies, as well as providing basic check charts that stipulate minimum inspection and maintenance requirements. Specific guidelines and procedures are developed by the contractor who solicits input from technicians.

Maintenance Intervals

MARTA's contract calls for monthly maintenance at a minimum for El/Es. The contractor, however, is required to consider age of equipment, OEM recommendations, and ASME requirements. A consultant to MARTA has started to track

shop comebacks (repairs that result in an additional service call to correct the initial problem). Based on the findings, MARTA will require the contractor to replace certain parts and take other actions at scheduled PM intervals.

Maintenance Management System

MARTA uses FASuites, a maintenance management system (MMS) program that uses an Oracle database platform. Before 2011, El/Es were not included in the agency's monitoring program because contractors performed the maintenance. MARTA has since entered all El/Es equipment into the system and includes all shop comebacks as well as scheduled maintenance and unscheduled repairs to help track outages and their respective causes. The agency does not, however, classify maintenance costs by labor and materials.

Scheduled Maintenance Versus Unscheduled Repairs

MARTA distinguishes between maintenance activities that are planned versus unexpected repairs and breakdowns and monitors those activities. Performance monitoring, however, is limited until the agency institutes its new MMS. If repeated failures are noted, MARTA will pressure its contractor to improve performance.

Spare Parts and Availability

Because maintenance is contracted out, all parts are purchased by the contractor. The contractor is required to maintain an adequate spare parts inventory, but MARTA realizes it must understand that certain cases have special circumstances. In the case of O&K escalators, for example, the company is out of business and finding parts is extremely difficult. Missed or delayed repairs resulting from a lack of spare parts is not currently tracked, but the agency also hopes to implement this capability with its new MMS.

Improving Maintenance Effectiveness

MARTA is still in the early stages of building an El/Es oversight department. Whereas some agencies find it necessary to reduce resources, MARTA is ramping up its oversight function. Once fully developed, however, the agency is confident its department will be among the best.

New Technology

Impact on Availability

As MARTA modernizes its older escalators the number of devices related to ensuring passenger safety essentially doubles from 10 to 20. The increased number of safety devices with the ability to detect potentially unsafe conditions also increases the number of equipment shutdowns and related service calls. MARTA is collecting data to compare the number of shutdowns pre- and postmodernization to correlate the relative change in shutdowns.

Comb impact device switches activated when comb plate movement is detected horizontally or vertically, while greatly improving safety, have proven to be especially troublesome at airports due to passengers inadvertently tripping the device when boarding with heavy luggage. The skirt deflection switch feature has also been troublesome from a nuisance standpoint due to school-age children purposely activating it to shut down escalators as a prank.

New Feature Benefits

Modernized escalators have fault code capability, something that the original units did not. The codes correspond to specific equipment faults, which facilitates troubleshooting and allows technicians and managers to respond accordingly. Safety features such as the comb impact device and skirt deflection switch found on escalators automatically shut down the equipment to dramatically improve passenger safety.

Nuisance Problems

Nuisance is a significant problem at MARTA as the agency struggles to deal with misuse and abuse of equipment by some patrons. Frivolous and unfounded claims made by some passengers also trouble the agency. It takes time to respond to nuisance calls and investigate false claims—time that is better spent on preventive maintenance and other activities to ensure safe and reliable El/Es operation. Incidents of unfounded claims are dwindling somewhat because of increased camera use. The agency is working to install video monitoring equipment at all El/Es locations. Currently, 75% of escalators and 50% of elevators are monitored with cameras. MARTA's new capital improvement project will include full coverage at both El/Es levels.

CHICAGO, ILLINOIS (CTA)

The Chicago Transit Authority (CTA) operates 159 elevators and 161 escalators at 144 stations over an area of about 240 mi^2 throughout the greater Chicago, Illinois, area. El/Es at CTA operate 24 h/day, 7 days a week with over 200 million passengers accessing the rail system annually. About 70% of CTA's rail system is accessible. Table 5 shows a classification of that equipment.

TABLE 5
CLASSIFICATION OF CTA EL/ES EQUIPMENT

Elevators			
Manufacturer	Type	Age (years)	Quantity
Mid-America	Traction and hydraulic	2–30	77
KONE & Montgomery	Traction and hydraulic	3–28	20
Anderson	Traction and hydraulic	7–32	19
Otis	Traction	20	32
Reliance	Traction	19	11
			Total 159
Escalators			
Manufacturer	Type	Age (years)	Quantity
Otis	RB	25	16
Otis	ML	63	15
Otis	506	28	8
Otis	510	22	2
Schindler		2–15	3
Haughton		42	2
KONE		3	16
Montgomery		42	73
O&K		18	18
Fujitec		7	8
			Total 161

Equipment Specifications

CTA relies on OEM specifications when procuring El/Es equipment and does not call for any unique requirements except those needed for special subway design installations. Some escalators have been in service since 1943, exceeding useful life expectations and presenting a host of other issues discussed below.

Safety, Availability, and Customer Communication

Safety and Legal Compliance

All CTA inspectors are QEI certified, and half of CTA's 32 escalator technicians are licensed. Elevator maintenance, however, is contracted to an outside vendor. The agency monitors and documents safety compliance through its safety department, which performs safety audits on every El/Es at each of its rail areas (i.e., Blue Line, Red Line, etc.) twice annually. Lessons learned from safety violations have resulted in improved adherence to Occupational Safety and Health Administration (OSHA) requirements and reduced news reports. El/Es injuries are defined and categorized by CTA as accident (slip, falls, and injuries), detainment (entrapments), or down (defective equipment).

Equipment Availability

CTA monitors El/Es availability systemwide in terms of uptime and downtime performance. Customer assistants placed at each station call in any defective El/Es to CTA's Control Center, which then contacts El/Es inspectors via radio to dispatch technicians. CTA uses a numbering system to further denote the status of its El/Es:

#1—Equipment up
#2—Equipment down
#3—Construction
#8—Accident
#9—Detainment

Reports are generated daily showing status of each El/Es.

The Control Center enters details about each defect into a computer program called Infor EAM (equipment asset management) system. Each entry is date and time stamped, recording when the El/Es unit went down and when it was placed back into service. Two procedures are used by CTA to track El/Es availability. For internal agency use, only unscheduled repairs such as breakdowns classify equipment as being unavailable; any scheduled maintenance performed to equipment is counted

as equipment being available for CTA's internal accounting purposes. This allows CTA to distinguish between equipment down for scheduled maintenance and unscheduled repairs.

For external reporting to its customers, any equipment not available for customer use is considered unavailable regardless of the reason. This more rigorous status system is used to inform customers of El/Es equipment status.

Leading causes contributing to El/Es being unavailable for service at CTA include door problems for elevators. For escalators, comb impact device switches are problematic, primarily caused by overload conditions. Stop button switches are troublesome for both elevators and escalators, oftentimes tripped purposely by passengers as nuisance pranks.

CTA feels that more participation by inspectors and technicians in meetings to provide input during the initial design stage when new stations are being planned or existing stations remodeled would improve El/Es availability. Additionally, CTA feels that the planning of new and upgraded stations must take into consideration additional personnel requirements needed to meet extra maintenance demands and to better satisfy code inspections.

To ensure that El/Es are repaired promptly to satisfy ADA requirements, CTA responds immediately to accidents and entrapments, and within 1 h for El/Es units downed for all other reasons.

Customer Communication and Education

When El/Es equipment is down and a station becomes inaccessible to disadvantaged passengers, paratransit bus service is established to take them to stations. Verbal announcements made on the train inform passengers of the bus service. In-train announcements are also made to inform passengers of the outages and alternative transportation options. In some cases passengers are instructed to bypass an affected station and return via the opposite platform where El/Es are operational.

Customers already within CTA's rail system are informed of downed El/Es via white dry erase board signs posted at each station. Customer service attendants manually update these dry erase board signs hourly to keep customers informed, providing an archaic but effective communication tool. TV monitors now being installed by CTA that display El/Es status are also available to customers; about 40% of CTA's rail stations are currently equipped.

Customers planning to use the rail system can telephone CTA at a 1-800 number to receive live El/Es accessibility status reports to determine if their point of boarding is affected by any downed equipment. Customers can also access the agency's Internet site at http://www.transitchicago.com/travel_information/accessibility_status.aspx. The site is organized by each rail line and includes current status as well as planned outages. An example of an Internet accessibility status notice is shown as Figure 2.

Customers communicate El/Es issues such as complaints, comments, reports of outages, and any suggestions via e-mail and telephone. Types of El/Es issues communicated include questioning why El/Es are down and asking how soon equipment will become operational. Equipment is sometimes purposely placed out of service by CTA because of equipment overload concerns at major events, but occasional patrons are often not aware of this. CTA staff receive and log-in each call, investigate the suggestion or complaint, and respond to every customer with an answer. Overall the agency feels it is doing a good job with its customer communication.

Personnel

Staffing Levels

CTA contracts its elevator maintenance and repair so in-house technicians are dedicated exclusively to escalators. Elevator maintenance and repairs are done monthly by contractors. A total of eight contracted technicians service CTA's 159 elevators; six are assigned to PM and inspections,

Customer Alert: Elevator at Belmont Temporarily Out-of-Service

Length:
Saturday, April 16, 2011
to **TBD**

Route(s):
Red Line
Brown Line
Purple Line Express

Impact Level:
Elevator Status

Full Description:
The elevator to the Howard-bound, Kimball-bound, and Linden-bound platform at Belmont (Red Line, Brown Line, and Purple Line Express) is temporarily out-of-service.

FIGURE 2 Example of CTA's Internet Accessibility Status Announcement.

while two contracted technicians perform repairs. Two in-house personnel conduct QA functions. Additional personnel to perform maintenance and repairs can be requested of the contractor by CTA due to weather, emergencies and special conditions as called for in the contract. CTA has mixed feelings regarding its contractor. On the plus side, the contractor assumes all liability; on the negative side,

- Work is more costly,
- CTA still needs to provide an oversight function,
- CTA needs to make sure that correct and quality parts are being used, and
- CTA also had to spend time informing the contractor of special conditions that exist in transit, which are more severe than the typical contractor applications.

CTA services all 161 escalators with a staff of 20 in-house technicians, who collectively perform PM tasks, inspections, and repairs as needed. CTA's in-house escalator staff has been short six technicians for about 3 years now due to budget constraints. Despite the shortfall, CTA seeks to improve El/Es uptime by researching reasons for downed equipment and improving its communication with other agencies to exchange information. Both contracted and CTA El/Es technicians work 8 h/day over one shift, 5 days per week Monday through Friday. Because technicians only work one daytime shift, maintenance activities are not targeted during off-peak hours. During weekends and hours outside the normal work shift, CTA calls in workers when 15% or more of its El/Es are down.

CTA does not feel it has a sufficient number of human resources (in-house personnel and contracted services) to effectively repair and maintain El/Es. The combination of being short staffed along with the increased number of heavy repairs needed because of aging equipment places additional loads on the maintenance staff.

Training

Training is provided by equipment vendors for new installations. Since in-house training is limited, CTA makes extensive use of on-the-job training (OJT) and mentoring. Lack of training aids, such as mock-ups, makes it difficult to do classroom training because CTA's El/Es equipment is so detailed and complex. In CTA's opinion, students really need to work with El/Es equipment hands-on. Bringing technicians out into the field and providing instruction on actual equipment is an effective way for CTA to train its workforce. In addition to needing more training overall with a focus on hands-on delivery, CTA believes its training program could be enhanced by including more in-depth electrical print reading, troubleshooting, and mechanical maintenance exercises and directed training on adjusting equipment to specification tolerances.

Qualifications and Licensing

Currently, there are no licensing requirements for El/Es technicians; however, Illinois state licensing requirements will be imposed in the near future. CTA is responding by participating in the national training consortium and increasing its overall training efforts to prepare technicians for certification.

Maintenance

Written Maintenance Program

CTA's maintenance program is documented with written work procedures and checklists. The agency is also considering use of time standards for some routine jobs. The agency feels its maintenance program is proactive in that PM inspection data are used to help better understand the root cause of problems and adjust its maintenance program accordingly. An example is CTA's seasonal PM program where by October all heaters are inspected and made functional before they are needed in winter months. Likewise, before summer, all vent fans are checked and made operational.

Maintenance Intervals

Regarding its in-house escalator maintenance, CTA performs maintenance daily, monthly, and yearly. The daily inspection is a visual one; within a month each escalator receives a daily inspection. The monthly inspection and lubrication PM consists of lubricating vital parts and inspecting condition of steps, combs, handrails, stop switches, and other parts. The yearly PM consists of comprehensive inspection and servicing.

Contracted elevator maintenance is done on every unit on a monthly basis according to a specified inspection and servicing list that includes doors, switches, fan, phone, emergency lighting, controllers, ropes, counterweights, roller guides, seals, and so forth. Intervals are based on code requirements, local experiences, and OEM recommendations. Technicians provide input to establishing those intervals.

Reconditioning, overhauls, and replacements are done as needed. CTA is planning to replace 52 units within 5 years with the intent of removing the oldest equipment from service. Finding replacement parts for older units has become very difficult, which increases maintenance and downtime.

CTA's engineering group and QEI-certified inspectors provide QA oversight to maintenance and repairs performed by its in-house escalator technicians and contracted elevator workers. QA is conducted twice every 6 months and periodically. CTA's inspectors also perform acceptance testing on new equipment installations.

Maintenance Management System

All work orders (WOs) are entered into CTA's EAM system provided by Infor. Reports, generated by the Human Resources Department, include overall equipment status and details pertaining to how many times specific equipment has been down, how long the equipment was down, and root causes of specific equipment problems. The system was last updated in July 2010, when CTA changed to adhering to the latest version of ASME A17.

Maintenance Costs

CTA classifies its maintenance cost by parts and labor, as well as by asset type. The agency pays its elevator contractor a set hourly rate for labor; major parts are also charged to CTA with the contractor paying for small item parts. Warranty costs are handled by OEMs. Regarding in-house maintenance costs for escalators, CTA stays within an allotted budget. Each WO has cost breakdown, but the agency simply does not have the resources to track costs very closely.

Scheduled Maintenance Versus Unscheduled Repairs

CTA distinguishes between scheduled maintenance and unscheduled repairs, but admits monitoring is lax. Needed information is provided on WOs and worker time sheets, and the agency is attempting to gather more data to improve its monitoring capability. The data will allow CTA to track unplanned maintenance events more carefully to improve its existing abilities to determine the root cause of unscheduled repair activity to reduce their occurrences.

Spare Parts and Availability

Spare parts for escalators maintained in-house are ordered primarily on recommendations made by foremen and inspectors. While CTA believes it maintains a satisfactory parts inventory it also understands that certain high-priced items are not cost-effective to inventory. As an example, a rotor costing $12,500 recently took 2 weeks to arrive from Germany, resulting in the equipment being down the entire time. CTA estimates that about 2% of its El/Es repairs are delayed due to missing spare parts. For escalators in service since 1943, some parts need to be custom-made, which extends downtime until parts arrive. If it had the luxury of conducting more frequent and lengthy inspections, CTA believes that technicians would note parts needing replacement in advance of failure, giving them sufficient time to order parts and have them in stock when needed.

New Technology

Impact on Availability

For CTA, new El/Es safety features translate into more maintenance requirements. The agency monitors the impact of those features and estimates that a minimum of 20% additional time is needed for maintenance and repairs.

Technician Adaptation

Orientation of new El/Es features is done through OJT and OEM training, which is written into the contract. OEMs provide manuals and a specified amount of training for all new equipment delivered. CTA believes it has the capability to maintain and repair advanced technology equipment primarily because it has selected a quality group of technicians.

Benefits of New Features

The ability of new technology to record, store, and display fault codes has been extremely helpful for troubleshooting, while the primary benefits of new equipment to passengers include the extra lighting found on escalators and the additional safety devices found on El/Es.

NEW YORK CITY (NYCTA)

New York City Transit Authority (NYCTA) operates 192 elevators and 176 escalators at 468 stations throughout New York City, operating 24 h/day, 7 days a week, carrying approximately 1.6 billion passengers annually. NYCTA maintains its El/Es equipment entirely with in-house staff. Table 6 shows a classification of NYCTA's El/Es equipment.

Equipment Specifications

NYCTA has developed its own equipment specification. Included are

- A unique elevator specification for top of car safety curtains,
- Sleep mode where escalators' speed is reduced when no passengers are detected and automatically resumed as passengers approach, and
- Remote equipment monitoring (Liftnet) for both elevators and escalators.

Safety, Availability, and Customer Communication

Safety

Safety is upheld by an in-house program using the ASME A17 code for periodic and routine inspections. Supervisors inspect technicians' work on a regular basis, while the engineering department performs random safety audits.

TABLE 6
CLASSIFICATION OF NYCTA EL/ES EQUIPMENT

Manufacturer	Type	Age (years)	Quantity
Elevators			
Canton	Hydraulic	5	58
CEMCO	Hydraulic	10.6	66
MCE	Hydraulic	6.6	31
Others	Hydraulic	20	11
MCE	Traction	10.3	21
Otis	Traction	23	5
Total			192
Escalators			
O&K	Conventional	13	84
Fujitec	Conventional	6.5	34
KONE	Conventional	4.1	27
Otis	Conventional	22.5	24
Schindler	Conventional	2.2	7
Total			176
Combined Total			368

Equipment Availability

NYCTA classifies El/Es equipment as down anytime equipment is not available for customer use regardless of the reason, which includes scheduled repairs and maintenance. Response time policy for responding to shutdowns is 20 min, with technicians having access to parts 24 h/day, 7 days a week. The agency does not currently schedule overhauls and rehabs and sees this as an opportunity to improve availability. A recently implemented approach to conducting PM activities and a remote monitoring feature added to equipment have helped improve El/Es availability. Both are described below.

Customer Communication and Education

Communication to customers is via NYCTA's website, which informs customers of any out-of-service equipment so they can make alternate arrangements. They also announce outages over the PA system and via electronic signs located throughout the system. The agency is also a member of the Elevator and Escalator Safety Foundation (http://www.eesf.org/), which provides NYCTA with outreach guidance. NYCTA personnel use this assistance to travel to various stations throughout the system to inform passengers of El/Es safety. Elevators are equipped with intercoms, which not only promote customer safety but can also be used as a tool for relaying maintenance information.

Customers communicate with NYCTA via phone lines, e-mail, and the agency's website. All communication from customers is investigated; the Customer Relations Department responds to concerns and other customer issues.

Personnel

Staffing Levels

As noted previously, NYCTA has 246 in-house maintenance personnel assigned to El/Es with no contracted services. All technicians work on elevators and escalators equally with no specialization. NYCTA feels it has adequate staffing levels. To service its combined El/Es fleet the agency assigns 124 workers to PM and inspections, 37 to repairs, and 23 to overhauls; 12 workers perform QA oversight and 50 workers have various other responsibilities. To increase efficiencies, NYCTA has created what it calls PM Packages for each type of El/Es, which are described below. Based on the tailored PM approach, NYCTA was able to give technicians more time for certain PMs based on the number of tasks involved.

Work Schedules

NYCTA El/Es workers are available 24 h/day, 7 days a week, via three shifts per day. Scheduled maintenance activities are scheduled during off-peak hours to reduce customer impact.

Training

NYCTA provides in-house training as follows:

1. Hydraulic Valve Body: 3 days
2. Introduction to Electrical Schematics Basic: 3 days
3. Elevator Door: 3 days
4. Escalator Maintenance: 2 days
5. Hydraulic Elevator Maintenance: 1 day
6. Traction Elevator Maintenance: 1 day

The agency is also participating in the national training consortium and has several training mock-ups including a running escalator and various major elevator mock-ups to use as training aids. Despite the training program, NYCTA does not feel workers are given adequate training because of the large number of different types of controllers and electrical systems found throughout the system. They feel that to improve training, additional training aids and mock-ups of newly installed equipment in the field are needed, along with placing more emphasis on hands-on and visual training.

Qualifications and Licensing

NYCTA technicians are not required to be certified or licensed, although several supervisors are QEI certified.

Maintenance

Written Maintenance Program

NYCTA's maintenance program is documented with written work procedures and checklists. It has also developed a series of PM Packages, a set of PM procedures and a checklist established for each type of El/Es equipment. Previously the agency used a generic approach with similar documentation to address the PM needs of all equipment equally.

Maintenance Intervals

NYCTA workers provide El/Es routine and periodic PM at 4-, 6-, and 8-week intervals. Elevator rope replacements are done at 5-year intervals. Escalator step chain replacements are performed at 10-year intervals, while escalators are scheduled for replacement at 25- to 35-year intervals.

NYCTA uses the ASME A17 safety code and OEM recommendation, as well as factoring in age, El/Es rise (length), location, and usage of equipment to establish scheduled maintenance intervals.

Maintenance Management System

NYCTA's MMS was updated in March 2011. One update to the MMS was to incorporate and emphasize what the agency refers to as "Five or More Outages." The system flags cases in which a particular piece of equipment is down five or more times in a given week. Those units are examined thoroughly to determine the cause and seek solutions to prevent additional outages. Data collected from the investigations are then used to enhance the PM Packages described above where specific PM tasks are assigned to specific equipment at specified intervals.

The agency uses its MMS to distinguish between and monitor scheduled maintenance events and unscheduled maintenance repairs. Reports are generated as needed to determine performance as it relates to how much time and money are spent performing maintenance tasks that are planned and therefore anticipated, as opposed to addressing unanticipated failures and breakdowns. The MMS also classifies maintenance costs by labor and materials, as well as asset type.

Spare Parts and Availability

NYCTA forecasts spare parts requirements and stores them at three central satellite locations located throughout the rail station network, which reduces the time needed to obtain needed parts and perform repairs. Their spare parts availability is adequate but could be greatly aided with more standardized equipment.

New Technology

For NYCTA, the use of Liftnet, the remote monitoring system described above, has reduced response time for repairs. Other new technology features such as safety sensors, however, have increased the need for technical training, making it difficult to find qualified technicians. Although technicians receive OEM and in-house training on new technology, the training could be improved with increased training mock-ups and visual aids for more hands-on training as discussed earlier.

PHILADELPHIA, PENNSYLVANIA (SEPTA)

The Southeastern Pennsylvania Transportation Authority (SEPTA) operates 106 elevators and 50 escalators at 156 rail stations throughout the greater Philadelphia area. El/Es at SEPTA operate 16 h/day, 7 days a week carrying nearly 321 million passengers annually. Table 7 shows a classification of that equipment.

TABLE 7
CLASSIFICATION OF SEPTA EL/ES EQUIPMENT

Elevators		
Manufacturer	Age (years)	Quantity
Unspecified	N/A	Total 106
Escalators		
Manufacturer	Age (years)	Quantity
KONE	2–13	36
Fujitec	2–13	11
ThyssenKrupp	1	2 Total 50

Equipment Specifications

SEPTA relies primarily on El/Es technical specifications issued by the OEM. While unique elevator specification requirements are limited, the agency does call for a deteriorated roller detection device for its escalators.

Safety, Availability, and Customer Communication

Safety Compliance

Code A17 is the principal standard that governs SEPTA's elevator and escalator inspection and maintenance protocols, which when followed ensures safe operating performance of equipment. Additional safety requirements are contained in manuals prepared by the OEMs for each piece of equipment. All code- and equipment-related documents are kept at SEPTA's headquarters and also made available at field offices for reference as needed—a requirement of A17.

At the core of SEPTA's safety program is a series of documented preventive maintenance inspections (PMIs) that the agency conducts daily, weekly, monthly, and annually based on the A17 code, OEM requirements, and agency experiences. The purpose of the aggressive inspection schedule is to identify faulty equipment in advance of failure, thereby allowing equipment to operate as designed and prevent passenger injuries. In addition to its own inspections, SEPTA contracts with a qualified third-party inspection company to perform annual inspections to independently confirm state certification requirements.

SEPTA's Systems Safety Department conducts its own annual assessment in addition to the independent third-party audit to further ensure maintenance and safety compliance. SEPTA's internal annual assessments are conducted exclusively as a record and document audit to determine the Bridge and Building maintenance department's conformance with SEPTA's internal Inspection and Maintenance protocols for its El/Es units.

SEPTA's annual internal audit scope includes the following:

1. Identify the existence of written SEPTA and industry standards for railroad El/Es inspections and determine whether they are readily available and put into practice.
2. Identify the existence of applicable written procedures exclusive of standards (i.e., procedures based on agency experience that go beyond industry standards) for performing inspections and determine whether they are readily available and put into practice.
3. Identify the existence of applicable written worksheets for performing inspections and determine whether they are readily available and put into practice.
4. Qualitatively review inspection documentation and worksheets and determine if the documentation was appropriately completed and processed.
5. Identify applicable inspection frequencies and determine whether inspections are conducted in the time frame specified by SEPTA and whether a tracking mechanism was in place to ensure conformance.
6. Determine if inspection information is recorded and tracked electronically and if the electronic data match hard copy documentation.
7. Determine whether physical plant records were centralized and secured in a reasonable manner.

Equipment Availability

SEPTA tracks El/Es availability and issues reports on a daily basis. Uptime is defined as equipment that is "functioning and can perform service for public usage," whereas downtime is defined as equipment that is "not functioning and cannot perform service for public usage." If El/Es units are down because of scheduled maintenance, however, they are counted in the uptime category, even though they are unavailable for passenger use. Units are only counted in the downtime category when unscheduled repairs are being made and when annual inspections are conducted.

SEPTA believes additional field training (as opposed to classroom instruction) and improved parts ordering and inventory control procedures are needed to improve El/Es equipment availability. The leading causes that contribute to El/Es being unavailable for service consist primarily of malfunctioning parts, such as electrical circuit boards.

Customer Communication and Education

SEPTA offers several ways of informing customers whether El/Es are operational, both during and before travel. A toll-free, 24-h El/Es status hotline number is updated immediately when changes occur. Patrons can also access the agency's website to view equipment status and an "Alternate Accessible Service" list for travel options. SEPTA also uses safety barriers and "Out of Order" displays placed at kiosks and in front of the equipment to communicate out-of-service conditions to the public.

SEPTA participates in National Escalator and Elevator Safety Awareness Week by having system safety personnel travel to several stations and schools to discuss escalator and elevator safety with customers. Awareness instructions include reminding customers to take some simple yet effective steps to stay out of harm's way. When using escalators, for example, customers are instructed to always use handrails, stand in the middle facing forward, and keep loose clothing away from edges. On elevators, they are instructed not to force doors

open or closed and, if they got stuck, to push the "help" button and wait for assistance.

Customers can communicate El/Es concerns, comments, and suggestions through station kiosks, SEPTA's service desk, by calling the agency over the phone, and through SEPTA's website. Common customer communications consist of reporting equipment malfunctions and complaints regarding the extended time it takes to make equipment operational again.

SEPTA's Customer Service Group responds to customer communications by issuing a complaint ticket to the responsible El/Es department, which issues a WO, investigates the reported issue, corrects the problem, and then reports back to the Customer Service Group to close out the WO. The customer group then follows up with the customer by informing him or her on how the issue was resolved. Regarding methods that would improve customer communication, SEPTA feels it needs to centralize the video camera system and link it to Customer Service to provide real-time display capability.

Personnel

Staffing Levels and Work Schedules

SEPTA employs 30 maintenance personnel to collectively repair and maintain a total of 156 escalators and elevators. They work 5 days per week, Monday through Friday. Weekend work is done on an on-call, overtime pay basis. Technicians are required to work on all jobs equally with no specialization.

Contract services include elevator cab rebuilding and renovation and escalator handrail replacements or vulcanization, which is carried out by one or two contracted workers. About one or two contracted workers also perform quality control functions for state inspections. SEPTA feels that contracted work is more costly, but jobs get completed faster. SEPTA does not feel it has enough technicians, in-house or contracted, to test, maintain, inspect, and repair El/Es. In a time of reduced budgets, SEPTA is concentrating more effort on detailed PM and planning functions to reduce unexpected breakdown and repairs, especially those requiring long lead times.

Training

SEPTA has a training center and related program to provide instruction in preventive maintenance and repairs. The agency is in the process of purchasing one escalator and one elevator as mock-ups for training. Training also consists of vendor-provided, ongoing apprenticeships and participation in the national training consortium. According to SEPTA, training needs to provide increased knowledge of regulatory codes, field work, and case studies.

Qualifications and Licensing

SEPTA technicians are not required to be licensed or certified to perform their duties. However, SEPTA's training program will be used to prepare technicians for certification once the national training consortium completes course materials.

Maintenance

Written Maintenance Program

As required by ASME A17, SEPTA has a documented maintenance program. The program was last updated in March 2011.

Maintenance Intervals

Maintenance intervals are determined through a combination of ASME A17 requirements, OEM recommendations, and local experiences.

Maintenance Management System

Analysis of handrail life has led SEPTA to institute a program to replace escalator handrails every 5 years.

Spare Parts Availability

SEPTA's program for ordering spare parts and ensuring parts availability when needed is based on the OEM recommendations and its own experiences. The agency does not feel it keeps enough spare parts in stock to keep El/Es operational, instead focusing on the most common wear parts. It does not keep records to determine the percentage of El/Es repairs that cannot be made because spare parts are out of stock when needed. Conducting a risk assessment to determine the cost of stocking additional parts versus the impact caused by downed equipment is a step that it feels should be taken to improve spare parts availability.

New Technology

Planned Improvements

SEPTA is planning to install a centralized monitoring system on some of its El/Es to observe conditions in the field to better respond to impending failures.

Technician Adaptation

Technicians are trained on new technology through OEM training when new equipment is acquired. The agency feels that it needs a better way to approve and monitor OEM training.

SAN FRANCISCO, CALIFORNIA (BART)

Bay Area Rapid Transit (BART) operates 140 elevators and 176 escalators at 44 locations throughout the San Francisco Bay area, all of which are accessible. El/Es at BART operate 20 h/day, 7 days a week, carrying over 100 million passengers annually. Table 8 shows a classification of that equipment.

Equipment Specifications

BART begins by following the APTA guidelines and develops its own technical specifications for El/Es. Regarding elevators, the agency imposes several unique specification characteristics:

- Hands-free phones in lobby beside hall call buttons,
- Cameras inside of all elevators,
- Remote equipment monitoring system,
- Glass vision panels on elevator doors,
- Auxiliary oil recovery tanks for hydraulic elevators,
- Station agent booth controls and position display indication,
- Motion sensors that automatically bring patrons to next floor when door closes, and
- Automatic home floor features.

Regarding unique escalator specifications, BART calls for

- Remote equipment monitoring systems,
- Escalator fault displays at unit and on controller, and
- Increased step load requirements that exceed APTA guidelines.

Although the additional equipment adds additional initial expense, BART asserts that maintenance costs and safety-related claims are reduced as a result of the up-front expenditures.

Safety, Availability, and Customer Communication

Safety and Legal Compliance

Procedures used by BART to ensure compliance with applicable El/Es safety codes include

- Weekly quality control inspections,
- Weekly safety meetings,
- State-mandated conveyance certification classes on A17.1 for all mechanics, and
- Annual state inspections.

Regarding lessons learned from violations, BART had a state inspection violation pertaining to door zone locks. On

TABLE 8
CLASSIFICATION OF BART EL/ES EQUIPMENT

Elevators			
Manufacturer	Type	Age (years)	Quantity
MCE	Hydraulic	35	87
MCE	Traction	35	44
US	Traction	35	4
Montgomery	Traction	35	3
Westinghouse	Traction	35	1
Alimax	Traction	10	1
			Total 140
Escalators			
Manufacturer	Type	Age (years)	Quantity
Westinghouse	48N & 38E	35	88
Fujitec	PS-1200	13	28
Montgomery	5E	35	26
O&K	HD	15	19
Otis	RB & J	35	6
KONE	5TR	15	9
			Total 176

further investigation, the agency discovered that mechanics were altering door zone locks to make it easier to pick elevator doors when the elevator was outside the door zone (18 in. above or below the hall landing floor level), which would then allow BART mechanics to extract trapped passengers from the elevator no matter how far the elevator was from the landing. Despite the perceived benefit to mechanics, meetings were held to make them aware of ASME A17 code requirements and why those rules needed to be followed. BART also started to review A17 rules during weekly safety meetings.

BART defines "entrapment" as an incident in which passengers get stuck inside elevators. "Accidents" refer to patrons who fall (injured or not) while on/in El/Es equipment and passengers who have body parts, clothing, or personal items trapped in comb segments, skirts, handrails, and so forth.

Equipment Availability

Equipment is considered down anytime it is not available for customer use regardless of the reason. Scheduled maintenance actions would therefore render the equipment unavailable for tracking purposes, as would corrective maintenance, repairs, inspections, accidents, and entrapments. The only exception is for major capital improvement projects, which do not classify the equipment as being down. BART monitors El/Es availability in terms of uptime and downtime through use of a Data Stream WO system, which will soon be replaced by the MAXIMO Data Management System. To ensure prompt repairs to satisfy ADA requirements, BART must dispatch a mechanic within 1 h per a court-mandated agreement, which stems from an ADA lawsuit.

Comb impact faults are the primary cause of escalator shutdowns at BART. Although the duration of these calls is typically within 1 h, they still represent the main reason for shutdowns. Analysis of these shutdowns indicates that although the safety device operates as intended, it is usually triggered by patrons running down the escalator and jumping the last few steps in an effort to board a train before the doors close. When they land on the comb plate, the safety device cannot distinguish between a patron becoming entrapped or jumping on it and therefore shuts down the escalator.

To improve El/Es availability, BART believes that PM procedures need to be performed to a higher standard. Mechanics need to be given more time at the units to pay attention to all the details required to keep El/Es subsystems running efficiently. Proper checking, lubricating, adjusting, cleaning, and replacement of worn parts month after month are required to achieve this goal.

The installation of a trunked radio system, operational anywhere in the entire BART system including all tunnels and underground rooms, allows the agency to communicate with mechanics immediately and without exception to inform them of problems. The advanced radio system allows BART to respond quickly and efficiently to emergencies and downed equipment.

Customer Communication and Education

The ADA also requires that when an accessibility feature is out of order, the transit agency must take reasonable steps to accommodate individuals with disabilities. When El/Es become inoperable at a certain station, BART informs passengers and establishes paratransit bus service back to the affected station. Communication measures to inform passengers of inoperative equipment and alternative means of transportation include announcements made via electronic signs located at the entrance of all stations and over the systemwide PA system. Patrons can also receive El/Es status via BART's Internet website, BART's wireless website, Really Simple Syndication feeds, Short Message (texting) Service, e-mail and text message alerts, and via Twitter. Services indicate where and for how long El/Es are unavailable and note equipment currently being rehabbed.

A disability task force consisting of all types of disabled patrons meets once a month to discuss accessibility issues. BART staff participate in these meetings to better understand the issues and to update attendees of future and ongoing projects.

Typical customer communications to BART consist of dirty elevators, elevator doors not operating properly (too slow, too fast, they do not fully open, or they slam closed), and complaints that some repairs on escalators take too long to complete. The agency responds by phone calls, e-mails, or letters with an explanation. The agency also conducts a departmental analysis to determine if maintenance changes or equipment improvements are needed.

Personnel

BART maintenance personnel are assigned to service both elevators and escalators. The agency performs all of its maintenance, repairs, and minor projects and some overhauls in-house. Personnel work alone on maintenance and trouble calls but work in pairs on repair jobs. However, when its own workforce is overwhelmed with too much work, contractors are called in. Major overhauls are contracted to the lowest bidder.

BART is generally satisfied with "on-call" services provided by contractors because they are able to get equipment back in service in a timely manner when its own workers are inundated. Since the contractors tend to be from OEM firms,

work quality tends to be good and callbacks are infrequent. Disadvantages to using contracted services include they are slow to respond to BART's needs, they are more expensive compared to in-house services, and they provide poor communication regarding repair details.

Staffing Levels and Work Schedule

BART employs 28 technicians to service its 316 El/Es, with 23 assigned to PM, inspections, and light repairs and five assigned to repairs. Technicians work three shifts per day providing 24 h of daily coverage, 7 days per week through a rotating schedule that includes weekend coverage. The agency does not believe it has a sufficient number of human resources in in-house personnel and contracted services to effectively repair and maintain El/Es, citing that the ratio of equipment to workers is too high. To maximize its limited resources, BART is reducing travel time and making more efficient use of personnel by assigning technicians to El/Es in close proximity to each other. Storage of tools, equipment, and parts are located at most stations, and each technician reports to and leaves from his or her assigned route location.

Training

BART has a training program for its technicians, which serves as a model for El/Es training. The agency is also participating in the El/Es Training Consortium. According to BART, participation in the El/Es consortium will provide BART and others with a nationally accepted apprentice program, state license accreditation, and consistent training of existing mechanics.

BART's training documentation is excellent by any standard. Comprehensive training materials, included as a web attachment, provide students with the knowledge and skills needed to properly carry out an extensive list of El/Es tasks. One module entitled "About Preventive Maintenance," for example, describes the goals and objectives of PM and what type of lubricants are used and why. Another entitled "Governor Over-speed, Safeties and Run-by," found in the elevator module, contains detailed information, instructions, and illustrations needed to

- Understand all safeties involved when accessing the elevator hoistway, the car top, and the pit;
- Inspect governor, over-speed switch, and seal;
- Lubricate all pivot points of governor and its component but not the wire rope;
- Test governor switch; and
- Inspect the counterweight run-by.

There are separate instruction modules for elevators and escalators. Readers are encouraged to examine this extensive and well-developed library of training materials. Review questions are provided at the end of each training course to assess the learner's comprehension.

Qualifications and Licensing

El/Es technicians at BART are required to be certified through a state-run program, which also includes a 2-year recertification requirement administered by the state of California.

Maintenance

Maintenance Program and Intervals

BART has a documented PM program for both elevators and escalators. The elevator program, also included as a web attachment, is set up for bimonthly, monthly, quarterly, semiannually, and annual inspections. The inspection checklist includes a list of tasks that must be performed along with a method describing how each inspection is to be carried out. Methods include specific steps that must be performed for each inspection. Also included for each inspection is a numerical 1 to 4 coding system that provides additional instructions for each inspection task:

1. Check operation, adjust, and clean as needed;
2. Lubricate as needed;
3. Check for unusual noise or heat; or
4. Check for wear or breakage.

The escalator PM form is organized in four sections (top head, bottom head, steps, and top and bottom) and uses the same 1 to 4 numbered instructional coding system provided for elevators.

A separate set of procedures accompanies each PM form. PMs are expected to be completed no more than 2 days before or after the PM due date. If repairs are needed, technicians are instructed to contact the foreworker to determine how the repair is to be completed:

- Perform the needed repair yourself;
- Request assistance to perform the needed repair;
- A repair crew is required; or
- Not a safety concern and will be addressed at a later date.

The agency solicits input from technicians to develop inspection intervals and procedures. A feedback form is used to solicit that input. It also incorporates OEM recommendations. The complete set of BART PM procedures is included as a web attachment.

To improve maintenance effectiveness, BART believes that PM procedures need to be performed at a higher standard. Technicians require additional time to maintain and repair each El/Es unit and need to pay closer attention to all the details required to keep El/Es subsystems running efficiently.

This means proper checking, lubricating, adjusting, cleaning, and replacement of worn parts month after month.

Maintenance Management System

BART is presently using a Data Stream WO but will soon change to a MAXIMO Data Management System. The change will allow BART to gain a systemwide data management system, one that will provide better analysis of shutdowns by capturing more data. The existing management system is used to produce reports and review the reason why repairs were needed. Changes to the current management system are made annually or when new equipment is introduced.

Spare Parts Availability

BART's spare parts system automatically reorders parts based on preset minimum quantities. The agency believes it keeps enough parts on hand to keep El/Es operational.

CHAPTER FOUR

HIGHLIGHTS OF AGENCY SUCCESSES

Although each agency has different El/Es equipment, maintenance approaches, staffing levels, and operating environments, this chapter identifies successful practices put into place by these agencies to meet their specific needs. Those currently operating El/Es or planning new applications should consider these practices as a way of improving the safety and efficiency of their own operations.

ASSET MANAGEMENT

Up-front and ongoing planning where El/Es assets are managed like transit rolling stock is essential for effective El/Es operation. Asset management, defined here as cradle-to-grave planning and budgeting for El/Es design, installation, maintenance and repairs, spare parts, quality control, modernization, rehabilitation, and replacement is a critical but often overlooked El/Es function. It is critical in that asset management should begin during initial planning stages of a new start rail operation where agencies could then consider station designs that circumvent or limit the need for El/Es if possible to reduce initial and ongoing expenses. Regardless, El/Es are integral to all rail operations and ongoing labor and equipment costs must be considered for the life cycle of every rail station that has them. Asset management should also take into consideration an aging population, which will increase the use and related expenses associated with transit El/Es.

BART is one example of effective asset management where each El/Es in its operation is closely tracked through comprehensive documentation. That documentation includes an inventory of all El/Es, including date of installation and current age, maintenance and repair history, safety incidents, equipment upgrades and modernization, and other notes. The detailed documentation allows BART to review the history of each elevator and escalator and adjust PM activities and intervals, and make informed decisions regarding the need for upgrades and replacements.

Another noteworthy example of asset management is MARTA's modernization program that will rehabilitate and upgrade 117 escalators installed 30 years ago. In the first phase MARTA is modernizing 30 units, with another 30 scheduled for the next fiscal year. The program includes upgrading escalators with safety devices and reconditioning them to function as new. Doing so provides the public with safer equipment and improves availability due to increased reliability. CTA has a similar program to replace 52 of its oldest El/Es within 5 years because spare parts are difficult to obtain, which increases maintenance requirements and downtime. Likewise, NYCTA has an asset management program in place that schedules the replacement of 25- to 35-year-old escalators.

In an effort to improve asset planning for new stations and existing station upgrades, CTA realizes that it needs more participation by inspectors and technicians to provide valuable input during the initial design stage. CTA also realizes that the planning of new and upgraded stations must take into consideration additional personnel requirements needed to meet extra maintenance demands and to better satisfy code inspections.

EQUIPMENT SPECIFICATIONS

Crafting technical specifications that consider multiple experiences helps ensure that El/Es will provide safe, reliable service in harsher, heavy usage and in high-abuse transit environments. Agencies including MARTA, BART, and others incorporate APTA guidelines into their technical specifications because they were developed to reflect the specific heavy-duty requirements of El/Es operating in North American transit environments. The guidelines represent the best thinking of transit agencies, consultants, and El/Es OEMs. Although the additional requirements established specifically for transit add equipment costs, authors of the APTA specification claim through past experience that additional up-front costs will be more than offset by reduced life-cycle costs. Most important, use of APTA guidelines will improve customer safety, satisfaction, and convenience and increase the public's confidence, which in turn increases ridership.

Another essential equipment document is ASME A17, Safety Code for Elevators and Escalators, which establishes a standard for the design, construction, operation, inspection, testing, maintenance, alteration, and repair of El/Es. All agencies use this code as an integral element of their El/Es program. Although OEMs are responsible for delivering equipment that meets hardware requirements established by ASME A17, agencies must ensure that these requirements are upheld through maintenance, repair, and testing.

BART is a good example of an agency that adds specific requirements to its El/Es technical specifications. For

elevators, those requirements include hands-free phones located alongside hall call buttons, internal cameras, remote equipment monitoring, glass door panels, auxiliary oil recovery tanks for hydraulic elevators, and controls and indicators located on station agent booths. Escalator specifications include remote monitoring systems, fault displays, and step load requirements that go beyond the APTA guidelines. Remote monitoring systems that provide real-time status of equipment, failure codes, and other useful information are also used by NYCTA.

MARTA specifies and plans to eventually install additional video surveillance cameras at all El/Es locations. With 75% of escalators and 50% of elevators now equipped with cameras, incidents of unfounded claims are dwindling. MARTA's new capital improvement project will specify full coverage at both El/Es levels.

SAFETY

El/Es safety is the number one priority at every transit agency as reflected in their unanimous use of ASME A17, along with local codes and regulations to guide inspection, maintenance, and repair activities. Even though MARTA contracts for the maintenance and repair of its El/Es, the agency employs four in-house inspectors to ensure the contractor is complying with all applicable safety requirements. Each of MARTA's in-house inspectors is QEI certified. All of CTA's inspectors are also QEI certified and monitor safety compliance through a dedicated safety department, which performs safety audits on every elevator and escalator twice annually. SEPTA's safety program incorporates a series of documented PMIs that it conducts on a regular basis according to the A17 safety code, OEM requirements, and the agency's own experiences. The purpose of the aggressive inspection schedule is to identify faulty equipment in advance of failure to improve reliability and safety. In addition to its own safety inspections, SEPTA contracts with a qualified third-party inspection company to perform annual inspections to independently confirm state certification requirements. BART holds weekly safety meetings with its staff to discuss ways to improve safety.

AVAILABILITY

ADA requires that accessibility features, which include El/Es, be repaired promptly and that transit agencies take reasonable steps to accommodate individuals with disabilities who would otherwise use the feature. While all agencies have measures in place to make sure El/Es are available for service, each uses a different method to classify and track that availability. A good, straightforward definition of El/Es availability comes from BART and MARTA, which consider equipment as being down anytime it is not available for customer use regardless of the reason—the only exception being major capital improvement projects. BART tracks El/Es availability through a data management system, while MARTA uses a spreadsheet program.

To ensure prompt repairs under ADA, BART dispatches a mechanic within 1 h using a trunked radio system, which is operational anywhere within the BART system. Radio communication allows BART to respond quickly and efficiently to El/Es emergencies and downed equipment. For elevators designated as "special," MARTA requires its contractor to begin repair work immediately and work 24/7 to return downed elevators to service. MARTA oversees the contractor to make sure prompt repairs are made.

CUSTOMER COMMUNICATION AND EDUCATION

Keeping the public safe and informed requires effective agency-to-customer communication. SEPTA takes a proactive approach by sending safety personnel to rail stations and schools to discuss escalator and elevator safety. Public awareness training includes reminding customers to take some simple, yet effective steps to stay safe. MARTA continually plays recorded messages over the PA system, advising patrons to hold handrails and be careful when entering and exiting escalators.

All agencies surveyed make extensive use of traditional and electronic communication methods to inform patrons of El/Es status and receive customer input. Effective communication is not always complex. Customers within CTA's rail system are informed of downed El/Es equipment via white dry erase board signs posted at each station, updated hourly by station attendants to keep customers informed. Customers can also access CTA's Internet site to receive real-time El/Es status and planned outages. BART uses an extensive communication network to inform patrons of El/Es status that in addition to an Internet website includes Really Simple Syndication feeds, Short Message Service, and message alerts via e-mail, text, and Twitter.

Excellent examples of receiving input from patrons include MARTA and BART, which participate in local ADA committee meetings to inform the disability community of El/Es activities and receive input from that community regarding public accessibility issues. MARTA also receives patron feedback through Facebook, Twitter, and the agency's website and customer service hotline. CTA staff logs in all El/Es-related calls, investigates them, and responds to every customer with an answer.

When El/Es equipment does fail and become inoperable, each agency provides alternative transportation in the form of buses equipped with a wheelchair lift or ramp, typically referred to as bus bridges. Understanding that bus service can be inconvenient and add extra trip time, CTA makes systemwide PA announcements to inform passengers to bypass an affected station and return to the intended station via the other direction where El/Es are operational.

CONTRACTING

Because MARTA contracts out all of its El/Es maintenance, the agency realizes that strict oversight and accountability are essential to a successful and productive relationship. Four in-house QEI-certified inspectors continually audit the contractor's work. If repeated failures are noted, MARTA will put pressure on its contractor to improve performance. Contract language calls for the contractor to provide training as needed. Although minimum maintenance staffing levels are established, MARTA's El/Es contract allows workers to be brought in as needed to meet workload demands.

CTA chooses to contract its elevator maintenance and repair, leaving in-house technicians dedicated exclusively to escalators. Here the contractor assumes all elevator liability and CTA maintains good communication with the contracted workforce. BART only contracts out El/Es work when the agency is overwhelmed with repairs. SEPTA's contracted services include elevator cab rebuild and renovation and escalator handrail replacement and vulcanization. Contractors also perform certain quality control functions at SEPTA. Contracting allows SEPTA to get certain jobs done in a timelier manner.

TRAINING

As mentioned in chapter two, BART, MARTA, SEPTA, WMATA, and NYCTA, along with their union partners, are part of a consortium to develop a national Transit Elevator/Escalator Maintenance Training and Apprenticeship Program. Participation in this consortium, which is being developed as a joint labor–management partnership, will provide each agency with a comprehensive training program consistent with nationally established training standards. The sharing of resources will allow member agencies to deliver training far superior to that which each agency could accomplish individually.

Lacking training aids such as labs and mock-ups, CTA compensates by relying more on OJT and mentoring. Bringing students out into the field gives them hands-on exposure to the actual equipment they will be working with on a regular basis. NYCTA provides employees with a series of 1- to 3-day courses offered on a monthly basis and uses training mock-ups to make that training more meaningful. SEPTA, a member of the El/Es consortium, is working on a 4-year training program using consortium materials in part to provide workers with additional code knowledge, field training, and case study exercises. BART, also a member of the El/Es consortium, has developed a library of comprehensive training materials that it uses to instruct its employees in a consistent manner and is included as a web appendix to this study. BART also reviews ASME A17 rules during weekly safety meetings with maintenance personnel.

SEPTA is currently working on a 4-year program to improve its training effectiveness, placing a stronger emphasis on providing additional safety code knowledge, field training and case study exercises. The agency is also in the process of acquiring actual elevator and escalator mock-ups to be used as training aids. MARTA shows that when maintenance is contracted, contract language needs to address training requirements.

DOING MORE WITH REDUCED BUDGETS

With all agencies facing budget issues, some are taking noteworthy steps to improve efficiency. To reduce travel and response time, BART assigns technicians to El/Es in close proximity to each other. Technicians also leave from and return to their route location instead of having to travel back and forth to an agency location, which often is far away from the El/Es they will be working on in a given day. BART also stores tools, equipment, and parts at most station locations to save travel time. The steps allow BART to significantly reduce maintenance and repair times. NYCTA houses its spare parts at three centrally located depots, also to reduce travel time by technicians.

Although CTA has been short six escalator technicians for 3 years, the agency has improved El/Es availability by researching reasons for downed equipment and improving its communication with other agencies to exchange information. SEPTA is concentrating more of its El/Es efforts on conducting more detailed PM to reduce unexpected breakdowns. The agency is also concentrating on problem El/Es equipment to reduce the likelihood of breakdowns.

PROACTIVE MAINTENANCE

Comprehensive and documented maintenance programs improve safety and increase equipment reliability. Proactive measures required to develop and document these programs ensure that employees perform maintenance and repair tasks in a like manner, a manner that the agency determines is the best based on OEM recommendations, its own experiences and conditions, and industry guidelines. While ASME A17 calls for a written Maintenance Control Program (Section 8.6.1.2.1), BART takes the requirement one step further by developing a comprehensive and well-documented version that serves as an excellent industry example. Although resources are needed to create and maintain such a system, BART feels the safety benefits more than justify the extra effort.

Although MARTA does not have in-house maintenance personnel, the agency is wise to employ four in-house equipment inspectors who audit contractor maintenance and equipment condition. Inspectors are all QEI certified, even though Georgia does not require the same certification for its state inspectors.

MMS is an essential tool for tracking maintenance activities and productivity. CTA uses such a system to generate reports that reveal equipment breakdowns, duration of those

breakdowns, and the root causes. Information generated from the MMS is used to adjust scheduled maintenance activities to reduce the frequency of unscheduled repairs. SEPTA uses its MMS to track repair activities and adjust spare parts inventories accordingly to ensure adequate parts availability. MARTA uses its MMS to track repeat failures on equipment. Based on the findings, MARTA requires the contractor to replace certain parts and take other actions at scheduled PM intervals.

Scheduling El/Es maintenance in advance of need is another proactive example of PM. CTA has seasonal PM programs in place that include making sure heaters are all working before the cold winter months arrive and checking the operation of vent fans before summer months. While all agencies have scheduled PM intervals based on local conditions and A17 and OEM requirements, MARTA goes further by requiring its contractor to consider the age of El/Es when developing PM intervals. NYCTA uses MMS data to replace certain parts before they fail; an elevator rope replacement at 5-year intervals is one such example. Analysis of handrail life has led SEPTA to institute a program to replace escalator handrails every 5 years.

CHAPTER FIVE

CONCLUSIONS

The findings show that effective maintenance of elevators and escalators (El/Es) is essential to providing safe and reliable vertical transportation services to rail customers. When equipment does fail, agencies need to respond quickly to make needed repairs, provide alternative transportation when necessary, and use a variety of communication approaches to inform passengers of El/Es status and transport options. El/Es outages disrupt passengers, especially those with disabilities who rely on that equipment the most to reach their desired station. Findings also convey a sensitivity that surrounds this topic, which stems in part from the attention and negative publicity agencies receive when passengers are inconvenienced by downed El/Es. Adding to this sensitivity is a sense one gets from interviewing El/Es personnel that despite the importance of providing safe and efficient vertical transportation, the significance of this is overshadowed by more traditional transit modes, where bus and rail vehicles are seen as more vital and appealing.

Findings from chapter two reveal that while agencies have publications available to them regarding safety codes from ASME, guideline specifications from APTA, and accessibility requirements through ADA, little is available to assist them deal with the many challenges they face in providing vertical transportation services in a public transit environment.

The in-depth case studies presented in chapter three clearly establish the challenges:

- Unique El/Es applications exist where passenger use and environmental conditions are more severe than with other building-type applications.
- Lack of equipment standardization within each agency coupled with aging infrastructure greatly contributes to increased failures and maintenance needs.
- Insufficient personnel and resources in some cases affect an agency's ability to adequately maintain and repair equipment.
- Shortage of training and related educational resources restricts technicians' ability to obtain needed knowledge and skills.
- Difficulty obtaining spare parts for some El/Es adds to the length of downed El/Es.
- Public nuisance problems where patrons purposely shut down equipment as a prank aggravates agency efforts to maintain El/Es availability.
- Added El/Es features greatly improve passenger safety but also contribute to the number of equipment shutdowns and inconvenienced passengers.

The case studies of chapter three point out that most agencies surveyed do the bulk of their maintenance and repairs in-house, while typically contracting out for major refurbishments and replacements. When services are contracted out, strict oversight by the agency is absolutely essential to ensure satisfactory contractor performance. In cases in which El/Es are maintained collectively by agency technicians (i.e., no specialists), knowledge and skills needed by those technicians are greatly increased. Not all agencies are required to have licensed and certified technicians but several are preparing them for certification through training. When developing technical specifications and planning expansions, input from technicians is essential.

Case studies also show that agencies are reluctant to provide, or do not have, information pertaining to unscheduled repairs and breakdowns, making it difficult to gauge their own performance. Additionally, chapter three shows that agencies use a variety of definitions to classify El/Es being unavailable for service, making performance comparisons between them difficult. While some agencies provide full maintenance coverage of El/Es equipment, others have more traditional work schedules, requiring them to call in workers when needed after normal business hours, which affects response time. Agencies also use a variety of measures to make prompt repairs as required by ADA and to inform passengers of downed El/Es equipment and alternative transportation.

Most important, the case studies featured in chapter three demonstrate that agencies understand their El/Es responsibilities and use a combination of fundamental and innovative procedures to carry out those responsibilities. Chapter four culls out the successful practices, which include

- Comprehensive and documented maintenance programs that adhere to ASME, ADA, and other local requirements and take into consideration original equipment manufacturer recommendations and local conditions;
- Asset management planning where the need for ongoing El/Es activities becomes an essential and integral agency function;
- Increasing preventive maintenance and inspections beyond those required by code to ensure public safety

as well as giving the agency added protection from costly injury settlements;
- Use of hands-on training and mentoring as an effective way to enhance technician knowledge and skill levels;
- Participation in a national consortium that will provide agencies with more comprehensive training programs where resources are shared on a joint labor–management basis;
- Improving worker efficiency by assigning them to geographic areas and storing tools and parts locally to reduce travel time;
- Using maintenance and repair data to seek the root cause of problems to reduce unintended failures and equipment downtime;
- Increased use of video surveillance to reduce public nuisance pranks and frivolous lawsuits; and
- Use of traditional and advanced communication systems to inform customers of El/Es status and alternative transportation services.

LESSONS LEARNED

Lessons learned from this synthesis study that could be of value to other agencies include the following:

- Upper managers and public officials need to have greater awareness of the specialized conditions and needs of those who maintain El/Es.
- Participation by all agency departments in the asset management process ensures that planning and budgets take into consideration life-cycle elements of ongoing maintenance and repairs, modernization, and replacements.
- Consider circumventing the need for El/Es during initial station design to reduce on-going expenses. If this is not possible, consider installing redundant equipment to improve accessibility when equipment fails.
- Effective maintenance improves El/Es availability and requires technician input and continual training. Monitoring is essential to benchmark and improve maintenance performance.
- Instituting a central data collection point for all downed equipment from several sources (e.g., patrons, technicians, station agents, etc.) provides passengers with accurate El/Es status information.
- Educating customers regarding proper use of El/Es and expanding the use of video surveillance improves safety and discourages public nuisance.

FUTURE STUDIES

Based on information collected from this synthesis, some suggestions are offered for future study. They include development of

- Standard definitions to monitor and measure El/Es availability nationally,
- Standard definition of "prompt repair" for all agencies to use that expands on the ADA definition,
- A process that transit agencies could use to determine appropriate staff levels needed to effectively maintain and repair El/Es,
- Guidance to assist agencies to effectively monitor contractor activities and performance,
- Additional El/Es standards,
- An expanded study to provide additional information regarding asset management plans, safety, communications, and use of universal designs, and
- An Internet forum where El/Es professionals can exchange information.

ABBREVIATIONS AND ACRONYMS

BART	Bay Area Rapid Transit
CTA	Chicago Transit Authority
EAM	Equipment Asset Management
El/Es	Elevators/escalators
MARTA	Metropolitan Atlanta Rapid Transit Authority
MMS	Maintenance management system
MRL	Machine-room-less elevator
NYCTA	New York City Transit Authority
OEM	Original equipment manufacturer
OJT	On-the-job training
O&K	Orenstein & Koppel (escalators)
OOS	Out of service
PA	Public address system
PM	Preventive maintenance
PMI	Preventive maintenance inspection
QA	Quality assurance
QEI	Qualified Elevator Inspector
RSS	Really Simple Syndication
SEPTA	Southeastern Pennsylvania Transportation Authority
SMS	Short Message Service
TRIS	Transportation Research Information Services
WMATA	Washington Metropolitan Area Transit Authority
WO	Work order

APPENDIX

Survey and Compilation of Agency Responses

Synthesis Questionnaire

Elevator and Escalator Maintenance and Safety Practices

Purpose of This Survey: As transportation facilities in the United States age, as well as face an increase in usage, the quantity of properly functioning elevators and escalators available for public use declines. Elevator and escalator (El/Es) outages reduce the confidence and limit the opportunities of passengers who rely on vertical transportation technology to access public transit. In addition, accessibility regulations highlight that continual availability of vertical transportation equipment is a core element of transit travel.

This questionnaire is intended to obtain in-depth information from various members of your agency to determine how maintenance actions, communication strategies, staffing assignments, and new technologies are implemented to provide safe and reliable El/Es operation to users in a cost-effective manner. Information gained from the surveys and other sources will be synthesized into a report that will serve as a useful source of information to your peers. Feel free to use additional pages and attach documents. **Thank you for completing this survey!**

Transit System Characteristics

Question 1
Elevator Details

Agency	Manufacturer	Type	Age (years)	Quantity
BART	MCE	Hydraulic	35	87
	MCE	Traction	35	44
	Montgomery	Traction	35	3
	Westinghouse	Traction	35	1
	Alimax	Traction	10	1
	US	Traction	35	4
Total				**140**
CTA	Mid-America	Traction and hydraulic	2-30	77
	KONE and Montgomery	Traction and hydraulic	3-28	20
	Anderson	Traction and hydraulic	7-32	19
	Reliance T	raction	19	11
	Otis	Traction	20	32
Total				**159**
MARTA	Westinghouse	Traction–4 Hydraulic–44	30+; most installed in late 1970s and early 1980s	48

	Dover	Traction–2 Hydraulic–30	15–30	32
	Schindler	Traction–4 Hydraulic–9	6–10	13
	KONE	Hydraulic	2–10	4
	CEMCO	Hydraulic	9–30	4
	US	Hydraulic	30+	2
	Mowrey	Hydraulic	15	2
	Montgomery	Hydraulic	30 and 13	2
	Otis	Hydraulic	30+	1
	Millar	Hydraulic	13	1
Total				**109**
NYCTA	Canton	Hydraulic	5	58
	CEMCO	Hydraulic	10.6	66
	MCE	Hydraulic	6.6	31
	Others	Hydraulic	20	11
	MCE	Traction	10.3	21
	Otis	Traction	23	5
Total				**192**
SEPTA	Unspecified	N/A		106
Total				**106**
Total all agencies				**706**

Question 2
Escalator Details

Agency	Manufacturer	Type	Age (years)	Quantity
BART	Westinghouse	48N and 38E	35	88
	Fujitec	PS-1200	13	28
	Montgomery	5E	35	26
	O&K	HD	15	19
	Otis	RB&J	35	6
	KONE	5TR	15	9
Total				**176**
CTA	Otis	RB	25	16
	Otis	ML	63	15
	Otis	506	28	8
	Otis	510	22	2
	Schindler		2–15	3
	Haughton		42	2
	KONE		3	16
	Montgomery		42	73
	O&K		18	18
	Fujitec		7	8
Total				**161**

MARTA	Westinghouse Modular 100	Modular	30+ years	117
	Montgomery	Conventional	15–23	10
	O&K	Conventional	25+	17
	Schindler	Conventional	7–11	5
Total				**149**
NYCTA	O&K	Conventional	13	84
	Fujitec	Conventional	6.5	34
	KONE	Conventional	4.1	27
	Otis	Conventional	22.5	24
	Schindler	Conventional	2.2	7
Total				**176**
SEPTA	KONE	N/A	2–13	37
	Fujitec	N/A	2–13	11
	ThyssenKrupp	N/A	1	2
Total				**50**
Total all agencies				**712**

Agency	Hours of Operation	No. Days per Week	Annual Passenger Usage
BART	20	7	100 million plus
CTA	24	7	200 million
MARTA	22	7	80 million
NYCTA	24	7	1.6 billion
SEPTA	16	7	321 million

Question 3
Percentage of Rail System That Is Accessible

Agency	No. Stations	% of System Accessible
BART	44	100%
CTA	144	70% (approx)
MARTA	38	100%
NYCTA	468	27% (approx)
SEPTA	156	N/A

Equipment Specifications

Questions 4–7

Agency	Specs. Developed by Agency or OEM?	Unique Elevator Requirements	Unique Escalator Requirements	Exceeding Useful Life Examples
BART	Agency specs.	- Hands-free phones beside hall call buttons - Cameras inside of all elevators - Remote monitoring system - Glass vision panels on elevator doors - Auxiliary oil recovery tanks for hydraulic elevators - Station agent booth controls and indications	- Remote monitoring systems - Escalator fault displays at unit and on controller - Increased step load requirements that exceed APTA guidelines	Yes
CTA	OEM	Sometimes a unique design must take place to be installed in subways.	Sometimes a unique design must take place to be installed in subways.	Yes; Escalators in service since 1943; parts must be custom-made.
MARTA	Agency specs.	None	None	Yes; Most of the 117 Westinghouse Modular escalators are well over 30 years old and have exceeded their useful life; modernization program now in progress
NYCTA	Agency specs.	Top of car safety curtains	Sleep mode, remote monitoring (Liftnet)	Yes
SEPTA	OEM	None	Deteriorated roller detection device	No

Question 5b
Willingness to Share Equipment Specifications with Others

Agency	Elevator	Escalator
BART	Yes	Yes
CTA	No	No
MARTA	Yes	Yes
NYCTA	Yes	Yes
SEPTA	Yes	Yes

Safety, Availability, and Customer Communication

Question 8
Legal Compliance and Lessons Learned

Agency	Code and Safety Compliance Procedures	Lessons Learned from Violations
BART	- Weekly quality control inspections - Weekly safety meetings - State-mandated conveyance certification classes on A17.1 for all mechanics - Yearly state permit inspections	State inspection violation regarding door zone locks being nonoperational caused agency to hold meetings to ensure mechanics were aware of A17.1 code requirements and why the rules needed to be followed. Also started to review A17.1 rules during weekly safety meetings.
CTA	- All inspectors are QEI certified and half of the escalator repairmen are licensed. - Safety department oversees compliance and performs audits. Three inspectors are state licensed and QEI to review compliance. Each area (i.e., blue line, red line, etc.) is audited twice per year.	OSHA, news reports, and company experiences.
MARTA	- All elevator and escalator maintenance and repairs 100% contracted. - To ensure that the contractor is complying with all applicable ASME and local codes, MARTA has four in-house QEI-certified inspectors on staff that routinely witness maintenance activities and perform random equipment assessments to audit equipment condition and code compliance. - MARTA's Safety and Quality Assurance Department also plays an active role in monitoring code and contract compliance. - MARTA's Test and Evaluation Department has one of the most stringent acceptance programs that utilizes both ASME and APTA code requirements for testing equipment. - MARTA has also hired an outside consultant to supplement the Elevator and Escalator Department staff and provide periodic full ASME A17.2 inspections on selected elevators and escalators throughout the year. - Each member of the Elevator and Escalator Department and supplemental staff has a safety responsibility, which includes performing accident investigations, assisting police, and reviewing video recordings. - Additionally, MARTA's Safety Department performs periodic safety audits on all work.	An escalator incident cuased agency to change from quarterly brake checks to monthly.
NYCTA	Inspection Team A17.1 for periodic and routine inspections	N/A

SEPTA	- Pennsylvania State Code A-17 is the principal standard governing SEPTA's elevator and escalator inspection and maintenance protocols—Code book is available at SEPTA's Bridge and Building Engineering (B&B) Headquarters. - Additional technical requirements are contained in OEM manuals for each machine and also retained at the field office. - Rigorous scheduled PM and inspections (PMI) program; see maintenance section for details. SEPTA personnel perform all daily and monthly elevator and escalator PMI, plus annual preventive maintenance. Additionally, qualified third-party contractor performs the annual state certifications. - SEPTA System Safety Department conducts annual safety audit. The internal audit scope includes: 1. Identify governing written SEPTA and/or industry standards for railroad (RRD) escalator/elevator inspections—and determine whether they are readily available and used. 2. Identify applicable written procedures (exclusive of standards) for performing inspections—and determine whether they are readily available and used. 3. Identify applicable written worksheets for performing inspections—and determine whether they are readily available and used. 4. Qualitatively review inspection documentation/worksheets—and determine if the documentation was appropriately completed and processed. 5. Identify applicable inspection frequency—and determine whether inspections are conducted in the timeframe specified by the Authority, and if a tracking mechanism was in place to ensure conformance. 6. Determine if inspection information is recorded/tracked electronically—and if the electronic data comport with the hard-copy documentation. 7. Determine whether physical plant records were centralized and secured in a reasonable manner.	Increased record keeping

Question 9
How El/Es Injuries Are Defined, Categorized, and Monitored

Agency	How El/Es Injuries Are Defined, Categorized, and Monitored
BART	"Entrapment" at BART refers to passengers stuck inside elevators. "Accidents" at BART refers to patrons who fell (injured or not) and passengers who had body parts, clothing, or personal items trapped in comb segments, skirts, handrails, etc.
CTA	Accident—for slips, falls, and injuries Detainment—for entrapments Down—for defective equipment Numbering system used to denoted status of El/Es: 1—equipment up 2—equipment down 3—construction 8—accident 9—detainment Daily report generated showing status of each El/Es
MARTA	Working to define
NYCTA	N/A
SEPTA	For National Transit Database: Code 09A = In station/bus stop associated with escalator Code 09B = In station/bus stop associated with elevator For FRA: Code C3 = On escalator (under location codes) Code A8 = In elevator (under location codes)

Question 10
How Agencies Define and Monitor El/Es Availability

Agency	Is El/Es Availability Monitored?	How Is Availability Performance Tracked?	How Is Availability Performance Defined?	How Is Equipment Counted When Down for Scheduled Repairs/Maintenance?
BART	Yes	Data Stream WO System soon to be replaced by MAXIMO Data Mangement System	"Uptime" at BART means that an elevator or escalator is available for use. "Downtime" at BART means that an elevator or escalator is not available for our patrons to use. Preventative maintenance, corrective maintenance, repairs, inspections, accidents, or entrapments all	Unavailable

			count against us and are considered as "downtime." Major capital improvements, however, do not count against "downtime."	
CTA	Yes	Through customer assistants placed and in charge of each station, calling in any defective El/Es to our Control Center. Then contacts (via radio) inspectors to dispatch personnel to repair.	Two availability systems are used. For internal agency use, only unscheduled repairs are counted as down and unavailable. Routine maintenance performed to equipment is counted as available. Tracking is done on the agency's Infor EAM system. For external purposes, any equipment not available for customer use is considered unavailable regardless of the reason. This status system is used to inform customers of unavailable El/Es.	Internal purposes: Available External purposes: Unavailable
MARTA	Yes	Currently by spreadsheet, but is not timely. Monthly status reports are not generated until the 2nd week of the following month. Working to track data electronically in MMS to generate real-time tracking and reporting capability.	Equipment is considered down any time passengers are unable to access it. Only exception is when equipment is down for long-term modernization upgrades.	Unavailable

NYCTA	Yes	Computer-based program generates reports on demand.	Equipment is considered down any time passengers are unable to access it.	Unavailable
SEPTA	Yes	Daily reports	Uptime: Equipment functioning and available for public usage. Downtime: Equipment not functioning and can not provide service for public usage.	Available However, repairs and annual inspections are marked as unavailable.

Questions 10e–f

Agency	Leading Causes of Equipment Unavailability	Ways to Improve Availability
BART	Comb impact faults are the number one reason for shutdowns. The duration of these calls is usually under 1 h. Analysis of these shutdowns indicates the safety device operated as intended and was usually caused by patrons running down the escalator and jumping the last few steps in an effort to board a train before the doors close. When they land on the comb plate, the safety device can't tell the difference between a patron becoming entrapped or jumping on it and shuts down the escalator.	Preventative maintenance procedures need to be performed at a higher standard. Mechanics require more time in the units and need to pay attention to all the details required to keep elevator and escalator subsystems running efficiently. Proper checking, lubricating, adjusting, cleaning, and replacement of worn parts month after month are required.
CTA	Door problems are leading for elevators; for escalators, comb impact. Stop button switches are troublesome for both, oftentimes used on purpose by passengers as nuisance. Sometimes thieves use these buttons to rob passengers.	Include inspectors and mechanics in meetings when the El/Es design phase begins for new or remodeling of stations. With the addition of new stations, consideration needs to be made that additional personnel is needed to meet these increased maintenance demands and to better satisfy code requirement inspections.
MARTA	Equipment age contibutes to increased failures and maintenance requirements.	Modernize the equipment.
NYCTA	Major repairs and maintenance events such as rope replacements, bearings, and head shafts.	Schedule overhauls and rehabs.
SEPTA	Malfunction of parts including soft-start and electrical circuit boards.	Field training (as oppossed to classroom learning) and improved component inventory

Question 11
Satisfying ADA Requirements That Accessibility Features Must Be Repaired Promptly

Agency	Agency Definition of Prompt Repairs to Satisfy ADA	Policies to Ensure Prompt Repairs to Satisfy ADA
BART	Per court-mandated agreement stemming from an ADA lawsuit, a mechanic must be dispatched within 1 h.	The installation of a trunked radio system, which works anywhere in the entire BART system, including all tunnels and underground rooms, allows us to immediately and without exception communicate with our mechanics to inform them of problems. This allows us to respond quickly and efficiently.
CTA	Respond immediately to accidents and entrapments; within 1 h for all other downed units.	Respond immediately to accidents and entrapments; within 1 h for all other downed units.
MARTA	The MARTA maintenance contract classifies elevators as either "critical" or "special" depending on their location and use (see definition below). For elevators designated as "special," work to repair the elevator and return it to service must begin immediately and crews will work 24/7 to return it to service. Special stations are defined as those that have only one elevator or are located at key stations (airport and center transfer station). All remaining elevators are classified as "critical" and carry the same requirements as those designated as "special" with the exception that work can be deferred until the start of the following day if approved by the Manager of Elevators and Escalators.	Oversight of contractor to assure work begins immediately.
NYCTA	Respond time to shutdown is 20 min. We have access 24/7 to parts and labor.	Adhere to 20-min response requirement.
SEPTA	N/A	N/A

Question 12
Accommodating Individuals with Disabilities When Equipment Is Out of Order

Agency	Procedures to Accommodate Disabled When El/Es Are Unavailable
BART	Paratransit bus service is set up between the affected stations when El/Es are out of service.
CTA	Paratransit bus service is set up between the affected stations when El/Es are out of service. Announcements are also made to inform passengers to bypass an affected station and return via the other direction where El/Es are operational.
MARTA	Bus bridges are put in place to transport patrons around affected stations.
NYCTA	Website can be used to notify customers that elevators are out of service (OOS) so they can make alternate arrangements. Station announcements are also made.
SEPTA	Out-of-order display at cashier booths and in front of the equipment, safety barriers, and SEPTA's information website.

Question 13
Communication Procedures

Agency	Communication Procedures When Equipment is Unavailable	Other Information Communicated	Educating Passengers About El/Es Usage
BART	- Electronic outage signs at the entrance of all stations - Anouncements over the PA system - Online services also indicate where and for how long elevators are unavailable or are currently being rehabbed. - Online services include BART's Internet website, RSS feeds, SMS, e-mail and text message alerts, and Twitter.		
CTA	- Internet - 1–800 phone status report line - Posted signs - TV monitors at 40% of the stations	A white dry erase board is in every station showing the status of our elevators. Customer service agent at each station keeps it updated.	Signs posted at each unit.
MARTA	- PA announcements at stations - Operator messages on trains and buses - MARTA website (only when equipment is out of service for extended periods) - Appropriate signage at station entrances	There is also a scrolling message board at most stations that can post El/Es information as appropriate.	There are recorded messages that play at regular intervals on the PA system that advise patrons to hold handrails, be careful entering and exiting the escalators, etc.
NYCTA	Website—We provide customers a website where they can view the current list of elevators OOS.		Signage, elevators, and participation in Escalator Safety Foundation, which helps provide needed information that allows NYCTA to conduct customer outreach El/Es safety activities at stations.
SEPTA	- Out-of-order display at cashier booths and in front of equipment - Safety barriers - SEPTA information website		Awareness training conducted at stations and schools

Questions 13c–e

Agency	Customer Communication Methods to Agency	Typical Customer Communications to Agency	Agency Response to Customer Communications
BART	A disability task force consisting of all types of disabled patrons meets once a month to discuss these problems. BART staff also bring them up to speed on future and ongoing projects.	- Dirty or smelly elevators - Elevator doors not operating properly (too slow, too fast, don't fully open or slam closed) - Major repairs on escalators take too long to complete	Phone calls, e-mails, or letters with explanations or departmental analysis to see if changes or improvements need to be made
CTA	E-mail or phone	(1) Questioning why El/Es are down; (2) asking how soon equipment will be operational (often equipment is purposely put out of service because of overload concerns at major events, but occasional patrons do not realize this)	CTA staff receive and log in each call, investigate, and respond to every customer with answer.
MARTA	A community ADA committee external to MARTA meets regularly throughout the year to address public accessibility issues including vertical transportation. MARTA staff attend these meetings. In addition to this venue, patrons including our patrons with disabilities can provide feedback through Facebook, Twitter, our website, and a customer service hotline.	(1) Reports of equipment thought to be out of order; (2) escalators not running in a direction that is deemed convenient for them (i.e., one direction in the morning and the opposite in the afternoon; (3) elevators not functioning at every corner of the station.	Complaints are routed to the appropriate manager who is responsible for that area of concern from Customer Service. Issues are investigated and responses are routed back to Customer Service for discussion with patron or group.
NYCTA	Phone lines, e-mail, and website	All of above	E&E investigates and answers through Customer Relations Department.
SEPTA	Through cashier booths, service desk, phone, and SEPTA website	Malfunction complaints, equipment takes too long to become operational again	Customer Service group issues a complaint ticket to the responsible department, which will investigate the issue, correct the problem, and then report back to Customer Service to close the work order. Customer

			Service group will correspond to the customer if customer left contact information.

Question 13f

Agency	Steps Needed to Improve Customer Communication
BART	N/A
CTA	I think we do a good job. Each call is followed-up with an answer.
MARTA	Real-time web status (current system only provides info on long-term outages)
NYCTA	N/A
SEPTA	Centralize the video camera system and link to the Customer Service Department to provide real-time display.

Personnel

Question 14
Agency Use of Specialists or Generalists for El/Es Maintenance and Repair

Agency	El/Es Technicians as Specialists or Generalists
BART	Generalists—work on both El/Es
CTA	Specialists—Escalators are mostly taken care of in house. Elevators are maintained by an outside contractor.
MARTA	Generalists—work on both El/Es
NYCTA	Generalists—work on both El/Es
SEPTA	Generalists—work on both El/Es

Question 15
Services Contracted Out to Vendors or Third-Party Service Companies

Agency	Contracted Services (Y/N)	Scope of Contracted Services	Number of Personnel Involved
BART	Yes	Perform all maintenance, inspections, repairs, minor projects, and some overhauls in house. Contractors are called in only when the agency is overwhelmed with repairs. Major overhauls are also contracted to the lowest bidder.	PM: N/A Repairs: Overhauls: Replacements: Quality control (QC):
CTA	Yes	Elevators are maintained by an outside contractor. Maintenance and inspections are done on a monthly basis.	PM: 6* Repairs: 2* Overhauls: as needed Replacements: as needed QC: None by contractor; 2 in house (*Additional personnel requested by CTA due to weather and special conditions as called for in the contract.)

MARTA	Yes	MARTA has 100% contract services for preventative maintenance, repairs, and all work done on the agency's vertical transportation equipment. The agency also has a separate contract for its modernization project. At this time both contracts are held by Schindler.	General Maintenance PM and repairs: Min 16 per contract, 18 typical, others brought in as needed to meet contract requirements QC: 2 Other: 1 Superintendent Modernization/Replacements MARTA has a separate contract for a modernization project regarding the aging Westinghouse Modular escalators. About 14 technicians are dedicated to this project; more are brought in when needed. MARTA is also planning to replace all of the O&K escalators under contract since parts availability has become a critical issue.
NYCTA	No	N/A	N/A
SEPTA	Yes	Contract services include elevator cab rebuild and renovation, and escalator handrail replacement or vulcanization. Contractors also perform quality control functions.	PM: 0 Repairs: 1–2 Overhauls: team Replacements: 1–2 QC: 1–2 (for state inspections)

Questions 15c–e

Agency	Satisfied with Subcontracting (Y/N)	Subcontracting Advantages	Subcontracting Disadvantages
BART	Yes. Contracts usually involve an OEM, so quality is good and callbacks infrequent	Helps to get units back into service in a timely manner	- Slow to respond to our needs - Expensive compared to in-house service - Poor communication of repair details
CTA	Mixed	Contractor assumes all liability; good communication	Costly. Agency also has to provide oversight, make sure that correct and quality parts are being used. Also had to inform contractor of special conditions that exist in transit, more severe than typical applications.
MARTA	Yes	In MARTA's maintenance agreement, all liability is transferred to the contractor.	None, the contract is working well.
NYCTA	N/A		
SEPTA	Can always be better	Jobs done faster	Budget issues (additional cost)

Question 16
In-House Technician Breakdown: When El/Es Are Maintained Collectively

Agency	Total In-House Technicians
BART	PMI and light repairs: 23 Repairs: 5 Overhauls: (contracted) Replacements: (contracted) Quality control: In-house El/Es managers Other: Total technicians: 28 Total El/Es: 316 Ratio: 1:11.3 Es/El
CTA	N/A – maintained separately
MARTA	(all contracted) PMI and repairs: 18 + 3 in-house oversight = 21 Total technicians: 21 (excluding modernization) Total El/Es: 258 Ratio: 1:12.3 El/Es (additional staff brought in as needed)
NYCTA	PMI: 124 Repairs: 37 Overhauls: 23 Replacements: 0 Quality control: 12 Other: 50 Total technicians: 246 Total El/Es: 368 Ratio: 1:1.5 El/Es
SEPTA	PMI and repairs Total in-house technicians: 30 Total El/Es: 156 Ratio: 1:5.2 El/Es

Question 16b
In-House Technician Breakdown: When El/Es Are Maintained Separately

Agency	Total In-House Elevator Technicians	Total In-House Escalator Technicians
BART	N/A – maintained collectively	N/A—maintained collectively
CTA	Elevators: contracted PMI: 6 Repairs: 2 Quality control: (2 in-house) Total technicians: 10* Total elevators: 159 Ratio: 1:16 El/Es (*Additional personnel brought in when needed)	Escalators: in-house PM and repairs: 20 Quality control: Total technicians: 20 Total escalators: 161 Ratio: 1:8 El/Es

MARTA	N/A	N/A
NYCTA	N/A	N/A
SEPTA	N/A	N/A

Questions 17–19
Work Schedules

Agency	Work Schedule	Are Activities Targeted Off-Peak (Y/N)	Do You Have Sufficient Personnel (Y/N)
BART	Hours per day: 27 Days per week: 7 Number of shifts: 3 Shifts rotate to provide 24/7 coverage	No	No The ratio of units to mechanic is too high.
CTA	Hours per day: 8 Days per week: 5 Number of shifts: 1 Same schedule for both in-house and contracted workforce. Weekends: workers brought in if 15% or more equipment is down.	No	No Due to age of escalators, more heavy repairs are needed.
MARTA	Hours per day: 12 Days per week: 5 Number of shifts: 2 (overlapping) Contract requires 90-min response time on all El/Es; technicians therefore must be on-call during weekends (repair of certain classification El/Es can be deferred pending MARTA manager approval).	Yes Scheduled maintenance on all "special" units must be done betwwen the hours of 2:00 a.m. and 6:00 a.m.	No
NYCTA	Hours per day: 24 Days per week: 7 Number of shifts: 3	Yes	Yes
SEPTA	Hours per day: 8 Days per week: 5 Number of shifts: 1–2 Weekend work assigned by managers as needed to on-call technicians at overtime rates.	Yes	No Not enough technicians working between PM, inspection, testing, maintaining, and repairing. Also, only 1.5 engineering staff assigned to El/Es—need to double or triple engineering resources.

Question 20
Doing More with Reduced Budgets

Agency	Activities Taken to Accomplish More With Less Staff and Resources
BART	- Cut down travel time by assigning mechanics to equipment next to each other or very close by. - Storage of tools, equipment, and parts are at most stations. - Each mechanic reports to and leaves from his/her route location.
CTA	In-house escalator staff down six technicians for 3 years now due to budget restraints. Despite the shortfall, agency seeking to improve El/Es uptime by researching reasons for downed equipment and improving its communication with other agencies to exchange information.
MARTA	Unusual condition for MARTA in that they are ramping up to build an effective in-house department to oversee contract services, conduct performance audits, and oversee modernization/equipment replacement projects.
NYCTA	Created specific checklists and procedures based on specific El/Es equipment to replace generic PM approach where one set of documentation was used to guide all PMs. Technicians were given more time to do PMs based on the revised approach. Also concentrating on problem machines based on data generated from MMS.
SEPTA	Concentrate more on the detailed PM and planning to reduce unexpected breakdowns and long lead-time items

Question 21
Work Assignments

Agency	Workers Assigned to Specific Tasks vs. Working on All Jobs Equally
BART	Technicians work on all jobs equally.
CTA	Technicians work on all jobs equally.
MARTA	MARTA's contract is performance based, calling for contractor to maintain and repair equipment as needed. Therefore, MARTA does not want to be in a position to dictate how technicians perform their assignments.
NYCTA	Technicians work on all jobs equally. All Maintainers have the same Civil Service status.
SEPTA	Technicians work on all jobs equally.

Question 22
Training

Agency	Available Training (Y/N)	Training Program Description[a]
BART	Y	
CTA	Y	For new installations, training provided by vendor. In-house training is limited, but most effective is OJT and mentoring. Lack of training aids such as mock-ups makes it difficult to do classroom training because equipment is so detailed and complex. Students really need to work with it hands-on, so bringing them out into field and providing instruction on actual equipment works best.

MARTA	N/A	MARTA's contract is performance based, calling for contractor to maintain and repair equipment as needed. Therefore, MARTA does not want to be in a position to dictate how technicians become qualified. The responsibility falls on the contractor to provide training.
NYCTA	Y	The following classes are given once a month: 1. Hydraulic Valve Body: 3 days 2. Introduction to Electrical Schematics Basic: 3 days 3. Elevator Door: 3 days 4. Escalator Maintenance: 2 days 5. Hydraulic Elevator Maintenance: 1 day 6. Traction Elevator Maintenance: 1 day Agency also has a training mock-up of a running escalator and mock-ups of key elevator components such as doors.
SEPTA	Y	Working on a 4-year training program with emphasis placed on providing additional code knowledge, field training, and case study exercises. SEPTA has a training center and training program (Preventive Maintenance and Repairs) for elevators and escalators. In addition, SEPTA currently is purchasing one escalator and one elevator for training purposes.

[a]Surveyed agencies are also participating in an El/Es Training Consortium where the cost and resources needed to develop comprehensive training are being shared by all parties with financial assistance provided by FTA.

Questions 22b and 22c
Training Adequacy

Agency	Adequate Training Provided (Y/N)	Needed Training Improvements
BART	Y	Participating in the El/Es Consortium will provide BART and others with nationally accepted apprentice program, State License Accreditation, and consistent training of existing mechanics.
CTA	N	Include in-depth electrical print reading, troubleshooting, and mechanical maintenance and adjusting equipment to specification tolerances. Additional hands-on training is greatly needed.
MARTA	N/A	N/A (Contractor's responsibility)
NYCTA	N	Maintainers do not receive the level of training needed to repair NYC Transit elevators and escalators. This is due to the vastly different types of controllers and electrical systems throughout Transit. Maintainers will require additional training and material. To improve training, more training aids and mocks-up are required.
SEPTA	N	Need more code knowledge, field training, and case study excercises.

Question 23
Certification and Licensing

Agency	Required Licensing (Y/N)	Requirements and How Licensing/Certification Achieved
BART	Y	Certification is run by the state, which requires a 2-year re-certification course administered by the state
CTA	N	Licensing will be required in near future, so CTA is increasing its training to prepare technicians for state licensing requirement.
MARTA	Y	MARTA does not have in-house maintenance personnel but they do have 4 in-house equipment inspectors that audit contractor maintenance and equipment condition. These inspectors are all QEI certified even though Georgia Department of Labor does not require certification for their state inspectors. Regarding the contractor's technicians, the state of Georgia requires all El/Es technicans to be licensed through testing and recertification.
NYCTA	N	Some supervisors are QEI certified.
SEPTA	N	SEPTA's training program will be used to prepare technicians for certification once we complete the Transit Elevator and Escalator Training Course materials being developed under the consortium.

Maintenance

Questions 24 and 27
Documented Maintenance Program

Agency	Do You Have a Document That Describes Overall Maintenance Program (Y/N)	If Yes, Are You Willing to Share a Copy of That Program with Peers?	Documents that Guide PMIs, Repairs, and Overhauls (Y/N)	If Yes, Are You Willing to Share with Peers?
BART	Y	Y	Y	Y
CTA	Y	N	Y Time standards being considered for basic jobs	
MARTA	Y The contract documents state that OEM recommendations of inspections and appropriate intervals must be followed and all ASME code and state requirements must be met. Additionally, MARTA requires increased inspection frequency on all safety devices and brakes for escalators.	Y	The contract documents with contractor stipulate inspection, maintenance, and audit frequencies as well as provide basic check charts that stipulate minimum inspection and maintenance requirements. Specific guidelines and procedures are by the contractor.	
NYCTA	Y	Y	"Five or More Outages" defined as an elevator or escalator that is down five or more times in a week are investigated; PM schedule and procedures are then	Y

			adjusted to reduce breakdowns. PM program is now tailored for each type of El/Es instead of using generic approach.	
SEPTA	Y	Y	Y Have documented PMI intervals, procedures, and checklists. Repairs are based on OEM instruction manual. Time standards are not included.	Y

Question 25a
Maintenance Management System (MMS)

Agency	Type of MMS Used	Last Time Changed
BART	- Presently using Data Stream Work Order System - Changing over soon to MAXIMO Data Management System - Changing to gain a systemwide data management system and better analysis of shutdowns by capturing more data	- Yearly review - When new equipment comes onboard
CTA	All work orders entered into EAM system, reports generated by human resources. Reports include: - How many times equipment was down, - How long the equipment was down, and - Root causes of specific problems.	July 2010 when CTA changed to adhering to 2007 version of ASME A17
MARTA	MARTA uses FASuites, which is a MMS program operating on an Oracle database platform. Before 2011, elevators and escalators were not included in the program since they were not maintained internally. The agency has since entered all equipment into the system and all callbacks and scheduled and unscheduled maintenance are entered into the system to help track outages and their respective causes. An enhanced MMS system is being planned.	During the last contract cycle, which was placed out to bid in September 2010.
NYCTA	Microsoft-based system provides historical repair data on each El/Es and generates reports according to need.	March 2011
SEPTA	Review work orders and quantify the results to the categories as needed	March 2011, updated every 2–3 years.

Questions 25b and 25c
MMS Applications

Agency	Use of Data to Support Decision Making	Maintenance Program Changes Made as Result of MMS Data
BART	- Monthly reviews of reason for repairs.	
CTA	N/A	N/A
MARTA	MARTA uses FASuites, which is a MMS program operating on an Oracle database platform. Before 2011, elevators and escalators were not included in the program since they were not maintained internally. We have since entered all equipment into the system and all callbacks and scheduled and unscheduled maintenance are entered into the system to help track outages and their respective causes.	Just starting the process; insufficient data available to comment at this time.
NYCTA	Data are used to identify reoccurring problems and adjust scheduled PM activities to minimize future unscheduled problems and breakdowns.	Developed PM checklists and procedures based on specific equipment
SEPTA	Handrail breakdown period vs. handrail inventory level	Due to short handrail life, SEPTA is working to replace the handrail every 5 years. Vandalized handrails are replaced immediately.

Question 26
Proactive vs. Reactive Maintenance

Agency	Proactive or Reactive Maintenance?	Explanation
BART	Proactive	PM is our core business.
CTA	Proactive	CTA goes through PM inspections to help them to understand problems and adjust maintenance program accordingly. Seasonal PM programs in place. Winter: heaters are all working by October. Summer: make sure vent fans are operational before warm weather arrives.
MARTA	Proactive	While overall approach is to be proactive, reality is such that there will always be times when reactive maintenance is needed.
NYCTA	Proactive	The purpose of PM is to try to prevent problems.
SEPTA	Proactive	The idea of PM is to prevent/avoid the breakdown situation.

Question 28
Elevator PM Intervals for Inspections

Agency	Elevator PM Inspection Intervals and Activities
BART	Monthly Bimonthly Quarterly Semiannually Annually (see detailed schedule of activities)

CTA	Detailed inspection and PM activities performed monthly.
MARTA	Contract calls for a minimum requirement of monthly maintenance. Contractor, however, is required to consider age of equipment, OEM recommendations, and ASME requirements.
NYCTA	Routine and periodic interval: PMs at 4, 6, and 8 weeks
SEPTA	Daily Weekly Monthly Annually

Question 28b
Escalator PM Intervals for Inspections

Agency	Escalator PM Inspection Intervals and Activities
BART	See sheets.
CTA	Daily visual inspection: as many units as can be inspected in a day; within a month each unit is inspected. Monthly PM: inspection and lubrication Yearly: Comprehensive inspection and servicing
MARTA	Contract calls for a minimum requirement of monthly maintenance. Contractor, however, is required to consider age of equipment, OEM recommendations, and ASME requirements.
NYCTA	Type I, II, III, IV, and V interval: 4, 6, and 8 weeks Repairs: Step chain replacement interval: 10 years
SEPTA	Daily Weekly Annually

Question 28c
Equipment Overhauls and Replacement Plans

Agency	Equipment Overhauls and Replacements
BART	
CTA	CTA wants to replace 52 units within 5 years to get the oldest equipment out of service. Getting parts is difficult with older units, which increases maintenance requirements and downtime.
MARTA	Most of the 117 Westinghouse Modular escalators were installed in the mid-1970s and early 1980s. With that age well over 30 years, they have exceeded the useful life of the equipment and, as a result, MARTA has aggressively pushed an escalator modernization program that has the first phase of 30 units 50% complete and the second phase of 30+ units getting ready for release in the coming fiscal year.
NYCTA	Rope replacement interval: 5 years Escalator replacements: 25–35 years
SEPTA	Some units replaced in house, others contracted out.

Question 29
Establishing Maintenance Intervals

Agency	Procedure for Establishing Intervals	Solicit Technicians' Input (Y/N)	How Legal Requirements Are Integrated
BART	OEM recommendations	Y	Follow OEM recommendations and ASME codes
CTA	Code, local experiences, OEM recommendations	Y	Follow OEM recommendations and ASME codes
MARTA	A consultant to MARTA has started to track repeated callbacks on equipment. Based on the findings, MARTA will require the contractor to replace certain parts and take other actions at scheduled PM intervals.	Y	
NYCTA	ASME A17, age, rise of equipment (length), location, usage, and OEM recommendations	Y	ASME A17
SEPTA	A combination of ASME A17, OEM recommendation, and local experiences	Y	ASME A17

Question 30
Scheduled Maintenance vs. Unscheduled Repairs

Agency	Is There a Distinction Made? (Y/N)	Is It Monitored? (Y/N)	Performance Measures
BART	Y	Y	
CTA	Y	Y But not as much as needed	Information can be obtained from worker time sheets; starting to track it more closely.
MARTA	Y	Y	None, but if repeated failures are noted, MARTA will put pressure on contractor to improve performance.
NYCTA	Y	Y	Reporting flexibility allows agency to view several performance measures such as downtime due to repairs and PM, length of PM and repairs, response time, etc.
SEPTA	Y	Y	No report on the ratio of scheduled and unscheduled

Question 31
Maintenance Costs

Agency	Classify Costs by Parts and Labor (Y/N)	Classify Costs by Asset Type (Y/N)	Cost Details
BART	Y	Y	
CTA	Y	Y	CTA pays contractor for labor based on set hourly rate, and for major parts (marked up an estimated 20% or more). Contractor pays for small item parts. Warranty costs picked up by OEM. Regarding in-house costs for escalators, CTA stays within allotted budget. Each WO has cost breakdown, but agency simply does not have the personnel to track costs very closely.
MARTA	N	N/A	N/A
NYCTA	Y	Y	N/A
SEPTA	N	N	N/A

Question 32
Quality Assurance

Agency	QA Measures to Determine Correct Maintenance	Who Conducts QA	How Often QA Conducted
BART		In-house	
CTA	Engineering group and QEI inspectors oversee both in-house escalators and contracted elevators; they also conduct acceptance testing.	In-house	Twice every 6 months and periodically
MARTA	In-house staff of four QEI inspectors ensure the contractor is complying with all applicable ASME and local safety codes.	In-house	Rigorously throughout the year
NYCTA	Supervisors verify technicians' work; engineering staff conducts audits on a periodic, random basis.	In-house	Daily
SEPTA	New equipment acceptance test and ASME/PA state requirement	Contracted	New equipment acceptance test and ASME/PA state requirement

Question 33
Spare Parts

Agency	Spare Parts Ordering Procedures	Enough Parts Kept in Inventory (Y/N)	Missed Repairs Due to Lacking Parts (%)	Steps to Improve Parts Availability
BART	Automatic reorder system based on preset minimum quantities	Y		
CTA	Recommendations made by foremen and inspectors	Y and N In some cases can't keep parts on hand due to high cost (e.g., a rotor costing $12,500 took 2 weeks to arrive from Germany, causing the equipment to be down the entire time).	About 2%. Some escalators in service since 1943 require that some parts be custom made.	More frequent inspections would allow technicians to note parts that will need replacement so parts can be ordered in advance of failure.
MARTA	All maintenance is contracted and all parts are purchased by the contractor.	Contractor is required to maintain parts inventory, but MARTA realizes it must understand in cases involving O&K where the company has gone out of business and finding parts is difficult or impossible.	Not tracked currently; hope to implement capability with new MMS.	
NYCTA	We forecast spare parts and store them in three central satellite locations.	Y	Not known	Standardized equipment
SEPTA	Based on the OEM recommendation and local experiences	N Spare parts are based on the most common wear parts only.	Not known	Risk assessment

Question 34
Improving Maintenance Effectiveness

Agency	Steps Needed to Improve Maintenance Effectiveness
BART	PM procedures need to be performed at a higher standard. Mechanics require more time in the units and need to pay attention to all details required to keep elevator and escalator subsystems running efficiently. Proper checking, lubricating, adjusting, cleaning, and replacement of worn parts month after month are required.
CTA	Installing new equipment after 30–40 years.
MARTA	MARTA is still in the early stages of building an oversight department, which is a slow-moving process. The agency is confident that when it is up and running it will be among the best in the industry.
NYCTA	PM schedule redesigned in March 2011 to account for specific equipment to replace generic approach
SEPTA	More knowledgeable technicians and training program

New Technology

Question 35
New Technology Impact on Equipment Availability

Agency	Examples of New Technology Impacts on Availability	Impact Monitored (Y/N)	Details
BART	Requires more maintenance	Y	
CTA	More safety features translate into more maintenance requirements.	N	Estimates that a minimum of 20% additional time is needed for maintenance and repairs.
MARTA	As older Westinghouse Modular escalators are modernized, the number of safety devices essentially doubles from 10 to 20 devices. With that increase in safety devices, the number of shutdowns will also increase. We are collecting data to compare the number of shutdowns pre- and postmodernization to correlate the relative change in shutdowns. We are also beginning to track the change in incident reports on the units.	Y	Comb impact device is especially troublesome at airports due to passengers boarding with heavy luggage. Skirt deflection switch also troublesome due to school-age children purposely activating it to shut down escalator as prank.
NYCTA	Liftnet, a remote equipment monitoring system, provides real-time status of breakdowns, which reduces response time.	Y	Agency can monitor uptime, downtime, time spent on repairs, fault codes, entrapments, response time, and other information from central, remote location.
SEPTA	Planning to install a centralized monitoring system	N/A	N/A

Question 36
Familiarizing Technicians with New Technology

Agency	Steps Taken to Familiarize Technicians with New Technology	Technician Ability to Work on New Technology (Y/N)	Other Comments
BART	Per every contract, all new equipment manufacturers are required to perform training.	Y	
CTA	On-the-job training and seminars provided by OEMs, which is written into contract. OEMs provide manuals and specified amount of training.	Y	Have selected a quality group of mechanics.
MARTA	N/A – Contract requirement	N/A	N/A
NYCTA	Contractual training and in-house training	N	More training is needed. Having hard time finding qualified and experienced El/Es technicians.
SEPTA	Through OEM company training when we have new equipment before acceptance test.	N	Need a better way to approve and monitor the OEM company training.

Questions 37 and 38
New Technology Contributions

Agency	New Features That Have Improved Maintenance	New Features That Have Improved Customer Experiences
BART	- Equipment fault displays - Remote monitoring systems	N/A
CTA	Code and fault recorders are helpful for troubleshooting.	- Escalators have more lighting. - El/Es have more safety devices.
MARTA	The modernized escalators have fault code capability, something that older equipment did not have. This new feature allows technicians and managers to see the type of faults that are occurring and respond accordingly. Codes help direct technician to problem.	Availability on the older equipment was suffering due to its age; modernization of equipment revitalizes the stations. The increased safety devices automatically shut down equipment to dramatically improve patron safety.
NYCTA	Liftnet	Intercoms, escalator electronic signs
SEPTA	N/A	N/A

Abbreviations used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation