REPORT

OF THE

AMERICAN PUBLIC TRANSPORTATION ASSOCIATION

PEER REVIEW PANEL

FOR

MEMPHIS AREA TRANSIT AUTHORITY

Memphis, TN

A Service of the Safety Management (Peer Review) Program of the American Public Transportation Association

REPORT

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ON

TROLLEY FIRES

AT THE

MEMPHIS AREA TRANSIT AUTHORITY

Published by the
American Public Transportation Association
1666 K Street, NW, 11th Floor
Washington, DC 20006
Michael P. Melaniphy, President & CEO

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Executive Summary

The Memphis Area Transit Authority (MATA) is a public transportation provider for the Memphis area. They transport nearly 11 million riders a year in the City of Memphis, other parts of Shelby County, and the City of West Memphis on fixed-route bus, para transit, and vintage rail trolleys.

As a recipient of federal funds, the Memphis Area Transit Authority (MATA) has the responsibility to use prudent practices in its operating and maintenance practices and purchasing activities. The procurement of quality products, cost-effective equipment, and services is a high-priority for the agency.

The vintage trolley service operates on three lines: Madison Avenue Line - 2.5 miles; Main Street Line - 2.150 miles; and the Riverfront Line – 2.350 miles. **See Appendix 1 - System Map**

MATA has four modern design traction power sub stations. Two large ones on the Madison Avenue Line and two smaller ones the Main Street Line. Each supplying 600 Volts dc to the overhead catenary systems for all three trolley lines. These sub stations have event recorders and it appears that during the time the trolleys caught fire, the equipment functioned as designed. The trolleys do not have event recorders.

Between November 2013 and April 2014, MATA experienced two major trolley fires both operating on the Madison Avenue Line. The two trolley fires on #452 and #553 occurred on November 4, 2013 and April 7, 2014 respectively and were completely destroyed. **See Appendix 2 and 3 - Summary of the incidents and photos of trolleys #452 and #553.**

The incidents occurred on the eastbound Madison Avenue Line as shown below:

- Trolley #452 on I-240 overpass bridge just west of Bellevue.
- Trolley #553 on Danny Thomas overpass bridge.

In April, Mr. Thomas D. Fox, Interim General Manager, for the Memphis Area Transit Authority (MATA) requested the American Public Transportation Association (APTA) to perform a peer review to help determine the cause of the recent fires on two vintage trolleys #452 and #553. **See Appendix 4 - Letter of Invitation from Memphis Area Transit Authority (MATA) Interim General Manager Tom Fox dated April 11, 2014.**

Both trolleys (#452 and #553) were from Melbourne, Australia and believed to have been manufactured in the 1920's and refurbished by MATA contractors between 1997 and 2002. These two trolley fires occurred on the Madison Avenue Line, one of three lines serving the downtown and Medical Center areas of Memphis.

After the April 7, 2014 fire, the trolley service on the Madison line was suspended and replaced with a bus service until it can be determined the cause of the problem and corrective actions can be taken.

Through discussions between APTA and Agency staff, it was determined the review would be conducted June 3 – 6, 2014. A panel of industry peers was assembled that provided expertise in vintage rail trolley operations and maintenance especially involving the Melbourne-type trolley vehicles.

Through the combined benefits of on-site interviews with MATA staff, review of relevant documents, and field observations the panel concluded its review with an oral report of its summary of observations and recommendations to MATA senior management which included Tom Fox (Interim General Manager), Alvin Pearson (Assistant General Manager), Don Forsee (Director of Rail Operations) and others.

The peer review team concluded that the primary cause and other possible contributory factors for the fires are as follows:

Primary cause:

a) A failure within the motor control circuit.
b) A fault in the propulsion system, which generated a current overload.
c) A defective line breaker which failed to protect the controller resulting in a severe flashover setting the trolley cars on fire.

Possible contributing factors:

a) Trolley cars were found not to be in compliance with the APTA Standard for Vintage/Heritage Trolley Equipment (*APTA SS-HT-001-05)* released on June 20, 2005.
b) Additionally, certain modifications, were done with no evidence of compliance with MATA's SSPP.

At the conclusion of the review, the team summarized their findings and made two primary recommendations:

- **Short term corrective actions (see also Section 5.1)**
  a. Suspend all trolley services.
  b) Use alternative vehicles to operate revenue service.
  c) Inspect, repair and certify a minimum of five trolley cars for revenue service.
  d) Update SSPP processes as needed to ensure implementation; training; documentation and quality assurance is adhered.
  e) Update staff skill sets to match daily requirements for vehicle checks.
  f) Tennessee DoT to perform a readiness review to certify a partial opening of the system.
  g) MATA to consider procuring the services of an industry peer review to assist in this process.

- **Long term corrective actions (see also Section 5.2)**
  a) MATA to seek resources for total fleet overhaul or replacement.
  b) Assure the continued use and implementations of the provisions of the SSPP and accompanying documents, thereby ensuring system safety at ALL levels of the organization.
  c) Initially, conduct a frequent internal audit of recordkeeping to assure that all operations, maintenance and procurement personnel are following the SOPs as regards reporting and vehicle configuration management.

The panel expressed their concern and emphasized that unless these causes are corrected, fires ***WILL*** *happen again. Furthermore, it was conveyed to MATA management that there could be trolleys currently operating on the lines which could catch on fire at any given moment.*

In response to these recommendations, MATA suspended its trolley service for the Main Street Line and Riverfront Line on Tuesday June 11, 2014 and replaced it with a bus service. Service for the Madison Avenue Line was previously suspended after the April 2014 fire.

The panel commends MATA on efforts undertaken to keep the trolley service operational. This is attributed to the dedication and resourcefulness of staff and their loyalty to MATA.

MATA is proactively working to procure the services of experienced industry consultants and contractors to assist in training their staff. They are also working on other system wide issues related to documentation, training, re-certification, repairs of trolleys, etc. in order to expedite the return of the trolleys to revenue service.

The peer review team also commends MATA for taking this difficult and bold step but one that is vital for the safety of their employees and customers.

Members of the review team are appreciative for the opportunity to be of assistance to MATA and stands available to assist with any clarification or subsequent support that may be needed.

1.0 Introduction

MATA's vintage trolley rail system has become a part of downtown Memphis culture and is a tourist attraction all on its own. The year 2014 marked the trolley's 21-year milestone since the Main Street Line first graced the mall and began transporting millions through the heart of the city. Notable destinations along the trolley lines include the Pinch District, Cook Convention Center, Sun Studio, Peabody Place, Beale Street, the National Civil Rights Museum, the FedEx Forum, the Medical Center, and South Main's Historic Arts District.

The MATA Trolley inaugurated its first line in 1993, and made Memphis among the first of the cities to begin the revival of streetcar lines in the United States. Along with the San Francisco F line, the downtown San Jose historic trolley loop, the Seattle Waterfront line and the Kenosha Streetcar, it used refurbished streetcars up to 60 years old from other cities, and continues to rely on these vehicles today.

Most streetcar lines built after the Memphis system use so-called "modern" streetcars, which are built new, and have the latest technological features, but lack some of the charm of historic streetcars. These cars were also not available when MATA built their system; Portland, OR, was the first to use such cars, and that line did not enter service until 2001.

The streetcars which were brought from Melbourne, Australia, have served not only in Memphis, but also in San Francisco, San Jose, Savannah and Seattle. While the cars bought from Porto, Portugal are not common, they have also served well on the MATA system. In addition, a few of the MATA cars have been manufactured as new cars, but have the appearance of the old historic vehicles.

It is appropriate to note at this point that the two types of cars, historic and "modern", are in daily use on various streetcar systems throughout the United States, in some cases in mixed fleets. While both types have excellent safety records in general, they are built to considerably different specifications. Thus, to achieve comparable degrees of safety, the standards to which they are designed and built differ.

Recognizing the need for a safe design standard for so-called Heritage Streetcars, the APTA Streetcar Sub-committee developed and published 'APTA Standard for Vintage/Heritage Trolley Vehicle Equipment' (*APTA SS-HT-001-05)* released on June 20, 2005. This document has been widely adopted by systems which use this type of vehicle. Similarly, the same group has published a similar document, 'Modern Streetcar Vehicle Design Guidelines' *(APTA RT-ST-GL-001-03)* released on March 26, 2013 which covers so called Modern Streetcars. The end goal of both documents is to provide for safe and dependable streetcars, albeit certain design details vary.

Deferred, incomplete or incorrect practices within Memphis trolley system include development of comprehensive Standard Operating Procedures (SOPs) and Standard Maintenance Procedures (SMPs); training; and rolling stock maintenance. These types of deferred practices do exist in varying degrees, and are under correction within other streetcar museums and heritage rail transit agencies throughout the United States.

As the operational environment changes (due to external and internal causes), the risks to Memphis trolley system regular service operations increases also, but Memphis trolley system processes to control or mitigate these risks are not in place. This subsequent environment of higher risk is resulting in an escalation in the number and severity of incidents and accidents, and a decrease in rolling stock reliability, to a level in both cases that would be below the average experienced in today's street railway industry.

This review included the gathering of current paperwork records in order to performing a table audit (paper audit used to examine form use, sign off and filing) as a means of establishing operational integrity

to an external auditor. Current documentation is insufficient to cover existing practices. If continued, it will be ineffective in maintaining acceptable risk levels for the systems rolling stock and infrastructure and their operations and maintenance.

The practice that has worked with other like rail systems with similar risk escalations was to reestablish rolling stock (vehicles), infrastructure (track & structures) and competences (personnel skills) at the base level as required for current heritage street railway industry acceptable practices and standards, and establish a monitoring system to ensure this level continues. This would allow Memphis trolley system to maintain system operations at acceptable risk levels, and subsequently lower incident and accident rates. The sole purpose for base compliance to an industry and community standard is to achieve an acceptable level of safety.

Specialized, professional heritage rail consultants and contractors could work with current Memphis trolley system personnel and share their resource base. This team approach would minimize cost, ensure Memphis trolley system buys into the process and rapidly transfer all skill sets necessary for continued operation to local personnel.

Necessary work and documentation could be completed and phased in over 1 – 5 month period. This should then be reviewed at 12 months followed by continued monitoring and retaining on a periodic basis for a 2 year period. By then, MATA trolley system would be a stand-alone system and no longer reliant on external consultants or contractors.

2.0 Scope of Report

2.1 Statement of Work

The scope of the APTA review was specified in an agreed upon statement of work.

The APTA Peer Review process is well established as a valuable resource to the public transport industry for assessing all aspects of transit operations and functions. These peer reviews are conducted on-site by experienced and respected transit professionals who are selected on the basis of their subject matter expertise, and who voluntarily provide their time and support to address the scope required. Peer reviews provide transit agencies with an unbiased review of projects, organization structure, technical approach, policies and procedures, application of technology or other topics as requested by the transit agency.

The scope of this review focused on investigating the causes of the last two trolley fires and developing recommendations for corrective action. The observations and recommendations provided through this peer review are offered as an industry resource as a means of strengthening MATA's programs, practices and strategies.

The review focused on the following areas as requested by MATA. Some areas of review were more in depth than others.

- Investigation into catastrophic fires to find cause and recommended corrective actions
- Examination of some MATA trolley operational & maintenance practices
- Review of safety & security plans and overall regulatory compliance
- Assessment of MATA trolley vehicles (rolling stock)
- Assessment of MATA trolley operations
- Review of some MATA personnel and their skill levels (competencies)
- Recommend corrective actions to any areas found deficient
- On-going monitoring (auditing) of the system safety processes

2.2 Approach

The panel took the approach of reviewing material that was provided by MATA in advance of the on-site meeting together with a detailed review of material presented once in Memphis. The panel also conducted several interviews with MATA staff and a City of Memphis EMA employee. **See Appendix 12 – List of MATA staff and Memphis City staff interviewed.** The panel toured the entire trolley system, noting the various grades (particularly on the Madison Line), neighborhoods, and restricted access and egress challenges on the Danny Thomas Bridge – the site of one of the trolley fires.

2.3 Deliverables

As specified in the agreed upon statement of work, the panel was asked to provide a presentation of their findings and recommendations resulting from an on-site peer review, together with a final report documenting its findings and recommendations.

3.0 General Overview and Observations

The panel commends MATA staff for their continued efforts to keep an aging vintage trolley service operational.

MATA requested the APTA peer review to help determine the cause of recent fires on two vintage trolley vehicles. The primary focus of this peer review team, as directed by the scope of work from MATA, are related to trolleys # 452 and #553. These two trolleys were from Melbourne, Australia, and believed to have been manufactured in the 1920's and refurbished by MATA contractors during a period from 1997 to 2002. Both fires occurred on the Madison Avenue Line, one of three lines serving the downtown and Medical Center areas of Memphis. The first of these two fires occurred on November 4, 2013 and the second on April 7, 2014. After the second fire, all trolleys on the Madison line were removed from service until the cause of the problem can be determined and corrective actions taken. A replacement bus service was implemented.

It was not possible to fully assess the two trolleys that were involved in the fires due to the extent of the damage, but the panel viewed the entire trolley fleet and closely examined and tested trolley cars #453 and #540. The panel interviewed members of management, operations, maintenance, safety and security as well as the City EMA staff. **See Appendix 12 – List of MATA staff and Memphis City staff interviewed**. A review was also made of System Safety Program Plan (SSPP) and other associated documents for the trolley system. The panel was thorough in their investigation which included examining the trolley spare parts and failed components, maintenance records, asset management, and training records. The review team also traveled the entire rail system using trolley #540.

The panel finds that program-wide issues can be broadly classified into the following categories:

- Staff levels
- Training
- Maintenance
- Safety committees
- Configuration management
- Systems Safety Program Plan (SSPP)
- Application of APTA Standard for Vintage/Heritage Trolley Vehicle Equipment
- Emergency preparedness
- System Safety Readiness Review plan

3.1 Staffing levels

a) The operators of the two trolley cars involved in the fires were interviewed. From the interviews and from some of the discernable video clips, we found that staff had done a commendable job in the performance of their duties and in getting passengers out of the car to a place of safety.
b) There does not appear to be a trained trainer with suitable accreditation for training operators and maintainers.
c) It is important to have a dedicated safety manager/trainer to ensure the necessary success of the agency.

3.2 Training

a) We found that there were several maintenance tasks that could only be performed by one person on staff.
b) Scant training records showing who received training and on what equipment, etc.

c) Limited equipment documentation for staff to determine how to calibrate and what the calibration specification should be used for various pieces of in-house equipment.
d) In 2008, a previous consultant prepared a full training course on controller maintenance including a PowerPoint presentation, handouts instructor's notes and exams. This perhaps may be helpful for reinstructing staff on controller equipment.

3.3 Maintenance

a) The pit area had a film of oil in several areas and is a potential for slip and fall incidents.
b) Several rail vehicle running gear also had areas of oil in excess of what one would consider the norm.
c) A large quantity of worn out parts, such as motors, compressors, trucks and controllers, were found in various state of disrepair. See Figure 1.
d) Defect Cards for Car #553 were reviewed for the period January 3, 2014 to April 6, 2014. Forty three defects were recorded during this three month period. Fire on this car was on April 7, 2014.
e) Defect Cards on Car #452 were reviewed for the period July 27, 2013 to November 3, 2013. Twenty nine defects were recorded during this three month period. A notable defect entry on November 3, 2013 was related to a 'pop' from the controller. The repair entry stated 'Adjustment made to the controller'. Fire on this car was on November 4, 2013.
f) There appears to be a disconnect between the SOPs, SSPP and what happens on the vehicles. There are little or no records on repairs done to the cars. As an example: Car #453, following a test of the line breaker overload operation, we found several motor covers were missing; wires were rubbing on the motor cases of truck frame members; there was evidence of an apparent fire at one end; it was noted that the controller had been recently replaced; and there was evidence of smoke damage behind the wooden panels. In reviewing the car records, there was no evidence of recent activities or record of replacing the controller. Unclear if the fire was older than it appeared or the documentation was missing.
g) Shop staff appears to perform tasks as instructed. However, there appears to be a lack of oversight by management staff to ensure written procedures are being followed.
h) There was a lack of training and maintenance documentation. No manuals on how to maintain the cars' electrical apparatus or the air systems. The team's impression was that because they had none, they did not know how or where to obtain such. Overall, the panel found this to be disturbing. There are many cities that operate this type of equipment and may be willing to share the information if asked.
i) Some MATA staff indicated that there is a lack of available maintenance manuals, etc.
j) On some cars inspected, we found the brake systems to be worn out. (See Figures 2 -6)
k) Some comments from staff interviewed stated that they experienced multiple flashovers each year and approximately one "Big" flashover each year.
l) We could not determine if maintenance staff interviewed the operators after the fires.
m) It would appear that no additional training was provided to the maintenance staff after the fires.

3.4 Safety Committees

a) The SSPP calls for four quarterly safety committee meetings per year. There was no evidence of this being held. Our understanding is that the last one was held in the 4th Quarter of 2013.
b) No dedicated safety person for the trolley system. In the absence of this, the Director of Rail Operations also acts as the safety manager for the trolley system.
c) Currently there is one Safety Manager for MATA who is required to investigate rail and bus incidents. He feels overwhelmed and expressed concern that while he is responsible for rail he has no input.
d) When staff was interviewed, it was apparent there was a lack of safety committees for shop and operations staff.

e) Training and re-certification records are on file at the HR department, therefore, the peer review team were unable to verify that all staff have had follow up training.
f) Staff indicated that there is a lack of documentation regarding meetings and if were held they have not been afforded the opportunity to read them.
g) Last FTA tri annual was in December 2012.

3.5 Configuration Management

- No apparent configuration management system is in place.
- Several modifications have been done to the trolleys, however, the configuration management process identified in the SSPP is not being adhered to. As an example a line breaker from one of the two trolleys that caught fire was transferred to another trolley which was operating in service. The information as to which car it was transferred to was not readily available. Nor is there any indication that the part was tested prior to installing on another trolley prior to entering revenue service.
- In the area marked for storage of heavy trolley items such as motors, compressors, etc., there appeared to be no order to the storage method, no tags on equipment, and no record of an inventory.

Figure 1 – Heavy parts storage area

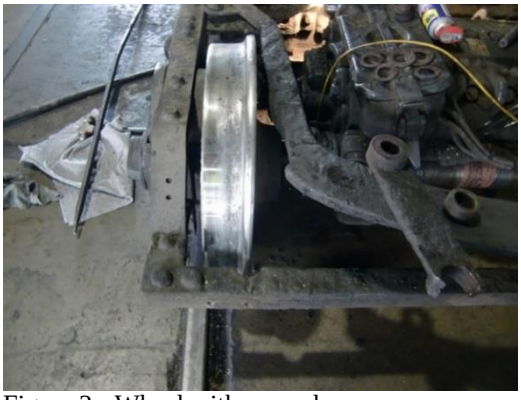


Figure 2 - Wheel with normal wear

Figure 3 - Trolley #453 Abnormal wear on left side tread. The narrow flange and uneven tread surface requires the wheel to be trued.

indicative of the level of wear

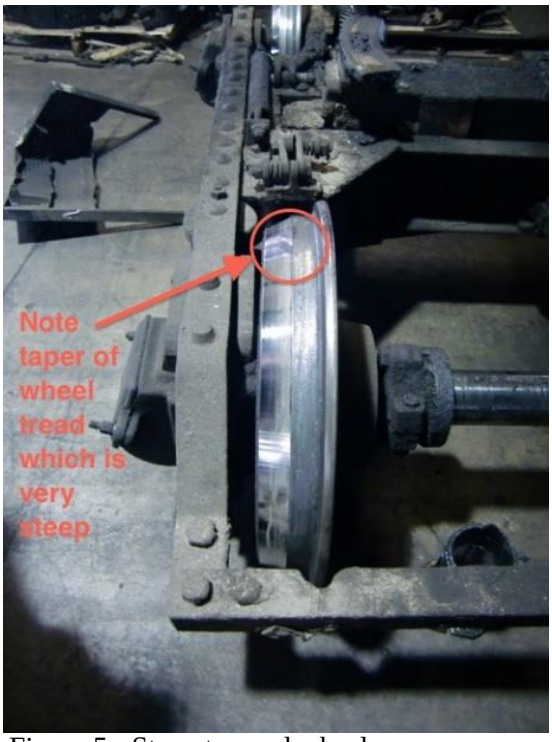


Figure 5 - Steep tapered wheels

igure 4 – Truck su

3.6 System Safety Program Plan (SSPP)

System safety is a critical component in every transportation agency, and a comprehensive SSPP is a key element for applying its principles. A properly implemented SSPP provides the basis for identifying any and all hazards that could interfere with customer and employee safety. Additionally, a well-crafted SSPP provides for the appropriate safety reviews of capital improvements, changes in equipment, and modifications in operating practices. A solid SSPP also includes concrete methods for eliminating, minimizing, and/or mitigating these hazards, and defines lines of responsibility for addressing potential hazards in an organization. Finally, it establishes safety and security tasks for departments and divisions within a transit agency that have a lead or support role in safety implementation.

a) Current SSPP was last updated in December 2013 and is considered adequate.
b) Incident reports for both fires were very brief. Need to have a more comprehensive reporting procedure and have supervisory oversight to ensure these reports are finalized and corrective actions are followed through.
c) SSPP requires a Corrective Action Plan (CAP) to be developed after each accident investigation. We were unable to obtain a CAP regarding the two trolley fires.
d) The SSPP refers to daily inspections and monthly preventative maintenance of the trolleys. Upon inspection of the vehicles, it would appear that some inspections were not being carried out on a regular basis in accordance with SSPP recommendations.
e) SOPs were last updated in July 2011. The SSPP requires an annual review and update as necessary.

3.7 APTA Standard for Vintage/Heritage Trolley Vehicle Equipment

The APTA Standard for Vintage/Heritage Trolley Vehicle Equipment *(APTA SS-HT-001-05)* was released June 20, 2005.

This Standard for Vintage/Heritage Trolley Vehicle Equipment establishes minimum requirements for equipping Vintage Trolley vehicles. (Herein, the term Heritage Trolley is used synonymously with the term Vintage Trolley). It includes programs and procedures that are to be established and documented in the Vintage Trolley System's System Safety Program Plan (SSPP), as well as equipment-related criteria that are to be documented in the Vehicle Safety Certification process.

The following introductory language is provided in the standard:

"APTA recognizes that some rail transit systems (or other Vintage Trolley operators) have unique aspects of their operating environment, that when combined with the levels of service that must be provided, may make strict compliance with every provision of an APTA Rail Transit Safety Standard impossible.

When a rail transit system (or other vintage trolley operator) is faced with this dilemma, that system may use its system safety program plan to specify an alternate means to achieve an equivalent level of safety as provided by the APTA Safety Standard. The System Safety Program Plan should:

- *Identify the Rail Transit safety Standard requirements that cannot be met.*
- *State why each of these requirements cannot be met;*
- *Describe the alternate means to ensure equivalent safety is achieved; and*
- *Provide reasonable basis (i.e. operating history or hazard analysis) for why safety is not compromised through the alternate means."*

Attached as **Appendix 10** is a check list of essential elements from the APTA Standard for Heritage/Vintage Trolley Vehicle Requirements to be used when certifying MATA trolley items.

3.8 Emergency preparedness

a) We understand that MATA used to have one field exercise and one table top exercises per year. Last emergency exercise with emergency responders was approximately 8 years ago.
b) MATA stated that they have trained emergency responders on how to lower the pantograph; release and apply the brakes; and disconnect power from the on-board trolley battery.
c) No written evidence that emergency responders have been trained.
d) City EMA manager confirmed that MATA has a seat at the Emergency Operations Center (EOC).

3.9 System Safety Readiness Review plan

MATA should actively be planning on developing a readiness review plan in preparation for resumption of trolley revenue service. The following are provided to assist MATA in developing this plan:

a) Interim Operations Plan

Perform a Hazard Analysis on current Memphis trolley operations and establish an interim operations plan that will meet acceptable safety levels. This may include short-term closure, restriction or change of operations. As Memphis trolley system is not following any documented risk or hazard processes, the Department of Transportation's "Hazard Analysis Guidelines for Transit Projects" and current industry practice should be utilized.

b) System Safety Program Plan (SSPP)

Ensure Memphis trolley system SSPP that is condensed and tailored specifically for Memphis trolley system is followed. The SSPP address's the following 21 key elements:

1. Policy Statement & Authority for SSPP
2. Goals & Objectives
3. Overview of Management Structure
4. SSPP Control & Update Procedure
5. SSPP Implementation Activities & Responsibilities
6. Hazard Management Process
7. System Modification
8. Safety Certification
9. Safety Data Collection & Analysis
10. Accident/ Incident Investigations
11. Emergency Management Program
12. Internal Safety Audits
13. Rules Compliance
14. Facilities & Equipment Inspections
15. Maintenance Audits & Inspections
16. Training & Certification Program for Employees and Contractors
17. Configuration Management & Control
18. Local, State, & Federal Requirements
19. Hazardous Materials Program
20. Drug & Alcohol Program
21. Procurement Process

c) Standard Operating Procedures (SOP)

Formulate SOP's covering all O & M practices to comply with SSPP requirements.

d) APTA Standard

As part of the SSPP element item #18: Local, State, & Federal Requirements" adopt the APTA Standard for Vintage/Heritage Trolley Vehicle Equipment as a governing document. Conduct necessary work on rolling stock to ensure compliance.

e) Rolling Stock and Infrastructure Maintenance

As part of the SSPP elements "14: Facilities & Equipment Inspections" and "15: Maintenance Audits & Inspections" establish a documented maintenance management system and conduct mechanical repair of safety sensitive items of deferred and incorrect maintenance.

f) Personnel Recruitment

Conduct a recruitment drive to establish a personnel base that supplements current personnel and meets organizational succession planning needs. As part of the SSPP element "16: Training & Certification Program for Employees and Contractors". There is no purpose in having a safe and efficient SSPP if there are insufficient trained personnel for continuance of safe operations.

g) Training

As part of the SSPP element "16: Training & Certification Program for Employees and Contractors" train personnel to required levels and administer verifiable written exams to ensure knowledge base.

h) Monitoring

As part of the SSPP element "12: Internal Safety Audits" which ensures ongoing compliance to the SSPP, and subsequent commitment to safe operations perform regular scheduled table top and operational testing audits. In the case of casual and occasional non-compliance corrected actions to focus on structured and documented remedial training not on personnel discipline.

i) Self-Sustaining Safe Operations

A correctly managed SSPP becomes self-maintaining, with little external input. Regulated systems typically conduct an internal audit on one third of their plan yearly; with an external regulator (State Department of Transportation), auditing the entire plan every three years (varies). A consultant or peer transit agency personnel could perform the yearly audit. Apart from this inclusion, the Memphis trolley system trolley could maintain self-sustaining safe operations with a SSPP.

The existing Memphis trolley system SSPP may be used as the base document governing operations of a modern streetcar system in Memphis. Typically, risks for older trolleys and modern streetcars are similar in type, but higher in degree for heritage trolleys.

4.0 Findings

4.1 Primary cause of vehicle fires on trolley #452 and #553

After interviewing several MATA staff and reviewing the maintenance records and watching the video footage of the trolley frame by frame, we concluded the following reasons for the fires.

d) A failure within the motor control circuit.
e) A fault in the propulsion system, which generated a current overload.
f) A defective line breaker which failed to protect the controller resulting in a severe flashover setting the trolley car on fire.

The line breaker and controller are two primary components and below is a brief explanation of each one:

Line Breakers –The line breaker (sometimes referred to as a line breaker relay switch) is the first line of protection for the motor control circuit. The line breaker consists of essentially two portions: 1) A magnetically operated contactor for opening and closing the motor circuit, and 2) An overload relay for automatically opening the power circuit when the 600 Volts dc current exceeds a prescribed maximum value.

These parts are enclosed in a suitable metal box with a removable cover, arranged with brackets and porcelain insulators for mounting beneath the car body.

Controller – The type of controller used on the Melbourne cars is a K-35, manufactured by General Electric. The controller uses the full line voltage of 600 volts dc and regulates how much of this voltage is applied to the motor, which in turn determines the speed of the trolley.

See also Appendix 7 – Line breaker relay switches
See Appendix 8 & 9 – Trolley #453 and Trolley #540 tests to determine operation of the line breaker

4.2 Possible contributing factors of vehicle fire

Other factors that contributed to these fires:

c) Trolley cars were found not to be in compliance APTA Standard for Vintage/Heritage Trolley Vehicle Equipment (*APTA SS-HT-001-05)* released on June 20, 2005.
d) Additionally, the trolley cars, which were modified, were done so with no evidence of compliance with MATA's SSPP.

4.3 Other factors

a) A lack of enforced implementation of the Safety System Program Plan (SSPP).
b) Inadequate and incomplete Standard Operating Procedures (SOPs) and Standard Maintenance Procedures (SMPs).
c) There was evidence of failure to follow existing SOPs and SMPs.
d) From discussions with staff, there appears to be a need for more training for both operations and maintenance staff.
e) Many lapses in regular safety committee meetings and processes. No demonstration of existence of meeting minutes and how issues were documented and dispositioned.
f) MATA is eight years behind in compliance with FTA mandated annual field exercise requirements with operations, maintenance staff and emergency responder.
g) Failing to lower the pantograph from the OCS quickly and locking it the lowered position.

*The panel expressed their concern and emphasized that unless these causes are corrected, fires **WILL** happen again. Furthermore, it was conveyed to MATA management that there could be trolleys currently operating on the lines which could catch on fire at any given moment.*

5.0 Recommendations

The following corrective actions will ensure that MATA achieves an acceptable industry level of safety for the public and staff.

5.1 Short term corrective actions

a) Suspend all trolley services.
b) Use alternative vehicles to operate revenue service.
c) Inspect, repair and certify a minimum of five trolley cars for revenue service. (Number of revenue car5s for Main Street Line)
d) Update SSPP processes to acceptable industry levels.
e) Update staff skill sets to acceptable industry level.
f) Tennessee DoT to perform a readiness review to certify a partial opening of the system for Main Street Line and Riverfront Lines.
g) MATA to consider procuring the services of an industry peer review to assist in this process.

5.2 Long term corrective actions

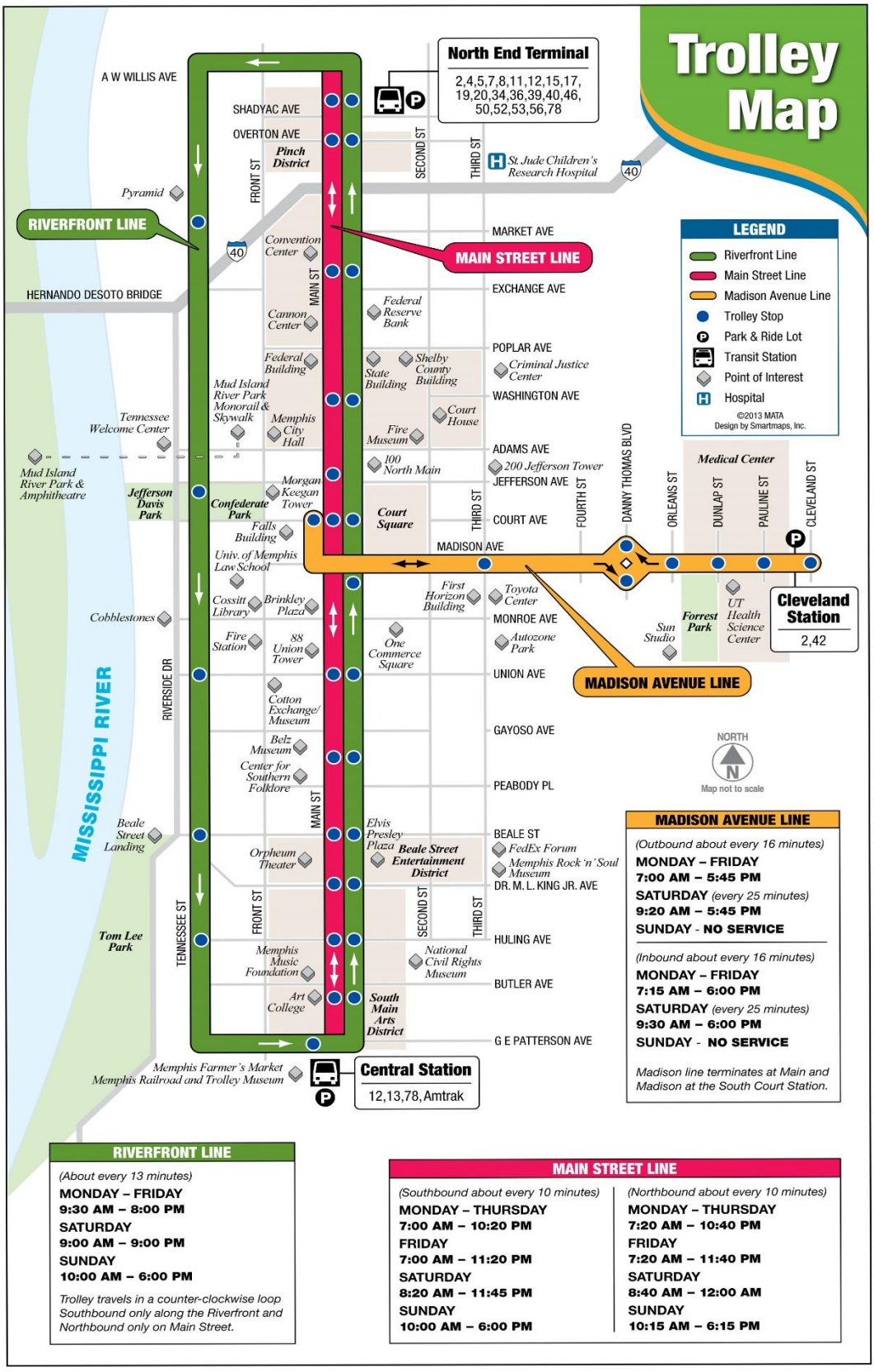
a) MATA to seek resources for total fleet overhaul or replacement.
b) Assure the continued use and implementations of the provisions of the SSPP and accompanying documents, thereby ensuring system safety at ALL levels of the organization.
c) Initially, conduct a frequent internal audit of recordkeeping to assure that all operations, maintenance and procurement personnel are following the SOPs as regards reporting and vehicle configuration management.

5.3 Other recommendations

a) Appoint a full time qualified trolley safety manager independent of the bus operating system.
b) Procure adequate resources to provide services specific to required documentation, training and hands on supervision.
c) In order for MATA to continue to safely operate they will require qualified oversight from the State Oversight Office (SSO).
d) MATA and State Oversight Office (SSO) to foster better communications with each other.
e) In order to operate safely, MATA staff will require better training manuals; training on the vehicle itself; other shop related topics; lock out/tag out procedures, etc.
f) Conduct on a regular basis field and table top exercises as outlined in the SSPP.
g) MATA should consider regular exercises with emergency responders on MATA equipment and as a minimum one per year.
h) MATA should develop a list of emergency responders trained, the types of equipment and dates of these training.
i) Need to convene Safety Committee meetings as referenced in the SSPP. Peer review team recommends monthly meeting even though the SSPP references quarterly meetings.
j) Need to develop a Corrective Action Plan (CAP) procedure.
k) Set up a procedure for following through on the configuration management plan identified in the SSPP.
l) Arrange for worn out parts, such as motors, compressors, trucks, controllers, etc.), be serviced or rebuilt.
m) Develop an oversight procedure for checking on work done on defects reported on defect cards.
n) Develop a new style ‘Defect Card’ with a serial number, a procedure for logging each one when the trolley returns to the barn each night, and detailed action taken against each defect. Where possible, this method to be entered on a data base and tracked electronically.

o) The new defect card should have an area for the trolley operators name and ID; car number; date; a listing of defects, and an explanation for the defect. The card should also have a place for the maintenance technicians name; indicate parts used and their number; and a supervisor's sign off block.
p) Strengthen the oversight procedure to verify that SOPs and SMPs are being adhered to and documentation of car history is being maintained.
q) Develop maintenance training classes (even if the expertise needs to be procured) for motors; air compressors; controllers; line breakers; pantograph; lock out/tag out of energized equipment; and method of calibrating various pieces of equipment.
r) Modifications should be made to the trolley pantographs so that by use of a button in the cab, the pantographs can be lowered and latched until it is required to be raised.
s) Update the Rail Fleet Management Plan (RFMP). This should be used to help determine the mid and long-range plan for upgrade and possible replacement of the streetcar fleet.
t) Develop a System Safety Readiness Review Plan in preparation for resumption of trolley revenue service.

Appendix 1 – MATA Trolley Route Map



Appendix 2 – Summary of car fire on trolley #452

Caught on fire November 4, 2013

Figure 7 – Trolley #452 after the fire

Trolley #452 is a Melbourne type car. Believed it was manufactured about 1920 in Melbourne, Australia. Refurbished by MATA contractors between 1997 and 2002.

The fire occurred on the Madison Avenue Line on the I-240 overpass just west of Bellevue Road.

Information and assumption contained herein is based on the video footage plus interviews with staff and some observation by the peer review team.

As trolley #452 is proceeding along on Madison Street, the operator has the control handle in full power or "full parallel" point 8 position. (See Figure 14 for a Typical Cab Controller/Key Switch Position). At a moment in time, there was a flash in the controller (See Figure 15) and a subsequent fire begins. The operator backed off the controller initially to point 1 and moments later to the OFF position. The operator applied the brakes, and attempted to stop the fire by means of turning off the line breaker main switch behind the operator on a panel. (See Figure 13). The car slows down, and as it does, the fire becomes more intense. This would be due to the motors straining against the braking system and the motors drawing more current. The controller at this point is acting as the circuit breaker and is the weak link in the chain.

It is clear that had the line breaker and control apparatus functioned as designed, the line breaker would have opened (dropped out) and no power would be flowing through to the controller and motors. Looking at the arch it would appear the safety equipment did not function as designed and the motors continued to receive power. The flames from the arch appeared to be severe enough that the operator may have run the risk of getting their clothing on fire had they attempted to stay longer and move the controller all the way to the OFF position.

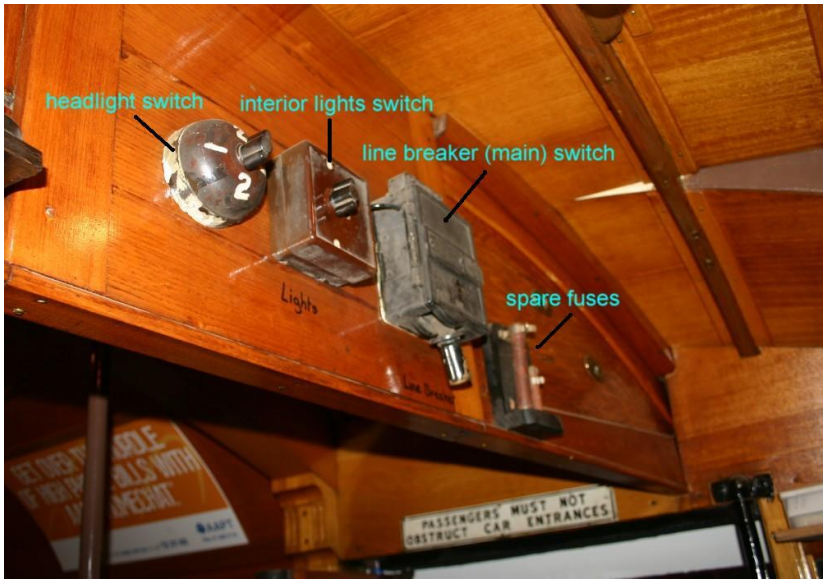


Figure 8 – Series of switches in a typical cab. They are located at ceiling level and behind the trolley operator.

Note the line breaker switch can be

manually operated by the operator.

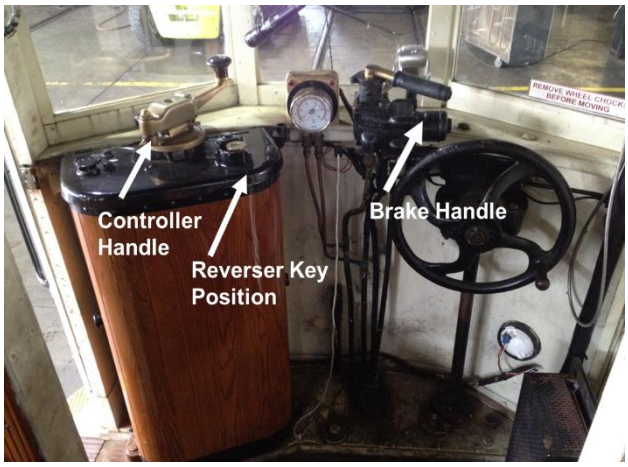


Figure 9 – Typical cab showing position of controller handle, brake handle and reverser key switch position

With the line breaker contact tips closed, this allowed more current into the controller due to the heavy current draw from the motors caused by the brakes being applied and trying to slow the car down. This caused the fire to become intense and severely burn the car.

The photo in the FTA report of June 2, 2014 (Figure 16) shows the pantograph still raised and connected to the overhead wire system. If the overhead wire was still energized, this would have greatly contributed to the fire.

In an emergency, had there been a way to lower the pantograph, and then keep it lowered, this might also have been a way to keep the car from being completely destroyed.

This car was partially stripped when the peer review saw it.

According to the shop staff, motor # 3 was shorted. Typically this would have happened at the same time as the controller was moved from notch 5 to 6. The line breaker overload, which should have protected the car wiring and motors failed to do so.

With the line breaker tips closed it allowed more current into the controller due to the heavy current draw from the motors caused by the brakes being applied and trying to slow the car down. This caused the fire to become intense and severely burn the car.

Figure 10 – Reverser drum on trolley #452 after the fire,

In an emergency, had there been a way to lower the pantograph, and then keep it lowered and latched down, would have been a way to keep the car from

being destroyed.

showing burned 600 volts dc fingers on the controller

This photo in the FTA report shows the pantograph still raised on the overhead wire system. If the overhead were still energized, this would have greatly contributed to the fire.

This car was partially stripped when the review team saw it. The line breaker we were told was moved to car 453.

Figure 11 – Trolley #452 on fire
Photo courtesy of FTA Report of a Safety Review of the Memphis Area Transit Authority (MATA) dated June 2, 2014

Appendix 3 – Summary of car fire on trolley #553
Caught fire on April 7, 2014

Trolley #553 is a Melbourne type car. Believed it was manufactured about 1920 in Melbourne, Australia. Refurbished by MATA contractors between 1997 and 2002.

The fire occurred on the Madison Avenue Line on the Danny Thomas overpass bridge.

Information and assumption contained herein is based on the interviews with staff and some observation by the peer review team.

The video footage and the car was completely destroyed by the fire.

Figure 12 – Trolley #553 after the fire.

Given that there was no video footage, the peer review team looked at what was left of the wreckage. Looking at the controller in this car, it showed the same arching inside the controller as car #452.

The peer review team would have preferred to have the car moved over a pit for further inspection underneath the car, however this was not possible due to MATA's strained resources, insufficient time of the review team and a storm that that resulted in a power outage.

The assumption in this case would be, had the line breaker overload relay operated as designed, it would have protected the car.

The photo in the FTA report June 2, 2014, shows the pantograph is still raised onto the overhead contact wire system. Had there been a way to lower the pantograph and keep in down and latched in an emergency it could have reduced the amount of damage to the car. Had the pantograph been lowered in of sufficient time there is no doubt it would have substantially reduced the damage to

Figure 13 – Trolley #553 showing the burnt out shell at one end of the car.

the trolley.
It also shows the lack of safeguards with the pantograph as it should have a means to hold it down in emergencies and be recognized by the fire department of a hazardous situation. The shop staff should also have a 'hot stick' capable of pulling the pantograph down in an emergency on their road call truck.

In the FTA report of June 2, 2014, page B-30, states that it is not clear if all 4 motors were working. The first bullet says the operator was able to notch the controller up to the 8th point, but only two motors were working. In the 2nd bullet, it states all 4 motors were cut in, however only two were working. It is not clear from that report as to how the FTA came to this conclusion.

It is also not clear from staff interviews and documents reviewed if the motors were ever checked and meg ohmed. Nor is there any evidence that the line breaker was checked for both operation and possible welded tips.

Figure 14 – Trolley #553 fire being extinguished by the Memphis City fire department.
Note: Pantograph is still raised and in contact with the overhead wire.

Photo courtesy of FTA Report of a Safety Review of the Memphis
Area Transit Authority (MATA) dated June 2, 2014

Figure 15 – Trolley #553 awaiting repair.

Figure 16 – Showing the limited clearance and the 6% grade over the Danny Thomas Blvd. Bridge on the Madison Avenue Line

The following photos show rail burn marks at the location where trolley #553 caught fire on the Danny Thomas Blvd. Bridge on the Madison Avenue Line. These marks occur when the motors cause the wheels to spin in the same place.

Figure 17 – Rail burn marks on the Danny Thomas Blvd. Bridge on the Madison Avenue

Figure 18 – Rail burn marks on the Danny Thomas Blvd. Bridge on the Madison Avenue Line

Appendix 4 – Letter of invitation from MATA General Manager

MATA

April 11, 2014

Michael Melaniphy, President
American Public Transportation Association
1666 K Street, NW, Suite 1100
Washington, DC 20006

Dear Mr. Melaniphy:

The Memphis Area Transit Authority (MATA) is requesting that APTA conduct a peer review to help determine the causes of recent fires on two of our vintage trolley vehicles. The two trolleys are from Melbourne Australia, believed to have been manufactured in the 1920s, and refurbished by MATA contractors in 1997-2002. Both fires occurred on the Madison Avenue Line, one of three lines serving the downtown and Medical Center areas of Memphis. The first fire occurred on November 4, 2013 and the second occurred on April 7, 2014. Since the second fire took place so soon after the first one we have taken the precautionary measure of removing all trolleys from the Madison Avenue Line until the cause of the problem and the corrective actions have been determined.

MATA would like the peer review to be focused on investigating the causes of the two fires and developing recommendations for corrective actions. Other related areas that should be reviewed are operations and maintenance practices, and the condition of trolley vehicles and infrastructure.

We are requesting a panel of 2-3 people who have specialized knowledge and expertise with vintage rail trolley operations and maintenance involving Melbourne-type trolley vehicles.

Due to the urgency of this situation, we request that the peer review be scheduled as soon as possible. MATA staff will make themselves available any time the panel can come to Memphis.

I can be reached at tfox@matatransit.com, or 901.722.7160 (office), or 901.331.7046 (cell). Alvin Pearson will be MATA's contact for this review. He has already been in communication with Jim Graebner of the APTA Streetcar Committee. Alvin can be reached at apearson@matatransit.com, or 901.722.7104 (office) or 901.508.3109 (cell). Thank you for your assistance.

Sincerely,

Thomas D. Fox

Thomas D. Fox, Ph.D., AICP
Interim General Manager

c: Alvin Pearson, Assistant General Manager

Appendix 5 – MATA Letter of indemnification

Appendix A

APTA PEER REVIEW PROGRAM

This is to acknowledge that the Memphis Area Transit Authority (transportation organization) has requested the American Public Transportation Association (APTA) to provide for *Transportation Organization* Peer Review services through APTA's wholly owned subsidiary, the North American Transit Services Association (NATSA) in accordance with the APTA Peer Review Program Guidelines.

APTA's Peer Review Program is designed to assist transportation organizations in addressing public transportation-related needs and issues through subject matter experts within the public transportation industry. Through the coordination by APTA and NATSA and the support of their respective own organizations, the subject matter experts convene at the requesting public transportation organization and conduct an intensive review of the issues to be addressed. Peer Review participation is conducted by mutual consensus and through industry acknowledgement that this service is an extremely valuable resource to strengthening and enhancing public transportation functions and effectiveness. The APTA Peer Reviews follow the format as described in the APTA Peer Review Guidelines.

The observations and recommendations as provided through the APTA Peer Review process are provided in good faith and as based upon the experience and skills of the Review panelists. The APTA Peer Review does not, nor is it meant to, represent a full organizational review. The Peer Review is intended to be used as a resource that, in conjunction with other assessment tools, can assist the requesting organization to evaluate their particular needs and issues.

Indemnification: To the extent permitted by law, the Public Transportation Organization agrees to indemnify and hold harmless APTA and NATSA, its officers and employees, and any Peer Review panelists and their respective agencies in the conduct of their activities for claims of any kind (including attorney fees) arising out of the provision of this Peer Review, except to the extent such claims arise or are caused by the negligence or willful misconduct of APTA, NATSA, its officers and employees, or Peer Review panelists.

The undersigned, duly authorized representative of the Public Transportation Organization agrees to the terms of the provision of this Peer Review service.

Transportation Organization

By: Thomas D Fox Date: 4/11/2014

Interim General Manager

Signature - Name and Title of Authorized Representative

Appendix 6 – Peer Review Agenda

APTA Peer Review of MATA Vintage Trolley Vehicle Fires Agenda

Monday June 2, 2014

6:00 PM Peer review team members get acquainted dinner.

Tuesday June 3, 2014

7:30 AM Peer review team to meet in hotel lobby

7:45 AM **Breakfast**

8:15 AM MATA team member to meet peer review members and accompany to MATA offices
Meet with MATA management staff, introductions and welcome remarks
Briefing by MATA as to the background for the peer review request
Scope and expectations of the APTA Peer Review
Review agenda
Transit passes

9:00 AM MATA organization chart
Overview of the system
Overview of the safety management system
Overview of the two incidents

10:00 AM **Break**

10:15 AM Tour of the system to include:
a) Control center
b) Maintenance shops
c) Maintenance training facility
d) Operator training facility
e) TPSS
f) Track

12:30 PM **Lunch**

1:30 PM a) Orientation of vehicle shops and staffing levels
b) Job descriptions, responsibilities and accountabilities
c) Vehicle technicians and other service staff
d) Detail inspection of rolling stock
- in its current condition
- with controller covers off
- underfloor inspection
- condition of electrical apparatus
- damaged equipment removed
- condition of spare equipment

3:30 PM Vehicle maintenance support overview
- Work order process
- Configuration management

5:00 PM End of Day 1

APTA Peer Review of MATA
Vintage Trolley Vehicle Fires
Agenda (cont'd)

Wednesday June 4, 2014

7:30 AM	Peer review team to meet in hotel lobby
7:45 AM	**Breakfast**
8:15 AM	Meet in MATA offices and other locations TBD as determined by MATA to discuss the following with staff:

- Rail maintenance supervisor – approx. 1 hour
- Rail technician mechanical – approx. 1 hour
- Rail technician electrical – approx. 1 hour
- Two (possibly three) trolley operators – approx. 30 minutes each
- Safety manager – approx. 2 hours
- Training manager/s for both trolley operators and maintenance staff – approx. 2 hours
- Staff member responsible for SSO reporting – approx. 2 hours
- Staff member responsible for parts procurement – approx. 1 hour
  - Process for procurement
  - What is in stock and how do they maintain those levels
  - What are the issues do they have with procuring parts

12:00 PM	**Lunch**
1:00 PM	Continue discussions with staff If discussions are concluded before 5:00 PM, peer review team to work on their own at MATA offices
5:00 PM	End of Day 3

Thursday June 5, 2014

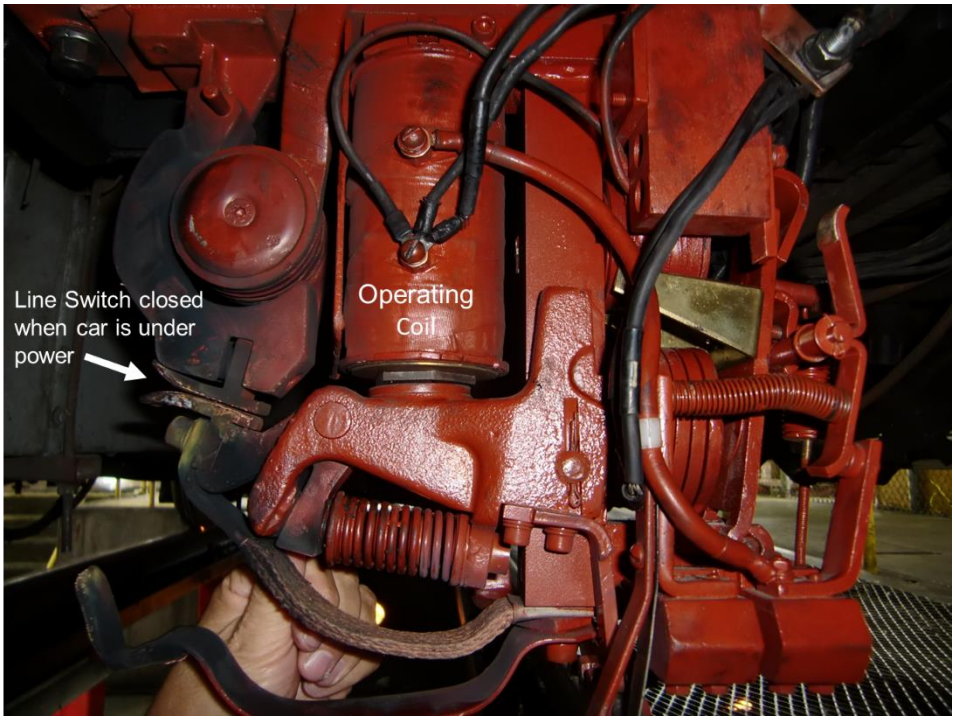
7:30 AM	Peer review team to meet in hotel lobby
7:45 AM	**Breakfast**
8:15 AM	Peer review team to spend the rest of the day at MATA offices to caucus in private, formulate information gathered, and prepare summary findings and recommendations for the exit conference on Friday
5:00 PM	End of Day 4

Friday June 6, 2014

7:30 AM	Peer review team to meet in hotel lobby
7:45 AM	**Breakfast**
8:15 AM	Team to conclude final preparation for exit conference
9:30 AM	Exit conference with MATA management staff
12:00 PM	Conclude exit conference

Appendix 7 - Line Breaker Relay Switches

Photos of the types of line breaker switches used to control the line breakers on the Melbourne trolleys. Typically, these are GE-DB Type 986 switches. The switch provides current to the coil in the line breaker via a LB-2A switch. On the K35JJ controllers it was originally a ratchet switch.



The line breaker over load is being pushed by hand to simulate the 600 Volts dc overload.

Figure 19 - The line breaker with the main operating contacts closed and the operating coil actuated. This is the normal state when the car is under power.

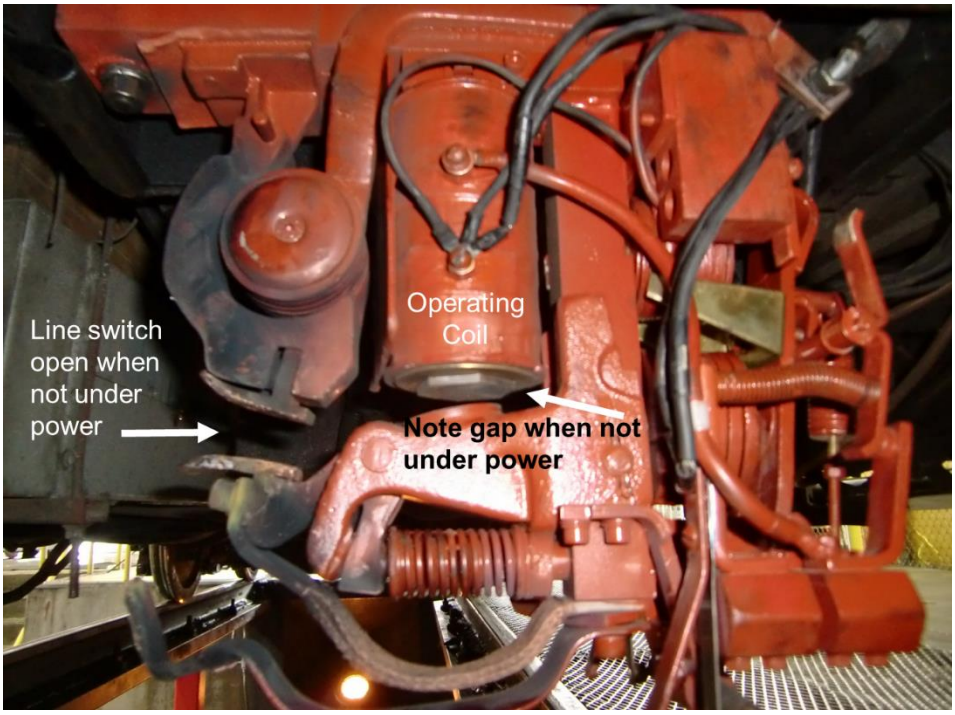


Figure 20 – When no power is present, the operating coil is disengaged and the line breaker switch tips are open.

Appendix 8 – Trolley #453 test to determine operation of the line breaker relay switches

On Thursday June 5, 2014 the peer review team inspected and tested car 453. The test was to see how the overload relay performed on the line breaker.

Initially, a visual inspection was made of the line breaker with the pantograph down and electrical power disconnected from the overhead contact system (OCS). Visually, there was a gap between the overload dogs (pieces of metal on the frame) that should come into hard contact with the line breaker's operating side and cause the main contact tips to physically come apart or be separated.

However the maintenance staff told us that they complete this test every so often and that the overload device works.

The car was placed on North Main Street with the pantograph up onto the OCS. With the car now energized, the line breaker cover was taken off to provide a visual observation of the line breaker and overload relay. The car operator was asked to place the brakes on full and then operate the car, first from point 1, then point 2, then point 3, then point 4, and finally to point 5. The line breaker should have opened up (via the over load relay) at point 3, or maybe point 4. Moving the controller handle from 1 through 5 increases the line load which in turn should cause the line breaker to open which it did not. It did not appear to even move (again it was visual). Further, the car motors were starting to overcome the brake system, making the car move on the tracks. The brakes should have held the car firm through this test. Wheel blocks were used to stop the cars moving during the next two tests. An attempt to make the overload on the switch function was repeated three times and each time the overload devise failed to perform as designed.

A failure of the line breaker to open creates a very dangerous condition resulting in no overload protection to the motor control circuit.

We also noted in a further inspection and review of the car, that one controller appeared to have been recently installed. After looking closely at the surrounding wood, one could see the varnish had been heated the finish distorted. Upon further checking behind a service door which led into the cabinet over the controller, the backside of the cabinet had evidence that a fire must have occurred. There was no documentation supporting either theory that the controller had been in a fire and/or changed out recently. However, the physical evidence showed otherwise.

Typical controller layout showing various points and the reverser key switch location

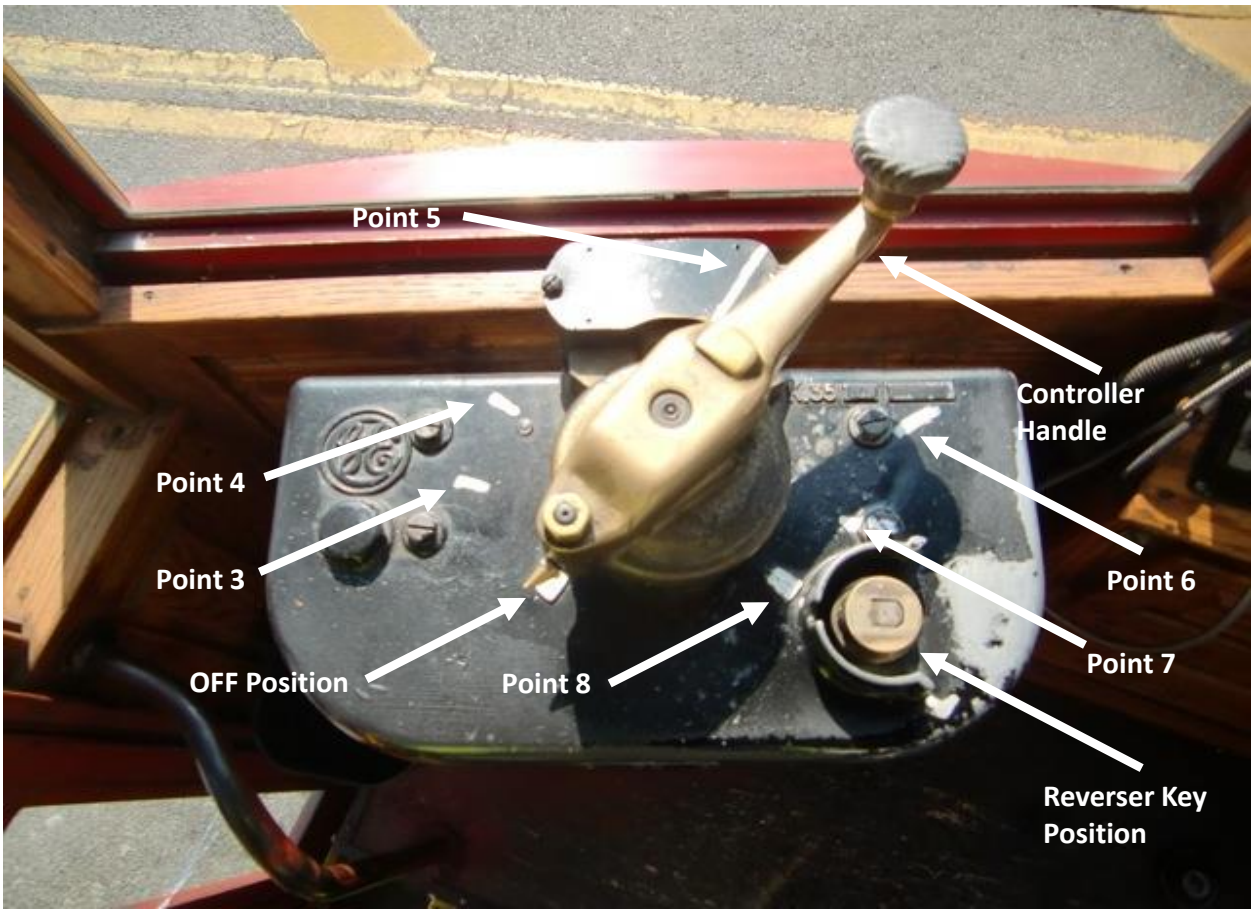


Figure 21 – Typical cab controller/reverser key position set up

Appendix 9 – Trolley # 540 test to determine operation of the line breaker relay switches

On Thursday June 5, 2014 the peer review team inspected and tested car 540. The test was to see how the overload relay performed on the line breaker. This test was similar to those conducted on trolley #453.

Initially, a visual inspection was made of the line breaker with the pantograph down and electrical power disconnected from the overhead contact system (OCS). Visually, there was a gap between the overload dogs (pieces of metal on the frame) that should come into hard contact with the line breaker's operating side and cause the main contact to physically come apart or be separated.

The car was placed on North Main Street with the pantograph up onto the OCS. With the car now energized, the line breaker cover was taken off to provide a visual observation of the line breaker and overload relay. The car operator was asked to place the brakes on full and then operate the car, first from point 1, then point 2, then point 3, then point 4, and finally to point 5. The line breaker should have opened up (via the over load relay) at point 3, or maybe point 4. Moving the controller handle from 1 through 5 increases the line load which in turn should cause the line breaker to open which it did not. It did not appear to even move (again it was visual). Further, the car motors were starting to overcome the brake system, making the car move on the tracks. The brakes should have held the car firm through this test. Wheel blocks were used to stop the cars moving during the next two tests. An attempt to make the overload on the switch function was repeated three times and each time the overload devise failed to perform as designed.

On further inspection of the car, both controllers were checked. It was found that one of the line breaker control devise on top the controller, was not correct and was laying on top of the two stationary contacts. This had the effect of bridging these contacts and caused the line breaker coil to be energized at all times and the operating contacts to be "made" all of the time while operating from that particular controller. It was also noted that one fire extinguisher was two years out of date.

Commentary for tests on both cars:

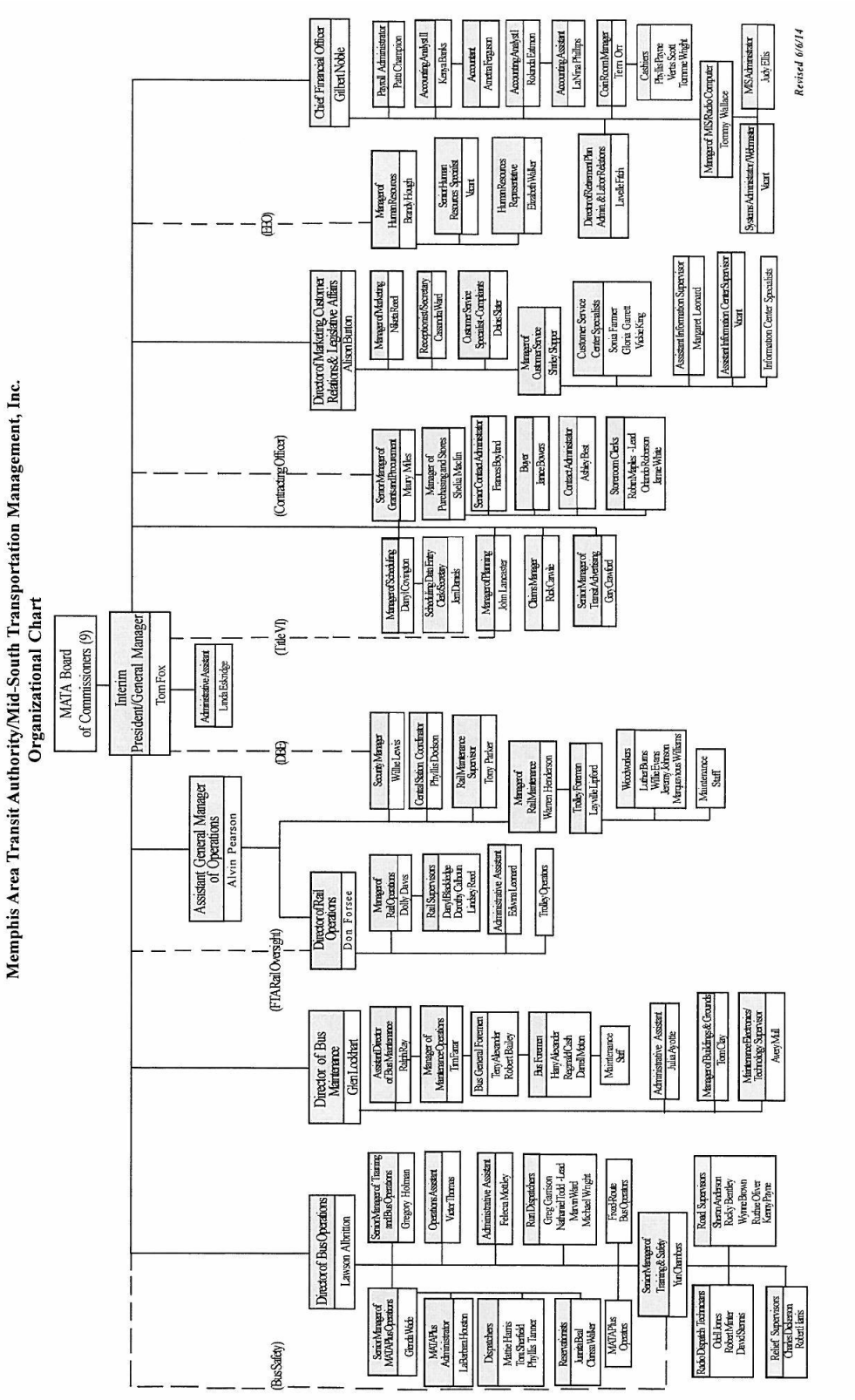
1. After the tests, both cars were brought into the shop for inspection.
2. The pantograph was lowered and disconnected from the overhead wire.
3. Removed controller covers and found all latches were in good working order.
4. Noticed a lot of dust in all the controllers and some metal shavings in one of them. Many of the fingers need dressing with sandpaper or filing and was lacking a light coat of Vaseline or other approved lubricant.
5. Some burnt areas were noted on the arcing plates and over spray from the use of insulating paint.
6. Many of the finger tips were not making proper contact with the segments. During routine preventative maintenance inspections, these fingers should be checked and adjusted to obtain proper contact on all control points.
7. Also noted that one of the controllers inspected, the LB-2 device was not properly adjusted allowing the line breaker contact tips to be made while the LB-2 handle was in its OFF position. This problem should have been detected and repaired during routine maintenance.
8. It was observed during the interview process and inspection that a number of controller flashovers have been experienced and reported ranging from small to moderate on a weekly basis.
9. THE TEST RESULTS ON BOTH CARS WERE IDENTICAL.

Appendix 10 – Check list of essential elements from the APTA Standard for Heritage/Vintage Trolley Vehicle Equipment

The following items are found in a narrative form in the referenced APTA Standard. These items have been developed into a check list to provide a minimum number of items to be certified when comparing MATA trolley items with the APTA Standard.

Section	Description	Compliance
4	**Programs & Procedures Applicable to all Vintage Trolley operations**	
4.1	Operating Rules	
4.2	Program of Instruction	
4.3	Maintenance Procedures and Instruction	
4.4	Maintenance Facility	
5	**Minimum Vehicle Equipment Requirements**	
5.1	Service Braking System	
5.2	Redundant Braking	
5.3	Parking Brakes	
5.4	Air Gauge & Low Air Alarm	
5.5	Stopping Distance	
5.6	Sanders	
5.7	Electrical Systems	
5.7.1	Documentation, Inspection & Testing	
5.7.2	Equipment Arrangement	
5.7.3	Wiring	
5.7.4	Control Arrangement	
5.7.5	Overload Protection	
5.7.6	Propulsion Line Breaker	
5.7.7	Main fuse Protection	
5.7.8	Auxiliary Circuits	
5.7.9	Lighting Circuits	
5.7.10	Lighting Protection	
5.7.11	Portable Fire Extinguishers	
5.7.12	Periodic Inspection & Training	
5.8	Wheel to rail interface	
5.9	Tamper resistance controls	
5.10	Emergency Exits	
5.11	Door Interlocks	
5.12	On-Board Safety Equipment	
5.13	Audible Warning Devices	
5.14	Interior Lighting	
5.15	Headlights	
5.16	Taillights	
5.17	Battery Backup/Emergency Lighting	
5.18	Grab Handles	
5.19	Pilot or Fender	
5.20	Windshields & Windows	
5.21	Mirrors	
6	**Additional Vehicle Equipment, Applicable Where Warranted**	
6.1	Deadman Interlock	
6.2	Low-Air Interlock	
6.3	Speedometer	
6.4	Turn & Stop Indicators	
6.5	Windshield Wipers/Defrosters	

Appendix 11 – MATA organization chart dated June 6, 2014



Appendix 12 – List of MATA staff and Memphis City Staff interviewed

The peer review team are appreciative for the opportunity to meet with the following staff and for the time taken out of their daily routine. We are also thankful for the City of Memphis EMA who also attended and provided us with information.

We found MATA staff to be very open, cooperative and helpful with our inquiries.

Alvin Pearson
Assistant General Manager

Don Forsee
Director, Rail Operations

Warren Henderson
Vehicle Maintenance Manager

Tony Parker
Vehicle Maintenance Foreman
(By telephone conference call)

Yuri Chambers
Safety Manager & Assistant Director of Safety/Training

Willie Lewis
ADA & Security Manager

Darryl Blackledge
Operations Supervisor

Constance Estes
Trolley Operator (trolley #452 November 4, 2013)

Harry Johnson
Trolley Operator (trolley #234 September 18, 2013)

Terry Issac
Trolley Operator (trolley #553 April 7, 2014)

Troy Chism
Trolley mechanic

Lt. Jim Logan
Manager of Office of Emergency Management (OEM)
City of Memphis