MIAMI-DADE TRANSIT

FIELD ENGINEERING, SYSTEMS MAINTENANCE, and STRUCTURAL INSPECTION & ANALYSIS DIVISION (FESM)

Divisional Modification Plan Review & Recommendations: COMPREHENSIVE REPORT

April 2007

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Miami-Dade Transit

Miami-Dade County Employee Relations Department

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Washington Metropolitan Area Transit Authority

Greater Cleveland Regional Transit Authority

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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

Project Objective and Process

The objective of this research project was to conduct an independent analysis to determine the reasonableness of a three-part divisional modification plan that was prepared by the Field Engineering, Systems Maintenance, and Structural Inspections & Analysis division (FESM) at Miami-Dade Transit (MDT). This assessment, which was completed by the Center for Urban Transportation Research (CUTR) at the University of South Florida (USF), included a review of the current state of FESM, a comparison of the division to similar groups at peer transit agencies, and the development of a series of recommendations related to each area of the divisional improvement plan. The project was formulated and completed under an existing inter-local agreement between Miami-Dade County and USF.

CUTR organized the research effort around three phases; each phase corresponded to an area of FESM. Specifically, the first phase of the project focused on the field test engineering section. Completed concurrently, phases two and three addressed the systems maintenance section and the structural inspection & analysis division, respectively. CUTR prepared an independent final report for each phase of the project. Later, the executive summary was compiled, and all four documents were bound in a comprehensive final document. The submission of the comprehensive report represented the completion of all project obligations.

During each project phase, CUTR reviewed the terms of a proposal to acquire personnel, to obtain equipment, and to modify the internal management structure of each corresponding area of FESM. Researchers documented the scope of responsibilities, as well as current staff positions, organization, and ongoing involvement in major projects. CUTR staff compiled information from FESM staff interviews, observations, agency documentation, data analyses (when available), and interviews with peer transit agency officials. CUTR examined FESM management techniques, supervisory ratios, and common practices. In addition, CUTR performed a regional compensation analysis for relevant positions in south Florida. Lastly, this research recommended specific actions for each FESM group.

Background

MDT is committed to providing safe and reliable transportation systems to the people of south Florida. The passage of the People's Transportation Plan (PTP) in 2002 created a legal obligation for MDT to improve and expand its transit service network to meet existing needs and to accommodate anticipated growth. Specific action items involved more than doubling the number of vehicles in the Metrobus fleet, modifications to Metrorail and Metromover vehicles, and engaging efforts to increase transit ridership. Clearly, such improvements are valued and welcomed, but the rapid pace and ambitious extent of the plan presented major challenges to most MDT divisions.

While the procurement of additional buses and the extension of rail lines are among the most discernible transit expansion measures, the internal agency infrastructure generally requires corresponding modifications in order to keep pace with increased operational and maintenance responsibilities. Several MDT divisions were originally conceived, staffed, and managed to service a 500-vehicle metro bus fleet. As the fleet grew larger, staff in some areas became pressed to the limits of their expertise in an effort to meet the additional workload. Left without a remedy, this circumstance would likely expose further critical issues. Corresponding measures to adequately staff and equip supporting divisions were deemed necessary otherwise well-intended service improvement efforts risked a contrary outcome.

By 2005, FESM managers had identified a number of staff and equipment deficiencies within each divisional area, and they recognized that planned agency growth would likely exacerbate such deficits. Without the development of an intervention strategy, personnel shortages had the potential to negatively impact the effectiveness of divisional engineering, maintenance, and inspection services. As such, FESM leaders devised a comprehensive plan to modify the divisional management structure and to address the growing demand for FESM services and the resultant expanding responsibilities. The modification proposal consisted of three plans; each focused on existing and anticipated staffing deficiencies specific to one of the FESM program areas.

Report Organization

The remainder of this executive summary presents an overview of each FESM plan and the analysis completed by CUTR, including an outline of the research methodology, a review of significant findings, and a synopsis of conclusions and recommendations. The following sections are intended to serve as a digest of the overall work completed for this project. For further details in any area, the reader is directed to the corresponding final report document(s) or the final comprehensive report.

PHASE 1: FIELD TEST ENGINEERING

At one time, MDT field test engineers reported to vehicle maintenance divisions and provided maintenance engineering support to equipment, systems, and small projects. The workload eventually grew to include developmental engineering services, large-scale systems implementations support, and at least minimal support to most MDT divisions. As such, field test engineers were incorporated into FESM and became responsible for five key areas of transit engineering: vehicles, train control, traction power, systems, and facilities. As responsibilities increased and the agency expanded, field test engineers also became more involved in non-engineering functions such as administrative, clerical, human resources, drafting, and other supportive tasks.

The first phase of this research effort focused on the plan to modify and improve the field test engineering section of FESM. The modification plan intended to add staff in deficient areas and to adapt the management structure to meet current and projected responsibilities. Overall, four specific areas of need were addressed, including:

1. Support for the Metrorail rehabilitation project;
2. Management of the universal automated fare collection (UAFC) project;
3. Support for Metrobus vehicle acquisition & maintenance efforts; and
4. Miscellaneous general requirements.

At the inception of this project, three groups comprised the field test engineering section: field maintenance engineers, fire & burglar alarms, and the electronic repair facility. The modification plan included measures to reestablish the section as a full-fledged division organized into seven specialty areas:

- Power & control,
- Vehicle support,
- Bus systems,
- Communications,
- Revenue,
- Product evaluation, and
- Transit facilities.

The modification plan also removed the electronic repair facility to the oversight of the FESM/systems maintenance section. To assure effectiveness and efficiency within the new field test engineering division, the plan stipulated that five of the seven specialty areas would be supervised by a specialized engineering manager.

Although five official vacancies existed within the current FESM/field test engineering section, the plan created additional clerical, technical, and management positions. Existing staff consisted of seven field test engineers (including four "leads"), two engineer (III) positions, one special project administrator, and one transit facilities superintendent/electrical. The modification plan identified twenty-seven new positions and reclassified eight existing positions. New and modified FESM/field test engineering staff included the following:

- Track systems engineer responsible for track maintenance programs, redesign, and support to track and guideway systems improvements and maintenance;
- Traction power engineer responsible for maintenance and repair of power delivery systems to Metrorail and Metromover guideways;
- Facilities maintenance engineers specifically dedicated to daily, routine facility systems and equipment;
- Mechanical engineers specifically dedicated to daily, routine bus or rail vehicle maintenance engineering needs;
- Electrical engineers specifically dedicated to serve daily, routine bus or rail vehicle maintenance engineering needs;
- Warranty engineers specifically dedicated to daily, routine rail vehicle maintenance engineering;
- Communications engineers specifically dedicated to meet relevant Metrobus vehicle maintenance engineering needs;
- Quality assurance engineers specifically dedicated to meet relevant Metrobus vehicle needs;
- Librarian or other staff positions specifically dedicated to maintaining a current library of technical documents; and
- Draftsperson to design, create, study, or provide technical engineering drawings.

Overall, the total compensation costs (annual salary plus fringe benefits) associated with full implementation of the twenty-seven new positions and eight reclassified positions were approximately $2.22 million. This figure included approximately $777,000 for required equipment associated with each new or reclassified position.

CUTR engaged a three-part analysis to review the FESM/field test engineering modification plan. First, a group of peer agencies was selected and reviewed. Then, CUTR compared and contrasted conditions and practices at the peer agencies with MDT. This step included an assessment of the manpower needs identified by the FESM plan. Lastly, CUTR conducted a total compensation analysis for each new and reclassified position.

CUTR enlisted WMATA (Washington, D.C.) and MARTA (Atlanta, Ga.) as peer agencies for comparison to MDT. The peer agency review focused on four general areas of interest: management philosophy, determining personnel needs, organizational structure, and evaluation techniques for employee productivity. CUTR found that the peers shared some characteristics and practices, yet differed widely in other areas.

WMATA and MARTA operated two modes of transit (bus and heavy rail) and were engaged in a variety of modernization and rehabilitation efforts. Similar to MDT, WMATA operated a diverse bus fleet, while MARTA operated a large percentage of alternatively-fueled vehicles. Each agency maintained several differences regarding its approach to field test engineering. However, similarities did exist in some cases.

Most engineering functions at WMATA were consolidated under one overarching division, and each engineering area included a full complement of support staff. Three chief engineer offices maintained most engineering responsibilities related to vehicles, facilities, and systems. WMATA engineering utilized a multi-tiered management hierarchy, which included assistant chiefs, managers, directors, supervisors, and various assistants. CUTR illustrated the example of the chief engineer-vehicles office. Specifically, this chief managed forty-six staff and organized the division into five areas: rail cars, rail car engineering, vehicle engineering, buses, and criteria, standards, & integration.

WMATA valued education and professional licensure among its engineering staff, and followed well-developed training and recruiting practices. Engineering managers engaged a proactive, preventive approach to problems, and maintained strong communication efforts. To maximize project management effectiveness, WMATA engineers used written work plans for most major efforts. WMATA resisted the use of engineering contractors, limiting contracts to specific tasks that could not be completed within the agency.

To determine staffing needs, WMATA engineering managers relied mostly on personal judgment and experience. To measure employee productivity, managers relied mostly on a subjective approach. Specifically, one-on-one meetings were conducted on a bi-annual basis to set goals, review progress, and discuss work performance. Fleet performance measures were not used during the process of individual evaluations.

Field test engineering functions at MARTA were generally managed by the operations division. Specifically, vehicle maintenance engineering service and warranty responsibilities provided technical support to bus and rail groups. The bus maintenance engineering service and warranty group had a staff of eight (including one manager) and was organized under the director of bus maintenance. The railcar maintenance engineering service and warranty group had a staff of eleven (including one manager) and was organized under the director of rail maintenance.

Engineering managers at MARTA relied mainly on a subjective approach to evaluate employee productivity. Specifically, one-on-one meetings were conducted on a bi-annual basis to set goals, review progress, and discuss work performance. Fleet performance measures were not used during the process of individual evaluations. In addition, professional engineering licensure was not a priority among vehicle engineering.

MARTA vehicle maintenance engineering engaged a policy of passive attrition. Specifically, although no staff were officially cut, engineering positions were eliminated rather than refilled as individuals left the agency. As a result, MARTA utilized engineering consultants whenever possible. An engineering consultant group maintained office space on MARTA property and was actively engaged in over one hundred separate projects.

CUTR relied on the peer analysis to evaluate the FESM modification plan. Data typically used for manpower-type analyses were not available for engineering positions, and work-time standards generally did not exist. In addition, fleet performance data were not directly relevant to an engineering staff comparison. Furthermore, quantifying engineering employee performance was difficult because of the nature of the duties and working conditions, such as long, non-traditional hours; rapid responses or brief investigations often requested with little advance notice; several ongoing tasks; and a general lack of documented work logs.

CUTR determined that the FESM/field test engineering modification plan was reasonable. The proposal emulated successful field engineering practices found to exist at the peer transit agencies. Specifically, both peers maintained specialized engineering groups, which were limited in focus and areas of responsibility. The peers also utilized specialized managers and multiple levels of oversight within each specialty area.

CUTR found that the proposed organizational structure and expanded complement of engineering personnel were sound and reasonable. Peer agencies arranged engineering groups to ensure highly efficient oversight. The peers also maintained a sufficient complement of staff among each engineering specialty area, which allowed personnel to maintain focus on their specific areas of responsibility. The FESM modification plan sought to enact these practices. In addition, the research effort showed that both peer engineering groups maintained various support personnel within specialized sections.

CUTR performed a total compensation analysis for each position allotted through the field test engineering modification plan. The analysis tool generated a market index figure for each position, which represented a simple comparison of MDT total compensation figures to the median amount for all similar positions among all other employers. Overall, total compensation rates for each of the seventeen classes of positions created or reclassified by the FESM/field test engineering modification plan were found to be competitive.

CUTR developed a series of recommendations based on the phase one results. Most importantly, the research effort confirmed that serious consideration should be given to enacting the terms of the FESM/field test engineering modification plan. Specifically, staff interviews, peer review efforts, and the comparison analysis demonstrated that the compliment of staff and management structure proposed in the plan would emulate methods proven to be successful. Without significant proactive steps, a result of decreased effectiveness among the field test engineering program seemed likely.

CUTR also identified additional steps that were likely to realize a positive impact on FESM/field test engineering. For example, the group should consider setting specific goals and objectives, and a clear mission statement should be developed and referred to as needed. Managers should also consider utilizing the strategic planning process to develop effective guiding principles for the new FESM/field test engineering division. CUTR also felt that it was crucial for upper-level management to understand and support the modification plan and to value a strong internal engineering program.

Other recommendations resulting from phase one involved strengthening communication practices between managers and staff, modernization of field test engineering office facilities, increasing training and recruitment opportunities, remaining current with the latest developments in engineering problem-solving techniques, and sharing best practices among other transit agencies.

The complete list of recommended actions is found in Chapter 5 of the phase one final report.

PHASE 2: SYSTEMS MAINTENANCE

Upon its inception, FESM/systems maintenance (FESM/SM) focused on tasks necessary to maintain existing equipment and systems. The group administered the installation, repair, and preventive maintenance of vital electronics equipment at MDT. This responsibility extended to all such equipment found in revenue and non-revenue vehicles, stationary facilities, and portable devices. Over time, the scope of services expanded, responsibilities increased, and each area of systems maintenance assumed additional responsibilities. Much advancement in systems-related technologies also impacted the workload. Planned transit enhancements, including the acquisition of new vehicles and the extension of rail service, is likely to further expand necessary duties in all areas of systems maintenance.

At the inception of this project, FESM/SM was organized into five work areas, including: farebox, fare collection, radio, electronic repair lab, and video/TELCOM. Each repair group faces ongoing challenges such as maintaining qualified and capable technical staff, complying with preventive maintenance inspection schedules, maintaining obsolete equipment, acquiring replacement components for out-of-production items, refurbishing existing component parts, implementing and maintaining new technologies, and responding to specific action and/or repair requests.

FESM/SM technical staff consisted of seventy-five unionized transit electronic technician (TET) positions in three areas of specialty: /lab, /radio, and

/systems. Under the current management structure, all technicians officially reported to one individual, the manager/SM. A significant amount of time spent by all FESM/SM repair groups involves preventive maintenance inspections and resultant repairs. In 2002, MDT began acquiring new buses as part of an effort to expand the fleet size. As a result, the number of scheduled PMs almost doubled between 2002 and 2004. Corresponding to this increase, FESM/SM experienced a significant decease in the percent of completed PMs. FESM/SM managers calculated that to fully comply with original manufacturer and FESM/field test engineering recommendations, fifty-two TETs dedicated solely to the completion of PM activities were required.

The second phase of the CUTR research effort focused on the plan to modify and improve FESM/SM. The modification plan intended to add staff in deficient areas and to adapt the management structure to meet current and projected responsibilities. Overall, three specific areas of need were addressed, including:

- Supervisory support (including reorganization and reclassifications);
- Technical support; and
- Administrative support.

Recommended modifications involved the reorganization of the section into more manageable groups, and the reclassification of the section to division status. Specific terms of the modification effort included the following staff acquisitions:

- 3 chief supervisors;
- 6 technical supervisors,
- 37 transit electronic technicians; and
- 2 administrative support staff.

In addition, the manager/SM was to be reclassified as chief/SM to oversee the reorganized systems maintenance division. The new FESM/SM division would consist of three overall work groups: revenue, communications, and power & electronic lab. Each work group would be managed by a chief supervisor, and specific maintenance areas within the groups would be managed by a technical supervisor. Overall, the total compensation costs (annual salary plus fringe benefits) associated with full implementation of the modification plan were approximately $2.9 million. This figure included approximately $330,000 for required equipment associated with each new or reclassified position.

Similar to phase 1, CUTR engaged a three-part analysis to review the FESM/SM modification plan. First, a group of peer agencies was reviewed. Then, CUTR compared and contrasted conditions and practices at the peer agencies with MDT. This step included an assessment of the manpower needs identified in the FESM/SM plan. Lastly, CUTR developed a series of conclusions and recommended actions based on the research effort.

As before, CUTR utilized comparable repair groups at WMATA and MARTA for comparison to MDT. The peer agency review focused on four general areas of interest: management philosophy, determining personnel needs, organizational structure, and evaluation techniques for employee productivity. CUTR found that the peers shared some characteristics and practices, yet varied considerably in other areas.

The organization, management structure, and ongoing practices among the peer agencies resembled the modifications proposed for FESM/SM. Both peers enlisted a multi-tiered management structure for systems maintenance areas. In addition, responsibilities were divided among a series of specialized work groups. Furthermore, technicians reported directly to an immediate supervisor rather than to an executive manager. Peer groups generally experienced difficulty in their efforts to monitor and review technician performance. Neither group utilized strict formulas to determine personnel needs. However, both actively engaged in policies designed to discourage technicians from switching between work groups and to preclude unqualified transit employees from picking into the systems maintenance group.

Other common systems maintenance challenges and concerns among the peers were noted. For example, both groups were in the process of implementing a “smart card”-type fare payment system. However, both groups were challenged to maintain older equipment and to find replacement components for older or obsolete systems. Neither peer group was responsible for review and archival storage of onboard video recordings, nor did they experience space concerns among repair shops or supervisory offices. Managers at both peer agencies described their concerns over the general lack of procedural documentation related to systems maintenance needs.

Only MDT had recently experienced a significant expansion among its metro bus fleet. As such, no comparable increases in systems maintenance demands were found among the peer agencies. However, peer groups agreed that overall, managers, especially those at the shop level, were most capable of determining staffing needs. This was especially true because employee productivity within systems maintenance was difficult to monitor and highly variable. Because typical data used for a manpower-type analysis were mostly unavailable for systems maintenance positions, work-time standards generally did not exist. In addition, fleet performance data were not directly relevant to the field. As a result, CUTR relied on the comparative analysis results to determine the "reasonableness" of the FESM/SM modification proposal.

Based on the condition that the peer groups already observed many of the policies and practices proposed in the FESM/SM plan, CUTR believed that the management structure and supervisory personnel acquisitions were sound and reasonable. Peer groups expressed a high level of satisfaction with existing arrangements, so it is reasonable to assume that the suggested changes to FESM/SM would be well-received and would likely result in improved efficiency and effectiveness.

Although no precise determination could be made regarding the specific number of transit electronic technicians requested, a plan to increase the number of technical staff seemed reasonable and justified when compared to current conditions and peer agency practices. For example, OEM standards and FESM/field test engineering recommendations for preventive maintenance inspections required fifty-two fulltime technical staff. However, only fifty-seven existing technicians were qualified to meet this need. If FESM/SM was to follow established guidelines to the letter, only five technical staff would be available for all other tasks. Additional examples strengthened the case to add staff.

CUTR developed a series of recommendations based on the phase two results. Most importantly, the research effort confirmed that serious consideration should be given to enacting the terms of the FESM/SM modification plan. Specifically, staff interviews, peer review efforts, and the comparison analysis demonstrated that the complement of staff and management structure proposed in the plan would emulate methods proven successful. A continued decline in effectiveness among the systems maintenance program seemed likely without significant proactive steps.

Additional steps that were likely to realize a positive impact on FESM/SM were identified. For example, the group might consider setting specific goals and objectives and developing a clear mission statement. Another advisement was to consider the strategic planning process for developing effective guiding principles for the new FESM/systems maintenance division. Other recommendations resulting from phase two involved developing a degree of specialization among selected technical staff, reassigning the video review process to non-systems maintenance personnel, engaging modernization of repair shop facilities, expanding training opportunities so that technical staff are knowledgeable in more than one are of systems maintenance, and refining a policy to maintain only qualified applicants for transfer into the division.

The complete list of recommended actions may be found in Chapter 5 of the phase two final report.

PHASE 3: STRUCTURAL INSPECTION & ANALYSIS

With the introduction of MDT Metrorail service in 1984-85, a structural inspection and analysis program was implemented to monitor conditions along the elevated railway infrastructure. As the system grew and new services were implemented, the expansion of inspection program responsibilities followed. The main objective of the FESM/structural inspection and analysis division (FESM/SIA) is to guarantee the safety of passengers by preventing catastrophic structural failures. The program focuses on early detection of structural flaws and other potential hazards along the Metrorail and Metromover systems. An effective inspection program should also minimize the extent of structural deterioration, resulting in lower repair costs.

Overall, FESM/SIA is responsible for inspecting, analyzing, reviewing, and documenting current conditions among the following MDT assets:

- elevated segments of the Metrorail system (*excluding* the topside of the guideway);
- Metrorail stations;
- elevated segments of the Metromover system (*including* the topside of the guideway;
- Metromover stations; and
- technical drawings of the Metromover and Metrorail system structures

FESM/SIA staff consists of one division chief, one inspector supervisor, four inspectors, and two drafters. Structural systems are inspected on a two-year cycle. Inspection results generate repair requests when necessary, and

FESM/SIA coordinates with the MDT track & guideway division to ensure completion of repairs. FESM/SIA maintains a field inspection book database, which includes repair action logs, findings, and structural drawings that graphically represent historical conditions and technical specifications of each 100-foot structural section.

The third phase of the CUTR research effort focused on the plan to modify and improve FESM/SIA. Unlike phases one and two, this modification plan was far simpler. While personnel, overtime, and equipment needs were addressed, the initial plan proposed to add just two staff: one engineering drafter (cadastral technician) and one secretary. Total costs associated with personnel acquisitions and related equipment were approximately $124,000. The plan also included inspector overtime costs (roughly $35,000) that were necessary to cover hazardous area inspections, which are completed during non-traditional business hours to minimize conflicts with roadway traffic. The effort was appended to include the reestablishment of an engineer (II) position dedicated to FESM/SIA. (Costs for this position were unavailable.)

Justification for proposed staff acquisitions was straightforward. Over the course of Metrorail and Metromover expansions, support personnel numbers had not kept up with FESM/SIA needs. As a result, drafters were unable to keep up with the workload generated by twice as many inspectors as well as start-up tasks associated with new structures. With no secretary dedicated to the division, drafters had also assumed many administrative duties. The situation was precarious because drafters were responsible for keeping the division in compliance with legally-obligated reporting criteria (Florida Statute 335.074). Furthermore, the secretary would help maintain the field inspection book library, which was in need of reorganization. The re-instatement and acquisition of the engineer (II) position was intended to afford the chief/SIA relief from double duty as the resident fulltime structural engineer and fulltime divisional oversight and management responsibilities.

To determine the reasonableness of phase three, CUTR again performed a peer agency review and comparison analysis. A total compensation analysis was also conducted. Lastly, a series of recommendations and conclusions were presented.

Like earlier phases, many practices and concerns among structural inspection groups at WMATA and MARTA were found to be similar to FESM/SIA. Each inspection group was organized under a larger, overarching group and was obligated to meet legal requirements. Although peers organized structural maintenance staff within inspection groups, FESM/SIA did not. However, the MDT division responsible for repairs was located in close physical proximity to FESM/SIA inspectors. Regardless of organizational structure, each inspection group agreed that such close working arrangements resulted in better communications between groups, greater productivity, and quicker responses to maintenance needs. Interestingly, only FESM/SIA employed drafters directly in the structures group.

Typical data used for a manpower-type analysis were generally not available for structural inspection positions, and work-time standards were not found to exist. In addition, fleet performance data were not directly relevant to the field. Again, performance data related to structures and inspections groups was minimal, so most comparatives were subjective. For example, regarding organizational structures, managers believed that their arrangements resulted in productivity gains, better communications, and quicker maintenance responses, but no data existed to support these claims.

The comparison analysis found that peer transit agencies retained engineering staff within their structural inspection and analysis programs. In addition, the most significant determinant of personnel needs was found to be the active managing officer of the group in question. While no work time standards were found to exist for structural inspection programs, it is reasonable to assume that FESM/SIA responsibilities will increase with further transit system expansion. In addition, the initial findings of the project showed that current staff were working at the reasonable limit of their collective capabilities. As a result, the establishment of an engineering (II) position within FESM/SIA was determined to be reasonable and justified.

Each structures group expressed concerns about the need for ongoing inspector training, yet it was often precluded by full schedules. Concerns were also raised about the arduous inspection process associated with steel box girders. Inspectors commonly found that this type of structure experienced premature deterioration more often than other designs. This was especially noted because recent Metrorail expansions were constructed using this configuration, and future expansions would nearly double the current mileage of the system.

Overall, the research analysis found that the FESM/SIA modification plan represented a proactive approach to curtail potential problems likely to result from insufficient personnel levels. The terms of the plan were determined to be sound and reasonable, and they warranted strong consideration for implementation. The research effort also showed that peer agency structural inspection groups maintained specific goals and objectives and defined a clear mission statement. FESM/SIA would likely realize positive results by emulating such practices. Furthermore, peer groups demonstrated superior organization and storage practices that were worthy of consideration. Such practices would also afford a much higher level of security for the sensitive documentation.

For the complete list of recommended actions for FESM/SIA, the reader is directed to Chapter 5 and the Appendix of the phase three final report.

MIAMI-DADE TRANSIT

FIELD ENGINEERING, SYSTEMS MAINTENANCE, and STRUCTURAL INSPECTION & ANALYSIS DIVISION (FESM)

Divisional Modification Plan Review & Recommendations:

PHASE ONE REPORT – FIELD TEST ENGINEERING

October 2006

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I. INTRODUCTION

This research project intended to assist Miami-Dade Transit (MDT) in documenting current internal processes, planned growth, personnel needs, and available resources within the Field Engineering, Systems Maintenance, and Structural Inspections & Analysis Division (FESM) and to develop recommendations for the plan to address them. This assessment, completed by the Center for Urban Transportation Research (CUTR) at the University of South Florida (USF), includes a review of the current practices within the division, a comparison with similar divisions at peer transit agencies, and recommendations for a division improvement plan. This project was performed under the existing inter-local agreement between Miami-Dade County and USF.

The overall research effort completed by CUTR was organized around 3 phases, which corresponded with each area of the FESM division. This report represents the completion of the FIELD TEST ENGINEERING phase of the project, which was the first phase of the project.

Background

MDT remained committed to providing safe and reliable transportation systems to the people of south Florida. Nonetheless, demands on the present systems continued to grow. With the passage of the People's Transportation Plan (PTP) in 2002, MDT became legally obligated to improve and expand its service. For example, planned growth among the Metrobus fleet will more than double the number of buses serving the citizens of Miami-Dade.

While such improvements were certainly welcomed by all, the rapid pace of expansion and the large number of newly acquired vehicles presented major challenges to most divisions within MDT. Specifically, many divisions originally conceived, staffed, and managed to accommodate a 500-vehicle metro bus fleet were compelled to meet the greater demands associated with a significantly larger fleet. Because of the high volume of additional responsibilities within the FESM division, staff were increasingly pressed to the limits of their specific areas of expertise.

At the time of this writing, FESM consisted of one division and two sections. To address challenges posed by MDT expansion plans and improvement projects, the FESM management team drafted an organizational modification proposal. Among the proposed changes were elevating the two divisions to division status. This proposed modification allowed for greater authority and oversight within the specific fields of engineering, systems maintenance, and structural inspection and analysis. Further modifications suggested by FESM management personnel addressed personnel shortages and established a more detailed hierarchy of management for each specific area of engineering.

Phase One Overview

During Phase One of this project, CUTR reviewed the proposal to add personnel, reclassify positions of oversight, and elevate the field test engineering section to division status. CUTR also documented the scope of field test engineering section responsibilities, section staff positions and organization, and ongoing major projects. Researchers gathered information from staff interviews, observations, agency documentation, data analyses, and interviews of peer transit agency officials. CUTR examined engineering management techniques, supervisory ratios, and common transit engineering practices. Specifically, transit engineering management styles and organizational goals and objectives are compared and contrasted. In addition, CUTR performed a regional compensation analysis for professional engineers in south Florida. Lastly, this research presented a series of recommended actions for the field test engineering section.

Report Organization

This research project involved 4 areas of effort, which are detailed throughout the 4 remaining chapters of this report. Chapter II described the current state of the field test engineering section, including major responsibilities, a review of staff positions, and presentation of an in-house sectional modification plan. Chapter III presented information compiled from peer transit agencies and provided a comparative analysis of peer agency practices and MDT. Chapter IV included an analysis of the in-house section modification plan, a salary comparison analysis for engineers, and a discussion of engineering staff productivity. The fifth and final chapter presented a series of conclusions and recommendations to improve the field test engineering section.

II. CURRENT STATE:
FIELD TEST ENGINEERING SECTION

Introduction

The intent of this chapter is to describe the current state of the field test engineering section, which is one component of the Field Engineering, Systems Maintenance, and Structural Inspection & Analysis Division (FESM) of Miami-Dade Transit. Specifically, the areas of responsibility of the section are presented, and the organizational structure of the section is discussed. Further, each staff position and its associated responsibilities are described in detail. Later, relevant portions of the proposed divisional modification plan are summarized.

The purpose of this review was to gain a thorough understanding of the scope of work for which field test engineering personnel are responsible. Further, the review showed the degree to which these responsibilities can be met, based on current staffing levels. Of specific importance were increases in responsibilities while the numbers of engineering personnel have remained constant. This documentation served as a basis for the analysis of the feasibility and appropriateness of the plan to modify the field test engineering section.

To complete this section, CUTR documented the current internal processes, division history, organizational structures, workload, and resource allocation within the existing field test engineering section. Information sources included a review of previously-produced reports, staff and management interviews, agency reports and proposals, and field visits. Several ongoing internal MDT projects that demanded the involvement of the field test engineering section were also described.

Scope of Field Test Engineering Responsibilities

Overview

Originally, the responsibilities of the FESM division focused on tasks necessary to maintain existing equipment and systems. Over time, the scope of services expanded, division responsibilities increased, and field test engineers assumed additional responsibilities. Any MDT division may formally request assistance from field engineering at any time and every MDT division receives at least some support from field engineering.

Overall, the broad scope of support provided by the field test engineering section included the following responsibilities:

- maintenance programs for all MDT divisions
- development of specifications
- implementation of small- and large-scale improvement projects
- various studies & analyses
- specific field engineering support to the following MDT divisions: ITS, Transit Engineering, Safety, QC/QA, Training (HR), Operations, Maintenance, and the Change Review Board.

Prior to 1999, field test engineers reported to MDT Metrobus, Metrorail, or Metromover maintenance divisions. As such, the majority of effort expended by the field test engineering section focused on vehicle-related maintenance services. Specific areas of service included: systems testing, maintenance program development & oversight, operations & maintenance procedures, engineering & construction, planning, training, contractor liaison, quality management & support, and engineering analysis & special reports. After 1999, field test engineers began reporting to the FESM division field test engineering section. As a result, many field test engineering responsibilities that had been minimal became vastly more important. These tasks included additional maintenance services, but also expanded engineering involvement in development services. Specifically, the additional maintenance services included information technologies support and equipment & systems redesign, while development services involved contract development & specifications, project management, project implementation, project feasibility studies, and code compliance.

Development Services

Before 1999, field test engineers reported very little contract and specification development for entire projects. Most specification development was limited to replacement parts and services. After 1999, field test engineering began to develop specifications for entire projects (such as acquisitions of new bus fleets, transit agency radio systems, modern fare collection systems, uninterruptible power supply and fire alarm systems, etc.) without the need or cost for consultants. Field test engineers continued to be responsible for this service, including the complete development of contracts for such projects. Related tasks involved organizing contractor design review meetings, systems availability, and specification and design revises. Further, field test engineers expressed significant participation in the contractor bid and selection process.

Project management by field test engineers prior to 1999 was generally limited to small-scale improvements to existing systems. After 1999, the section continued management of small-scale projects, but also became responsible for managing large-scale projects such as replacement of entire systems. Specific tasks included monitoring qualification tests, materials tests, pre- and post-shipment tests on location at vendor manufacturing facilities, and acceptance testing once the items arrive at MDT. Further, field test engineers were responsible for FTA-required plant inspections for best practices, as well as project documentation, including correspondence, technical manuals, drawings, reports, and plans. These items must be reviewed and controlled for all major projects, such as new fire systems, uninterruptible power supply systems, new fare collection systems, emergency lighting, and public address (PA) and voice enunciator systems. Field test engineers must also review and approve payment requests, various claims, and change orders. They also spent a considerable amount of working time arranging, coordinating, attending, and contributing to meetings with contractors and associated MDT divisions (i.e., Quality Assurance, Materials Management, Maintenance, and Operations.)

Prior to 1999, field test engineers' involvement in project implementations was generally limited to small-scale improvements to existing systems, such as single component retrofits or competitive purchases of consumable items. After 1999, field test engineering personnel became directly active in large scale project implementations, such as those mentioned above. Specifically, this responsibility involved the development and implementation of completely new maintenance programs for new systems. Field test engineers designed new processes and methods, and accounted for new equipment necessary to facilitate required maintenance operations. The training of maintenance personnel on new systems was also necessary, and field test engineers must provide perpetual, ongoing maintenance engineering service support to the new systems.

Field test engineering staff performed a limited number of feasibility studies for new systems prior to 1999. However, since MDT entered a period of considerable expansion of services, field test engineers became more widely involved in a growing number of complex feasibility investigations. Such tasks were generally above and beyond traditional maintenance services responsibilities, and engineers were required to submit proposals and scopes of services for a variety of improvement projects. For example, these tasks were necessary for an effort to install, operate, and maintain call boxes at every bus stop in Miami-Dade County (approximately 3,000 units). Additional examples of project feasibility studies tasked to field test engineering included those related to the Metrorail PA modification effort, automatic passenger counters, closed circuit television installations on vehicles and at stations, PBX upgrade and expansion, and the fiber optic network upgrade.

For work performed on MDT property prior to 1999, no effort was expended to comply with Miami-Dade County codes. Since then, all new systems implemented by MDT were reviewed by field test engineering personnel and made to comply with all county, state, and federal codes and regulations. Rather than reliance on outsourced services, field test engineering staff were responsible for obtaining all necessary permits and complying with related requirements, and closing permits as necessary. Specific fields involved with code compliance included electrical, communications, and IT.

Maintenance Services

Field test engineering played a key role in capital enhancements, especially by developing improvements for existing systems and developing purchase specifications for vehicles and necessary equipment. The group also developed preventive maintenance programs, investigated accidents and unusual occurrences, and conducted various equipment testing. Field test engineering engaged in technical component replacement, including working with original equipment manufacturers to acquire suitable alternatives to unavailable parts. When needed, technical specifications were designed, and potential replacements were tested as necessary to determine their acceptability.

Some divisions required greater input by field test engineering than others. For example, many responsibilities supported Metrorail performance and addressed obsolescence issues. Field test engineering also developed the preventive maintenance program. This duty involved determination of inspection intervals, clear documentation of maintenance requirements, and modification of OEM procedures as needed, based on unique, in-service experiences at MDT. Further, as equipment aged, field test engineers handled modifications and electronics issues. For example, the CAD/AVL system was originally designed for service with a 500-bus fleet however; the current composition of the fleet included almost 3 times as many vehicles.

The field test engineering section must be responsive to unscheduled needs, such as accidents, malfunctions, and other unusual occurrences, as they arise. For example, each accident or mishap on the Metromover system is investigated, as is each fire and bus accident that was obviously the result of a failure. In cases of fire, the response and investigation were immediate, and engineers expended considerable effort to determine the cause. In the event that several fires occurred, a wider investigation was usually completed. Ultimately, investigation findings were compiled into a written report and submitted to various MDT divisions, including bus maintenance, bus maintenance control, and safety. Prevention and/or corrective measures were included in such reports, as necessary. Field test engineering provided remedial training regarding incident-prevention or other remedies, as necessary.

The field test engineering section engaged in many quality control functions. MDT did not employ quality control inspectors, so the task was assigned to field test engineers. Each quarter, a new area of inspection focus was selected. Random observations and/or inspections were completed to ensure accuracy among maintenance personnel. For example, in the rail maintenance shop, a field test engineer had the authority to randomly board a vehicle and perform an inspection. In such instances, maintenance activities stopped while the field test engineer reviewed the inspection form and asked the attending technician to demonstrate the work being completed. In the event that a technician was not following the best known practice, corrective instruction was provided.

In some cases, field test engineering personnel were responsible for non-engineering tasks. For example, a lack of administrative personnel forced engineering staff to engage in many supportive tasks such as record-keeping, note-taking, note-transcription, and other documentation. Further, field test engineering personnel were frequently engaged in assignments beyond their specific areas of engineering expertise. For example, section personnel were tasked with preparing specifications for enhancements, re-constructions, and/or refurbishments to existing buildings and facilities. This was often especially problematic, and in some cases, lines of legal liability may have been crossed.

Additional Information – Field Test Engineering Support to MDT Divisions

As described earlier, an important purpose of this research effort was to acquire greater insight into the specific responsibilities of the MDT field test engineering section. The following paragraphs briefly provide additional details about engineering support in 5 key transit areas: vehicles, train control, traction power, systems, and facilities.

Field test engineers were responsible for support of vehicle operations and maintenance for all MDT modes, including Metrorail, Metromover, and Metrobus. Specifically, field test engineering personnel supported 136 Metrorail railcars, which operated on a 21-mile system. The section also provided engineering services to 29 Metromover vehicles that operated on a 4.4-mile automated guideway system. In addition, field test engineers were responsible to provide necessary engineering services to the over 1,000 Metrobuses, from a variety of manufacturers in the fleet.

Beyond the actual vehicles, field test engineering personnel were responsible for providing engineering service to the rail infrastructure, which included train control and traction power for both Metrorail and Metromover. Specific MDT train control assets that should receive dedicated field engineering support included the following:

Metrorail –

- 29 equipment room locations, including the yard facility
- 2 major control centers, including 1 for the William Lehman Center Yard Facility, and 1 for the total 22.5-mile system
- All wayside equipment, located throughout the 22.5 mile system and the maintenance facility.

Metromover –

- 19 equipment room locations, including the maintenance facility
- 1 control center
- All wayside equipment, located throughout the over 6-mile system and maintenance facility

Specific MDT traction power assets that should receive dedicated field engineering support included the following:

Metrorail –

- 23 AC unit substation locations, including at the William Lehman Center Yard Facility
- 22 750-volt DC traction power substations
- 1 6-track Stinger Trolley power system

Metromover –

- 19 AC unit substation locations, including at the maintenance facility
- All traction power substations located throughout the 6-mile guideway system
- Stinger shop power for the maintenance facility

Field test engineers were responsible to provide engineering support for a host of specific electrical equipment systems. In general, such equipment included fareboxes, telephones, radios, and fire alarms. The following is a complete list of these systems:

- 49 intrusion panels
- 31 Halon panels
- 70 fire panels
- 49 uninterruptible power supply
- 60 emergency trip stations
- 100 elevator telephones
- 120 emergency telephones
- 84 passenger-assisted telephones
- 9 console telephones
- 4 radio base stations
- 1130 mobile radios
- 678 handheld radios
- 916 vehicle logic units
- 994 transit control heads
- 136 communication controller units
- 19 CAD/AVL consoles
- 15 Maestro consoles
- 1042 DC-DC converters
- 2798 vehicle destination signs
- 610 vehicle closed circuit tvs
- 46 station signs
- 125 station closed circuit tvs
- 46 station PA systems
- 7 voice recorders
- 643 automated voice announcers
- 2 fiber networks
- 1 network of 25 SONET boxes
- 22 Metrorail fare collection systems
- 22 Metromover counter systems
- 916 Metrobus farebox systems
- 4 bus island farebox equipment systems

In addition, the current organization of the field test engineering section assigned the section direct responsibility for the electronics lab, which provided component repairs to Metrorail, Metrobus, and Metromover.

Prior to the development of the field test engineering section modification plan, MDT field test engineers provided limited engineering support to facilities. However, the plan included provisions for dedicated facilities-engineering support to include: all Metrorail stations and substations, the Palmetto Yard Metrorail maintenance facility, all Metromover stations and substations, the Metromover maintenance facility, all Metrobus maintenance facilities, all MDT administration buildings, and Metrobus, Metrorail, and Metromover central controls.

Section Organization

FESM is one of 4 divisions within MDT Operations. The position responsible for oversight of the division is referred to as: chief/FESM. The chief/FESM reported directly to the deputy director/operations.

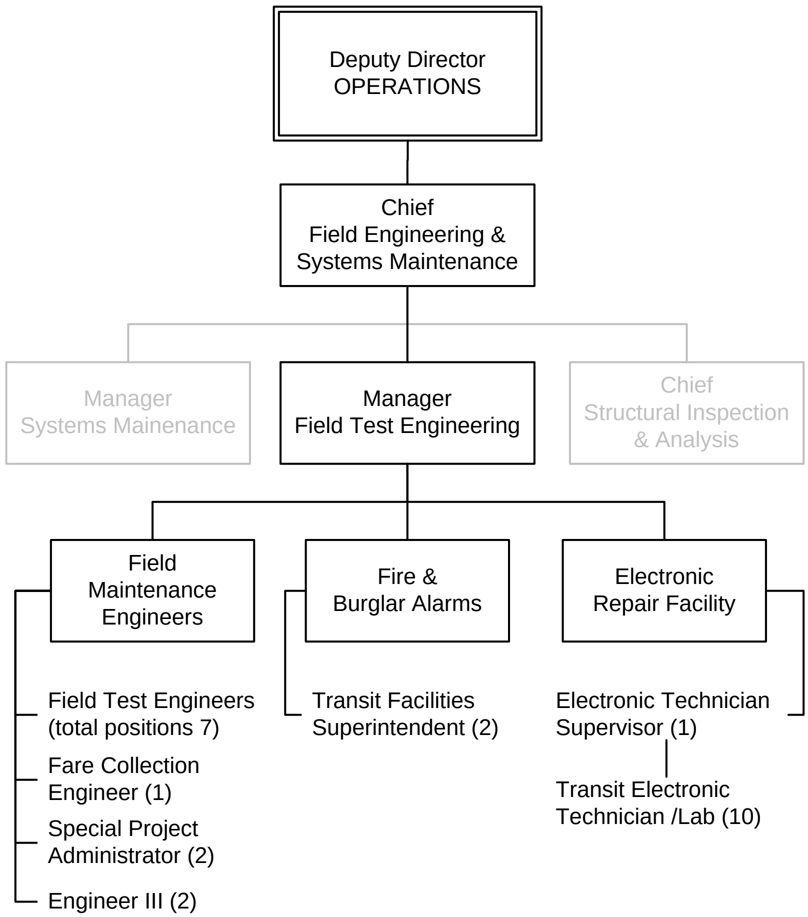
The field test engineering section was one of 3 areas within FESM. The position of section oversight was referred to as manager/field test engineering (see Figure 2.1). The manager/field test engineering reported directly to the chief/FESM. The manager oversaw 3 groups within field test engineering: field/maintenance engineers, fire & burglar alarms, and the electronic repair facility.

The field/maintenance engineer group included 12 positions, each of which reported directly to the manager/field test engineering. These positions included: 7 field test engineers (including 4 lead field test engineers), 2 special project administrators, and 2 engineer III positions. At the time of this research effort, 2 vacancies existed in this group.

Within the Fire & Burglar Alarm group, 2 positions were officially designated as transit facilities superintendent (electrical). Both positions reported directly to the manager/field fest engineering. At the time of this research effort, 1 vacancy existed in this group.

At the electronic repair facility, one electronic technician supervisor managed 11 staff positions, which were referred to as transit electronic technician/lab. The supervisor reported directly to the manager/field test engineering. Two technician positions were vacant at the time of this data collection effort.

Figure 2.1. Current Organizational Chart, MDT: FESM – Field Test Engineering Section



The following sections describe the official positions within the field test engineering section. Information presented for each position included general and specific responsibilities, involvement in special projects, employee evaluation techniques, the use of performance measures, and tasks completed during the course of a typical work day.

Field Test Engineers: Lead Field Test Engineer

There were 4 lead field test engineer (lead) positions within the field test engineering section of FESM. Each position was focused on a specific area within the transit agency, including: communications, vehicles, fare collection, and train control & traction power. The lead/vehicles covered all three modes of transportation provided by MDT (Metrorail, Metromover, and Metrobus). The lead/train control & traction power handled engineering issues related to the MDT facilities division, Metromover, and power distribution systems (PDS).

While specific job duties and obligations differed according to focus area, many general responsibilities and expectations of the lead field test engineer positions were similar. As such, one lead (train control & traction power) represented the position and provided CUTR with both broad and detailed task information.

Within the field test engineering section, the position of lead field test engineer reported directly to the manager/field test engineering. In general, the lead devoted 40% of working hours to maintenance and operations issues and 60% of time to special projects. Ideally, a maintenance engineer would spend 100% of time working on maintenance issues. Field test engineers were not bound by shift schedules and were available for work at all hours when necessary. This group was frequently required to work during non-revenue hours because necessary tasks would likely have a negative impact on both customer service and earnings. Overall responsibilities of the position included review of equipment malfunctions, communication with maintenance personnel, response to variable daily issues, and management of assigned special projects.

About 10% of the lead's daily effort was expended on communications with maintenance line supervisors and management of maintenance problems. Specifically, the lead received and reviewed a variety of malfunction reports to determine current status. Report data often included the frequency of equipment trouble, the status of operations, or recurring problems and issues. The lead determined whether or not problems or issues were unique to specific locations or to specific vehicles.

The lead investigated unique issues that arose during the course of the work day. Approximately 10% of time was spent in this manner. For example, specific power problems, fires, or other malfunctions may occur. In addition, the lead may be contacted to complete special work requests from high level agency officials, county commissioners, or other officials. Because such requests occur randomly, the lead was usually engaged in other regular project activities, which had to be put on hold in order to meet the needs of these special requests. In fact, special requests often became special projects themselves. Response to such requests must be immediate, so a lead usually does not take the time to log hours spent on them. The amount and frequency of special requests and the amount of effort expended on them may warrant one or more lead positions that are specifically dedicated to their focus. Because of the variety among the requests, leads from various engineering disciplines were considered necessary.

When maintenance engineers were first brought into the fold, extensive project management activities were not a major area of involvement for lead field test engineers. However, responsibilities evolved to include a variety of activities. For example, leads represented the general interests of MDT and the specific interests of MDT maintenance on project-related task forces and review bodies, and in the area of contract compliance. The lead expended from 30% to 40% of time actively managing ongoing special projects. They were involved at every stage of a project, from writing specifications and preparing the bid process to end-of-project responsibilities, such as closing permits, delivery of documents and manuals, and reviewing consultants' efforts. Examples of current, major special projects included the modernization of central control and 3 Metrorail expansion corridors (north, east-west, Miami Inter-modal center).

Each lead field test engineer managed salaried field test engineering staff. For example, the lead/train control & traction power had direct oversight of 2 engineers. However, project involvement may dictate that staff field test engineers reported to more than one lead. In general, supervisory ratios varied depending on the specific details of a project and ranged from as high as 10:1 to as low as 3:1. Strong, frequent, and open communication between leads and their reporting staff were vital to the success of projects. Daily correspondence was normal and often occurred frequently throughout the day.

With oversight of staff comes the responsibility of evaluating performance. In general, the lead field test engineer utilized an annual review process to judge employee productivity. Goals were set at the beginning of the evaluation period, and performance was based on project activity throughout the year. Specifically, staff were judged on whether their individual goals were met and how they interacted with other staff to complete projects as required. The review process was largely subjective, based on the views of the lead, the section manager, and/or other supervisors the individual may report to. It was significant to note that fleet performance measures were rarely tied directly to the measurement of field test engineering performance. Further, no data were used to directly evaluate engineering staff.

Employee performance feedback was mostly oral, although all positions of oversight also observed a monthly progress reporting process, which required that a formal progress report be generated and submitted to the immediate supervisor. Such reports were compiled by the manager/field test engineering and submitted to the division chief, who then submitted an overall report to the deputy director - operations.

Project management also involved oversight of MDT union employees. Through a formal process, the lead field test engineer can request labor support from relevant divisions as needed. Specifically, the chief or general superintendent from the involved division must grant the request and assign the necessary number of personnel to report to the lead.

> It is important to note that although the lead had oversight of the project and MDT staff temporarily assigned to the project, the lead maintained no official managerial authority over MDT employees.

This condition was a source of confusion and frustration among lead field test engineers (and non-lead project managers). The situation arose when the field test engineering section expanded but leads were not granted official management authority. As a result, the lead was responsible for employee oversight but had no real recourse to invoke discipline when necessary. As such, progress and effectiveness had the potential to be undermined in the event that employees under-performed. However, such occurrences were reportedly rare.

In the course of managing projects, the field test engineer was responsible for oversight of contractors. Specifically, contractors must prepare and submit weekly progress reports, which are reviewed by the lead. However, MDT did not utilize engineering contractors for maintenance issues. Leads also engaged in frequent contact with OEMs, including: Bombardier, Union Switch & Signal, Control Power Corporation, York, Carrier, Otis, Nortel, and Cisco.

Field Test Engineers: Fare Collection Engineer

The fare collection engineer position was actually one of the four lead field test engineer positions described earlier in this section. The distinct position was created to meet the increasing demands associated with the universal automated fare collection (UAFC) special project. Specifically, the designation allowed the lead field test engineer assigned to the UAFC project to officially forego almost all other responsibilities and devote fulltime effort to the project.

The fare collection project was originally conceived out of the need to modernize and standardize the system for collecting passenger fares on MDT transit vehicles. Specifically, each of the 3 transportation modes offered by the agency utilized a different method to collect fares. Clearly, this condition was inefficient, and with each system growing older and more difficult to maintain, implementation of an improved system was an obvious choice. Further, modern technologies that would allow compatibility among all 3 modes, commonly referred to as universal fare collection, were becoming increasingly available.

At the same time that MDT was considering universal fare collection options, administrators at TRI-RAIL were developing an idea for a regional fare collection system that would permit south Florida transit users to flow seamlessly from one area transit system to another and from one transportation mode to another. Ideally, the two agencies would establish a specific agreement, which would then allow additional transit agencies to adopt the regional system as they installed the necessary equipment. Such an ambitious and expansive fare collection improvement effort had yet to be implemented within the United States.

As the scope of the regional fare collection effort grew, the need for thorough technical specifications to support all varieties of buses, rail vehicles, and paratransit vehicles in use among the regional transit agencies became increasingly clear. In addition, implementations of other advanced equipment, such as automatic passenger counters, became part of the project. Participants hoped to utilize off-the-shelf systems, however, few manufacturers of such systems actually exist. As such, vendors scrutinized technical specifications and logged protests at appropriate points during the bidding process. As a result, the overriding agreement and the procurement specifications have gone through many revisions since the initialization of the project in 2000, and costs have grown to over $80 million.

At the time of this writing, a final revision of the technical specifications, agreeable to all interested parties (transit agencies and equipment manufacturers), had just been publicly released. Once a bid is accepted, the fare collection engineer will engage in a design review process. Further, the fare collection engineer will lead the effort to test equipment as it is manufactured and thoroughly review the test results. Specifically, the first 3 machines from each production batch get a round of testing. Following that, the fare collection engineer will oversee the implementation phase, which included equipment installation, in-service testing, and specification compliance testing. In addition, maintenance considerations of the UAFC equipment will also be identified. The fare collection engineer will also provide support, including training, documents, and manuals, to all other transit agencies as they implement the new system.

Until the new UAFC system was fully implemented, the fare collection engineer was also responsible for addressing maintenance and operational issues associated with the current (old) fare collection systems on MDT vehicles. Specifically, the fare collection engineer oversaw inspections and modifications of the current equipment. As the old system was phased out, new supported equipment included: new fare boxes, new fare gates (rail), ticket vending machines, automatic passenger counters, photo identifications (SMART CARDS), and ticket encoders.

The fare collection engineer had 1.5 dedicated and reporting staff. The supervisor of fare collection served as a full time assistant, while additional support for the UAFC project was provided on a part-time basis by the supervisor of the electronic repair facility (this position is detailed later in this section). The fare collection engineer also oversaw contractors and consultants as necessary. For example, consultants were retained to review the specifications of the UAFC project.

Special Project Administrator

Within the field test engineering section of the FESM Division, there were two special project administrator (SPA) positions, one of which was vacant. The SPA reported directly to the manager/field test engineering. The occupied position was focused mainly on Metrobus procurement however; the current SPA was considered the project manager for all bus-related projects (SPA-bus). Hired as a quality assurance engineer in association with the Metrorail implementation, the SPA-bus had 25 years of experience with MDT, in addition to a background in performance engineering and aerodynamics. Officially, the SPA position had no reporting staff; however, the SPA-bus oversaw one engineer-3 and oversaw light-duty staff occasionally.

Daily responsibilities of the SPA-bus centered largely on preparing and managing specifications for bus vehicle procurement. At the time of this writing, the current contract was a 5-year, $137 million agreement to acquire several hundred buses. The SPA-bus coordinated with the MDT Materials Management Division to write the technical specifications. The process involved reviewing requested inclusions in the contract. Such reviews involved approval or denial, or return of the request to its originator for further clarification(s). An appeals process was sometimes necessary before the specifications were finally sent out for bid. The SPA-bus also contributed to the preparation of requests for proposal documents.

The SPA-bus was among the most important liaisons between the vehicle manufacturers and bus maintenance personnel. As such, technical specifications for bus vehicle production also provided for inspections to be conducted within the manufacturing facility to ensure that the producer is meeting the design specifications. The SPA-bus prepared the in-plant inspection plans and specification sheets, and requested that the general superintendent of bus maintenance assign maintenance personnel to travel to the facility to conduct inspections. To give a variety of bus maintenance personnel exposure to the manufacturing process, different individuals were usually chosen for each trip. Further, the practice was meant to afford bus maintenance personnel the opportunity to observe and learn from factory techniques. (For example, a window replacement and installation that takes 4 hours in a maintenance facility may only require 10 minutes in the factory setting.)

The SPA-bus had a role in several ongoing bus maintenance-related activities, including preventive maintenance procedures, incident investigation, and vehicle modifications. Specifically, the SPA-bus contributed to designing preventive maintenance specifications and worked with the MDT Bus Maintenance Control division to evaluate the return on investment for preventive maintenance activities. Obviously, safety items were inspected, but the review also looked into other areas worthy of possible modification. The SPA-bus was not commonly involved with inspections at bus maintenance facilities, but quality inspections related to specific or recurring incidents were conducted periodically. For example, in the event of a fire, a complete analysis of the incident was usually performed. During the process, several similar vehicle models were examined to determine specific patterns of failure, if any.

The SPA-bus worked with vendors to design, test, and revise vehicle modifications when needed. Specifically, vendor modifications were tested by the vendor, while MDT bus maintenance and engineering tested non-vendor modifications. The SPA-bus established the bus change review board to review any and all potential modifications to vehicles in the fleet. However, the board did not meet regularly, and a backlog of items awaiting approval existed. Once modifications were accepted, the SPA-bus sent a modification notice to the Bus Maintenance Control division, which then issued the official modification to bus maintenance facilities. The Bus Maintenance

Control division added administrative codes, procedures, and recommendations to the notice as necessary.

The SPA-bus was involved in a variety of additional tasks. In general, 30% of working effort was expended on short term issues, while the remaining 70% was spent on long term projects. Tasks that usually required quick or immediate action by the SPA-bus included special requests from the agency director or county administrators, bus parts shortages, and incident investigations. Further, any issues related to safety received immediate priority. Anything that impacted the delivery of service to MDT customers was also a high priority. In addition to the ongoing projects of vehicle procurement and inspection described above, long term responsibilities included fuel contracts, warranty support, and informal train-the-trainer activities.

Transit Facilities Superintendent (Electrical)

At the time of this writing, only 1 of 2 transit facilities superintendent positions were filled within the FTE section of FESM. This position focused on fire and burglar alarms and had no directly reporting engineering staff. General responsibilities included project management, code compliance, inspections, and training. Because safety systems were carefully regulated, the daily tasks associated with this position were highly specialized and required the transit facilities superintendent to exhibit a precise degree of expertise.

A significant portion of the transit facilities superintendent's time (about 75%) was devoted to long term rehabilitation or refurbishment projects. Current rehabilitation efforts were focused on fire alarm systems in buildings, with rail station fire alarm systems slated to be updated next. The remainder of time was generally spent on short term responsibilities. Special work requests arose on occasion; they were most often completed on a short term basis.

The transit facilities superintendent performed many specific tasks during the regular course of managing systems rehabilitation efforts. First, a project plan was developed. The plan usually included procuring necessary materials, which may involve engaging a contractor to write the procurement specifications. The transit facilities superintendent reviewed the specifications and deals with material vendors. Specifically, proper documentation and permitting was required, and the superintendent ensured that sufficient replacement parts were ordered. In the event that a contractor was engaged to complete a portion of the project, the superintendent was responsible for facilitating approval by the "contracting-out committee". This committee was provided for by the collective bargaining agreement and afforded union employees a degree of influence in the process.

Intimate knowledge of and strict compliance with governing codes was a major responsibility of the transit facilities superintendent. Specifically, the National Electric Code book, which was revised every 3 years, was observed. Code compliance also involved adherence to the permitting process. The transit facilities superintendent obtained the appropriate work permits and then retained the responsibility to see that all work under the permit was completed. Once the permit was opened for a project, the superintendent had statutory supervision authority over all staff that worked on it. Such permits were time-limited, and the superintendent was responsible for closing it when the project was completed. Closing procedures included arranging for code inspections, attending to problems found (if any), and oversight of re-inspections and the final inspection.

The highly technical nature of responsibilities associated with this area mandated that communications between the transit facilities superintendent and project/maintenance staff be clear, timely, and effective. Specifically, the superintendent was obligated to respond to special requests for investigation and must physically inspect that all work performed complied with relevant codes. In addition, technicians may contact the superintendent for guidance on maintenance and operation of new systems or old, obsolete systems. In addition, this position had the authority to train and certify technicians as fire alarm agent technicians. Certification involved a background check and 14 hours of training, and technicians must be properly certified to work on fire alarms.

The transit facilities superintendent was also involved in preventive maintenance inspections of fire and burglar alarm systems. Specifically, the superintendent compiled OEM recommendations and code requirements to develop a preventive maintenance program. Selected OEMs related to this area included: APC, Simplex, Edwards, and Ansel.

Electronic Repair Facility:
Electronic Technician Supervisor & Transit Electronic Technician/Lab

There was one electronic technician supervisor (ET supervisor) within the field test engineering section of the FESM division. This was an hourly, GSA-Union position and reported directly to the manager/field test engineering. As a member of the UAFC project team, the individual in the ET supervisor position also reported to the fare collection engineer as a bus fare collection expert

(20 hours per week). Further, the ET supervisor retained a broad range of electronics repair experience (including aircraft, computer, and radio/telephone) and achieved progressive levels of education, certification, and licensure.

The ET supervisor managed the electronic repair facility, which was housed at the William Lehman Metrorail maintenance facility on the second floor. The ET supervisor had oversight authority over 12 full time, hourly transit electronic technician/lab positions, 2 of which were currently vacant. The facility operated during the day shift, Mondays through Fridays. Among the current staff, about half worked on a 4-day, 10 hours-per-day schedule, which the supervisor considered to be a more productive arrangement than the traditional 5-day work week. Mechanical and analytical skills among lab staff were highly specialized, and work assignments usually reflected their areas of expertise, which included rail equipment, soldering, electronic board battery replacement, programming, digital equipment, and microprocessors. Lab technicians were also commonly involved in support activities for special projects.

The overriding purpose of the electronic repair facility was to maintain a minimum spare parts ratio - to maintain an appropriate number of spare parts available in stock rooms. The lab and technicians were highly specialized, and they serviced a number of electronic bus and railcar components. Lab personnel repaired and refurbished components; then parts were re-distributed to maintenance facility stock rooms for use in regular repairs. Specific rail and bus electronic items serviced by the lab included: propulsion components, train destination signs, bus fare collection equipment, and auxiliary systems such as speakers, PA components, high speed over-voltage protectors, and the F-2 brake unit (an anti-skid device for railcars).

A typical day in the lab for the electronic technician supervisor, which began at 6 a.m., involved a variety of administrative tasks and problem-solving techniques. First, the ET supervisor reviewed work orders and other paperwork from the previous day to ensure that the work was completed properly and to look for discrepancies among hours and/or equipment. Next, the workload and work assignments were examined and redistributed (if necessary) in order to maintain an effective balance between rail- and bus-related tasks. As necessary, the ET supervisor also dealt with personnel matters, including sick calls, safety-sensitive position drug testing, etc.

For the electronic technician supervisor, there were concerns about parts extended beyond regular repair issues in the lab. Railcar parts may be up to 20 years old, and many were based on old or obsolete technology. Possibly, the original equipment manufacturer may no longer produce proper replacement parts, or in some cases, the manufacturer may no longer exist at all. As a result, locating acceptable substitute components was especially challenging, and the ET Supervisor utilized resourceful methods to acquire suitable replacements. For example, relationships with other transit agencies that operate similar rail vehicles (such as MTA in Baltimore) were being fostered in order to acquire functional salvage items. The ET supervisor also obtained spare parts through special orders, Internet searches, and special arrangements with vendors.

Based in part on the scarcity of specialized electronic replacement parts, MDT actively engaged in a policy of repairing and refurbishing such parts in-house whenever possible. The details of this process, and the role of the ET supervisor in it, were worth noting. After removing a malfunctioning part, the attending maintenance technician tagged it as "defective" and returned it to the stock area or stock room. A detailed description of the failure cause may or may not be included on the tag. Following this, the stock room clerk sorted defective parts according to who will repair them. Parts to be serviced at the electronic repair facility were placed in a designated area and retrieved by the electronic technician supervisor. At this point, the process may lag, because the supervisor didn't always have enough time to collect the defective parts on a daily basis. (Ideally, these parts would be delivered to the lab every day.) Once brought into the lab, defective parts were sorted for repair according to which technician(s) are most adept at the specific tasks required to restore them to working order.

Additional noteworthy information about the electronic technician supervisor and the electronic repair facility was related to productivity and performance. Technicians generally performed different tasks each day, so one of the only ways for the supervisor to gauge production is by physically observing that the employee was working. The backlog of items to be repaired also indicated general productivity, however no specific repair time standards existed for the components handled by the lab. Overall, the equipment was highly complex, and a considerable time investment might be necessary to pinpoint the causes of failures. As such, a trouble-shooting technique known as "fault isolation" is commonly utilized. Developed in the airline industry, this method called for the creation of wiring diagram flow charts to identify the exact sources of component failures. Through this step-by-step process, a technician found the problem quickly, or found that several steps of testing may be necessary. Once repaired, components were tested using a voltage load-simulating device.

FESM Division Modification Plan

The remaining section of this chapter introduced the proposed field test engineering section modification plan and summarized the conditions, concerns, and recommended actions presented in the plan. A more detailed discussion and analysis of the modification plan appears later in this report.

Overview

In February 2005, the chief/FESM submitted a detailed proposal to modify the structure of the FESM division and to augment the division's complement of field engineering and administrative support personnel. Throughout preceding years, demand for field engineering services grew at a pace that demonstrated FESM resources were becoming stretched too thin to adequately meet agency needs. Further, as responsibilities continued to expand, FESM decision-makers recognized the potential for a decline in service effectiveness. As such, a divisional improvement effort became increasingly necessary.

The overall intent of the FESM improvement plan was two-fold: It presented a responsive solution to existing personnel deficiencies, and it represented a proactive approach to meet future staffing and management challenges expected to accompany ongoing and forthcoming MDT transit improvement projects.

The FESM division modification proposal was presented in 3 plans. One plan was generated for each of the 3 areas within FESM: field test engineering, systems maintenance, and structural inspection & analysis. CUTR organized its research effort in a similar fashion. As such, this document focused on the field test engineering section modification plan (also referred to as plan #1 throughout this document). Subsequent phases of the CUTR project will discuss the remaining portions of the FESM proposal.

Plan #1 - Field Test Engineering Modification Plan

Field test engineers were directly involved in the design, acquisition, and implementation of many transit system improvements. As such, the first stage of the FESM modification proposal focused on the FESM field test engineering section. Plan #1 was organized into the following 4 components:

- Support for the Metrorail Rehabilitation project

- Management of the Universal Automated Fare Collection (UAFC) project
- Support for Metrobus acquisition programs and bus maintenance activities
- General requirements

Each component included specific personnel needs, costs, justifications, and services to be enhanced through implementation of the plan. Because field test engineering functions were complex and highly specialized, the FESM plan recommended that the section be reorganized into smaller, specialized groups. Manager positions would be created to oversee each field engineering group. The intended effects of smaller groups were more effective personnel supervision and project management.

It should be noted that the MDT quality assurance division submitted a separate, parallel request for 2 quality assurance engineers to support the rail project. Plan #1 also included the addition of 2 quality assurance engineers, one to support the UAFC project and another to support the Metrobus efforts. While the FESM plan included salary costs for these positions, the QA division maintained oversight of each, and neither position was included in one of the specialized groups created by the plan. 2 IT specialists were also added under the UAFC project. Again, salary costs for these positions were included in plan #1, but the MDT ITSS division maintained oversight of each and neither was included in one of the new specialized groups. As such, the QA and IT positions are included in this analysis, but they are not discussed to the same extent as direct field test engineering positions.

The following sections provide a very brief overview of each of the 4 major components of the FESM modification plan for the field test engineering section.

Rail Rehabilitation project

Field test engineering is obligated to provide electrical, mechanical, and warranty engineering services to support the Metrorail rehabilitation effort. Specifically, the project involved the complete overhaul of the existing railcar fleet, the purchase of 26 new railcars and 12 new Metromover vehicles, field engineering support for 2 new rail line extensions, and the technical warranty oversight and maintenance program development for the new vehicles.

Prior to the modification plan, no field test engineers were dedicated to full time support of the Metrorail rehabilitation effort. As such, the plan recommended the acquisition of 2 vehicle engineers and 1 warranty engineer, and the reclassification of a current field test engineer to manager/vehicle support (see Table 2.1). Plan #1 also detailed expected work duties and minimum knowledge, skills, and abilities for each job.

Table 2.1. Proposed Staff Acquisitions: Metrorail Rehabilitation Project

Action	New Position	Responsibilities	Education & Experience Requirements
Reclassify	Manager, Vehicle Support	· Develop, monitor, revise programs as needed (PM, campaign, etc.); daily operations support · Supervise Vehicle Support Engineering staff	· 20 yrs. exp. vehicle engineering, 10 yrs. lead · Bachelor of Science: Mechanical Engineering · MBA: Public Management (current occupant)
Acquire	Mechanical Engineer IV	· Mechanical oversight for all maintenance programs, special projects, retrofits, etc. for all rail fleets · Develop specifications, procedures & programs to improve rail maintenance programs	· Bachelor of Science: Mechanical Engineering · 7 yrs. exp. rail & auto. guide-way maintenance
Acquire	Electrical Engineer IV	· Electrical oversight for all maintenance programs, special projects, retrofits, etc. for all rail fleets · Develop electrical specifications, procedures & programs to improve rail maintenance programs	· Bachelor of Science: Electrical Engineering · 7 yrs. exp. rail electronics maintenance · 3 yrs. exp. electronics maintenance planning
Acquire	Warranty Engineer IV	· Oversee all warranty-related issues · Coordinate w/ Materials Mngmt. & Maint. Control	· Bachelor of Science: Elec. or Mech. Engineering · Min. 7 yrs. exp. in warranty (rail)

Universal Automated Fare Collection project

As described earlier in this chapter, the Universal Automated Fare Collection project was among the most ambitious projects of its kind to ever be undertaken in the U.S. However, only 1 full time field test engineer, along with 2 part time assistants, were assigned to the project. To be truly successful, FESM realized the need to offer a range of engineering support throughout the project period, from development and manufacture through implementation and regular operations and maintenance. Specific areas in need of strong support included: engineering, technical, administration, IT, quality assurance, and warranty support. As such, plan #1 called for the addition of 8 staff, including 4 engineers, 2 IT specialists, 1 administrative officer, and 1 production coordinator (see Table 2.2). Also, the existing fare collection (lead) engineer was reclassified as manager/communications & revenue.

Table 2.2. Proposed Staff Acquisitions: UAFC Project

Action	New Position	Responsibilities	Education & Experience Requirements
Reclassified	Manager, Communications & Revenue	· Supervise & coordinate all UAFC efforts · Supervise communications engineers	· Bachelor's Degree: Electrical Engineering · 20 yrs. / fare collection, elec. comm. systems
Acquire	Mechanical Engineer IV	· Upgrade & maintain UAFC systems · Support equip. & systems, inc. daily ops.	· Bachelor of Science: Mechanical Engineering · Transit mech. eng. Exp. (bus, rail, fare collection)
Acquire	Electrical Engineer IV	· Systems design & spec. review · Monitor, test, inspect UAFC elec. systems	· Bachelor of Science: Electrical Engineering · Transit elec. eng. exp. (bus, rail, fare collection)
Acquire	Warranty Engineer IV	· Oversee all warranty-related issues · Coord. w/ Mat. Mngmt. & Maint. Control	· Bachelor of Science: Elec. or Mech. Engineering · Min. 7 yrs. exp. in warranty, fare coll. equip.
Acquire	QA Engineer	· Will report to QA division · Ensure adherence to UAFC requirements	· Bachelor of Science: Elec. or Mech. Engineering · Min. 7 yrs. exp. in QA on large, capital projects
Acquire	IT Specialist (2 positions) (Systems Analyst II)	· Will report to IT division · Install & test new equip; integrate system w/ software, data, network, etc.	· Bachelor of Science: IT or Computer Science · Min. 7 yrs. exp. network configuration & mgmnt
Acquire	Administrative Officer III	· Liaison to BOCC, county mgr & attorney · Process & control docs., payments, etc.	· Bachelor of Arts/Sci: Business/Public Admin. · Min. 7 yrs. admin. exp. on large, capital projects
Acquire	Production Coordinator	· Establish & manage doc. library, inc. manuals, drawings, tech. docs, etc.	· Associates or Bachelor degree in related field · Min. 5 yrs. exp. maint. scheduling / prod. control

Metrobus Acquisitions & Maintenance

MDT actively engaged an effort to expand the Metrobus fleet to include over 1,200 buses by the end of the decade. However, only 2 field test engineering staff were available to support Metrobus, and these individuals were focused mainly on procurement. Unmanned responsibilities included contract development, testing and inspection, warranty claims, and maintenance plan development. Plan #1 recommended adding 8 engineering staff, including: 3 mechanical engineers, 2 communications engineers, 2 electrical engineers, and 1 quality assurance engineer (see Table 2.3). In addition, the existing special projects coordinator would be reclassified as manager/bus systems.

General Requirements

While the first 3 components of the field test engineering modification plan targeted specific special project needs, the last component covered all other shortfalls. This plan was considered the most proactive among the 4, as it anticipated future engineering needs and modern technologies. Specific areas of concern included contract development, systems and equipment production and installation, testing, inspections, and maintenance. Further, this plan detailed the effort to reclassify field test engineering status from section to division. Specifically, plan #1 added 8 staff, including 1 engineer in each of the following fields: mechanical-facilities, electrical-facilities, communications, track systems, and traction power (see Table 2.4). The 3 remaining additions would be support personnel: 1 engineering drafter, 1 office support specialist, and 1 secretary. 2 lead field test engineers would also be reclassified to manager status.

Table 2.3. Proposed Staff Acquisitions: Metrobus Acquisitions & Maintenance

Action	New Position	Responsibilities	Education & Experience Requirements
Reclassify	Manager, Bus Systems	· Manage all current and future bus procurements & maintenance programs · Oversee development of programs, modifications, improvements, etc.	· Bachelor of Science: (flexible) · Min. 5 yrs. exp. bus procurement, maint., Q&A · Currently holds position at MDT
Reclassify	Mechanical Engineer IV	· Mechanical oversight for maintenance programs, special projects, retrofits, etc · Develop bus mechanical specifications, improve procedures & programs	· Bachelor of Science: Mechanical Engineering · Existing employee at ME III level
Acquire	Mechanical Engineer IV (3 positions)	· Mechanical oversight for maintenance programs, special projects, retrofits, etc. · Develop bus mechanical specifications, improve procedures & programs	· Bachelor of Science: Mechanical Engineering · 7 yrs. exp. transit vehicle (esp. bus) maintenance · 3 yrs. exp. maintenance planning
Acquire	Electrical Engineer IV (2 positions)	· Electrical oversight for bus maintenance programs, special projects, retrofits, etc · Develop bus electrical specifications, improve procedures & programs	· Bachelor of Science: Electrical Engineering · 7 yrs. exp. bus electronics maintenance · 3 yrs. exp. electronics maintenance planning
Acquire	QA Engineer III	· Will report to QA division · Adherence to project requirements	· Bachelor of Science: Elec. or Mech. Engineering · Min. 7 yrs. exp. in QA on large, capital projects
Acquire	Communications Engineer IV (2 positions)	· Maintain all bus communications systems · Monitor & develop maintenance, PM, other programs for comm. equip.	· Bachelor of Science: Comp. or Elec. Engineering · 5 yrs. exp. in maintenance of transit (rail) comm. · 3 yrs. exp. in maintenance planning

Summary of Organizational Modifications

As submitted, the proposed FESM division field test engineering modification plan to support current and future transit growth at MDT significantly altered the organizational structure and augmented the responsibilities of field test engineering at MDT. Personnel numbers increased substantially, with several new positions created and a number of others reclassified.

Upon completion of the peer agency review in Chapter III, plan #1 will be further analyzed in Chapter IV of this report. Specifically, peer agency responsibilities, and the management practices and organizational structures implemented to meet those responsibilities, will be compared and contrasted to form the basis of the evaluation. Further, the plan #1 analysis section in Chapter IV will describe specific responsibilities and challenges of field test engineering at MDT, and will assess the suggested personnel complement and costs put forth to meet those needs.

Table 2.4. Proposed Staff Acquisitions: General Requirements

Action	New Position	Responsibilities	Education & Experience Requirements
Reclassify	Manager, Communications	· Supervise & coordinate all MDT communications system acquisition, maintenance, & design efforts · Supervise communications engineers	· 18 years exp. in maintenance, electronic lab supervision, engineering · Bachelor of Science: Computer Engineering
Reclassify	Manager, Power & Control	· Supervise & coordinate all MDT train control & traction power acquisition, maintenance, & design efforts, and manage relative engineers	· 23 yrs. exp. as train control engineer, inc. 7 yrs. as rail/transit systems technician · 20 yrs. exp. w/ MDT 10 yrs. as Lead FTE
Reclassify	Transit Facilities Superintendent – Elec.	· Supervise & ensure all electrical code compliance for installations, maintenance, etc. · Devise, monitor, revise fire alarm compliance	· Bachelor of Science: Electrical · 7 yrs. exp. transit electrical maint.
Acquire	Mechanical Engineer IV	· ME support for all existing and new facilities · Develop & oversee facilities maint. programs	· Bachelor of Science: Mechanical Engineering · 7 yrs. exp. trans. fac. /3 yrs. exp. maint. plan.
Acquire	Electrical Engineer IV	· EE support for all existing and new facilities · Develop & oversee facilities maint. programs	· Bachelor of Science: Electrical Engineering · 5 yrs. exp. trans. fac. /3 yrs. exp. maint. plan.
Acquire	Communications Engineer IV	· Develop comm. preventive maintenance prog. · Support daily maint., equip. modifications, etc.	· Bachelor of Science: Comp. or Elec. Engineer. · 5 yrs. exp. maintenance transit (rail) comm. · 3 yrs. exp. maintenance planning
Acquire	Track Systems Engineer IV	· Provide maintenance engineering support for upkeep & replacement of all system rail track · Design / redesign track, maint. program, etc.	· Bachelor of Science: Civil or Mech. Engineering · 5 yrs. exp. in maintenance of rail track systems · 3 yrs. exp. in maintenance planning
Acquire	Traction Power Engineer IV	· Manage maintenance & repair of power distribution systems for Metrorail & Metromover · Ensure proper maintenance compliance	· Bachelor of Science: Elec. or Mech. Engineering · Related transit systems experience
Acquire	Engineering Drafter II	· Support to all engineering sections · Organize & coordinate all project drawings	· Associate of Arts/Sci: Drafting / CAD · 3 yrs. exp. tech. eng. drawing
Acquire	Office Support Specialist III	· Maintain library of engineering documents · Support in budget & personnel matters	· High school diploma or equivalent · Clerical & supervisory experience
Acquire	Secretary	· Divisional administration functions · General clerical duties	· High school diploma or equivalent · 1 yr. clerical experience

III. PEER AGENCY REVIEW

Introduction

The practice of peer agency review as a component of public transportation research efforts is common. The method has repeatedly proven to be a highly effective means for gathering relevant information and comparing public transit agencies. Further, data transfer between transit agencies is often cited as a best practice, especially with information related to maintenance functions. Several steps may be involved in the peer review process, including preliminary data gathering, identification of additional data for further comparison, development of peer selection criteria, selection of peers for review, site visits, and final comparisons.

A sizable benefit of the peer review process is that review criteria are highly adaptable to the needs of the study. For example, one research project may require only general comparison between agencies, while the demands of another may warrant a highly specialized comparison. Further, a group of agencies selected as peers for one research effort may be completely inappropriate as peers for a different project.

In many ways, a peer agency review resembles a case study. Specifically, researchers arrange to visit an agency over the course of several days, conduct several interviews of relevant agency personnel, and observe common, relevant operating practices in order to compile a detailed profile of the peer. This technique allows for considerable interaction with peer agency officials and the familiar, yet informal, interview setting provides the opportunity for flexibility and a more relaxed and open interviewee. Furthermore, this method affords researchers the opportunity to establish a relationship that may benefit subsequent phases of the project or other future research endeavors.

Purpose

The goal of the peer agency review in this research effort was to document field test engineering methods in practice at other transit agencies. Four overall areas of concern guided the site visits, including: the organizational structure of the agency and the field engineering area(s); management philosophy and techniques used for prioritizing and assigning field engineering work; methods used to determine engineering personnel needs; and the ways in which the engineering employees' productivity is evaluated.

Regarding specific field test engineering functions, CUTR documented peer agency methods such as: support of rehabilitation and modification projects, writing procurement specifications, developing preventive maintenance programs, investigation of accidents and unusual occurrences, testing, addressing obsolescence issues, random vehicles inspections, and other capital enhancements.

Methodology

Past CUTR research efforts realized success by engaging in the site visit approach described above. With assistance and approval from MDT – field test engineers, CUTR identified 3 peer transit agencies for review. Primary factors considered during peer selection included growth trends and challenges similar to those faced by MDT. Peer selection was also based on prior knowledge of and relationships with the peer agency, peer agency multimodal transit service, and comparable fleet size.

Although 3 peer agencies were initially selected for case study, one peer agency proved to be very similar in practice to another. In addition, agency engineering officials were generally unavailable for a site visit and seemed somewhat reluctant to discuss operating methods in explicit detail. As such, researchers decided to forego the third site visit in order to focus on the other 2 agencies.

CUTR established contact with field test engineering counterparts at the peer agencies and gathered data through telephone interviews, published materials, previously-completed projects, and site visits to the agencies. Among the relevant information compiled during the site visits were: system extent and age, service characteristics, special environmental and climatic conditions, rehab investments (to date and planned), management philosophy, in-house vs. contracted activities, personnel details (including number of staff, qualifications, promotions, and training), shop capacity and capability relative to fleet size, labor environment, workforce characteristics, supervisory ratios and supervisory duties, and employee productivity.

Peer Agency Field Test Engineering Practices

The transit agencies selected for peer review were the Washington Metropolitan Area Transit Authority (WMATA), which served Washington, D.C., and the Metropolitan Atlanta Rapid Transit Authority (MARTA), which served the greater Atlanta area in Georgia. The following sections present peer agency review findings in detail. Further details related to individual peer selection criteria and peer research methodologies are included within each specific peer section.

WMATA

Overview

The Washington Metropolitan Area Transit Authority (WMATA) operated the second largest rail transit system and the fifth largest bus system in the US. The service area, with a population of 3.5 million within a 1,500 square-mile area, covered the District of Columbia, the suburban Maryland counties of Montgomery and Prince George's, the Northern Virginia counties of Arlington, Fairfax, and Loudoun, and the cities of Alexandria, Fairfax, and Falls Church. WMATA operated 2 transit modes: Metrobus (see table 3.1) and Metrorail (see table 3.2). Ridership in fiscal year 2004 was 336 million total trips, including 190 million rail trips and 146 million bus trips. WMATA is used by approximately 42% of people working in the central urban area.

Table 3.1. Peer Agency Operating Characteristics: WMATA - Bus Fleet

Bus Type by OEM	Fuel	Quantity	% of Total Bus Fleet
Flxible	diesel	351	24%
Orion	diesel	595	40%
Orion	CNG	250	17%
New Flyer	CNG	164	11%
New Flyer	hybrid	50	3%
Other	diesel	67	5%
TOTAL BUSES		**1477**	**100%**

WMATA Metrorail operated 904 railcars on 5 rail lines over 106 miles of track through 86 stations. The Metrobus operating fleet consisted of 1,477 buses that operated on 352 routes for a weekday average of over 135,000 revenue miles. The bus fleet was comprised of various manufacturers, including Orion, Flxible, New Flyer (CNG), and Ikarus and Neoplan, which were articulated.

Table 3.2. Peer Agency Operating Characteristics: WMATA - Rail Fleet

Rail Car Type by OEM	Quantity	Seats	Total Capacity	% of Total Rail Car Fleet
CAF/AAI	186	68	175	21%
Breda	428	68	175	47%
Rohr	290	81	175	32%
TOTAL RAIL CARS	**904**	**-**	**-**	**100%**

WMATA was involved in a variety of capital improvement projects. For example, the Transit Service Expansion Plan sought to double WMATA ridership by 2025. The agency was involved in a major capital improvement plan, which included system expansion projects and infrastructure renewal efforts.

Peer Selection Criteria & Research Methods - WMATA

Mostly at the suggestion of MDT field test engineering personnel, CUTR considered WMATA as a peer agency for comparison. Such unconventional selection criteria are not generally accepted for most research efforts however, this study was driven less by strict adherence to operating characteristics and more by discovery of imitable management techniques. Overall, operating characteristics and performance measures were very different between MDT and WMATA. However, like MDT, WMATA was engaged in a variety of capital improvement projects. As such, MDT field test engineers initiated contact with their counterparts at WMATA to gain knowledge and insight about engineering-related special projects management.

After CUTR became involved in this research effort, researchers pursued follow-up contact with WMATA engineering personnel. Initial investigation revealed that unique conditions existed among WMATA engineering divisions. For example, the agency had recently undergone an ambitious reorganization effort, only to have second thoughts about the shift. In fact, WMATA engineering staff initially tried to dissuade CUTR's interest, citing organizational uncertainty and the possibility that information gathered during site visits could end up invalid within weeks or months. However, it quickly became evident that WMATA management philosophy was innovative and worthy of inclusion in this study. In addition, no definite plan to further modify the engineering structure was in place at the time of this writing. As such, CUTR proceeded with the inclusion of WMATA as a peer for this study.

One similarity that was found to exist between MDT and WMATA is the vehicle mix (by type and by manufacturer) within their Metrobus fleets. Each agency has a combination of 30- and 40-foot buses, as well as mini-buses, articulated buses, and paratransit vehicles. Further, both agencies share similar metro bus OEMs.

From there, CUTR initiated contact with WMATA engineering personnel in positions deemed most relevant to the study and most comparable to the responsibilities of the MDT field test engineering section. Availability, willingness to participate, and accessibility were also determining factors in the selection of specific interviewees. One chief sought approval for his participation from the deputy general manager, including assurances that CUTR was not in any way affiliated with the Washington D.C.-area media.

To collect more detailed information about relevant field test engineering practices, CUTR interviewed the following WMATA engineering management personnel:

- Chief Engineer/Vehicles
- Manager/Vehicle Engineering
- (Acting) Chief Engineer/Facilities

The assistant chief engineer (ACE)/rail car engineering also attended and participated in a portion of the session with the chief engineer/vehicles.

It is also interesting to note that on the day before CUTR was scheduled to interview the chief engineer: facilities, the individual in that position resigned. As a result, the Assistant chief engineer/facilities – civil & track was elevated to acting chief engineer. Affording this research effort an exceptional level of courtesy, the acting chief honored the interview commitment.

The following sections illustrate the results of the WMATA interviews. Each position merited a separate discussion, including specific mention of the 4 general areas of concern and other relevant topics.

Organization - WMATA

Engineering functions at WMATA were consolidated under one division, collectively referred to as Planning, Development, Engineering, and Construction (PDEC). The head of PDEC was a deputy general manager, who reports co-directly to the WMATA chief of staff and the general manager/chief executive officer. Within PDEC, there were 8 offices / departments / units that collectively had oversight of 1,166 staff positions (see Figure 3.1).

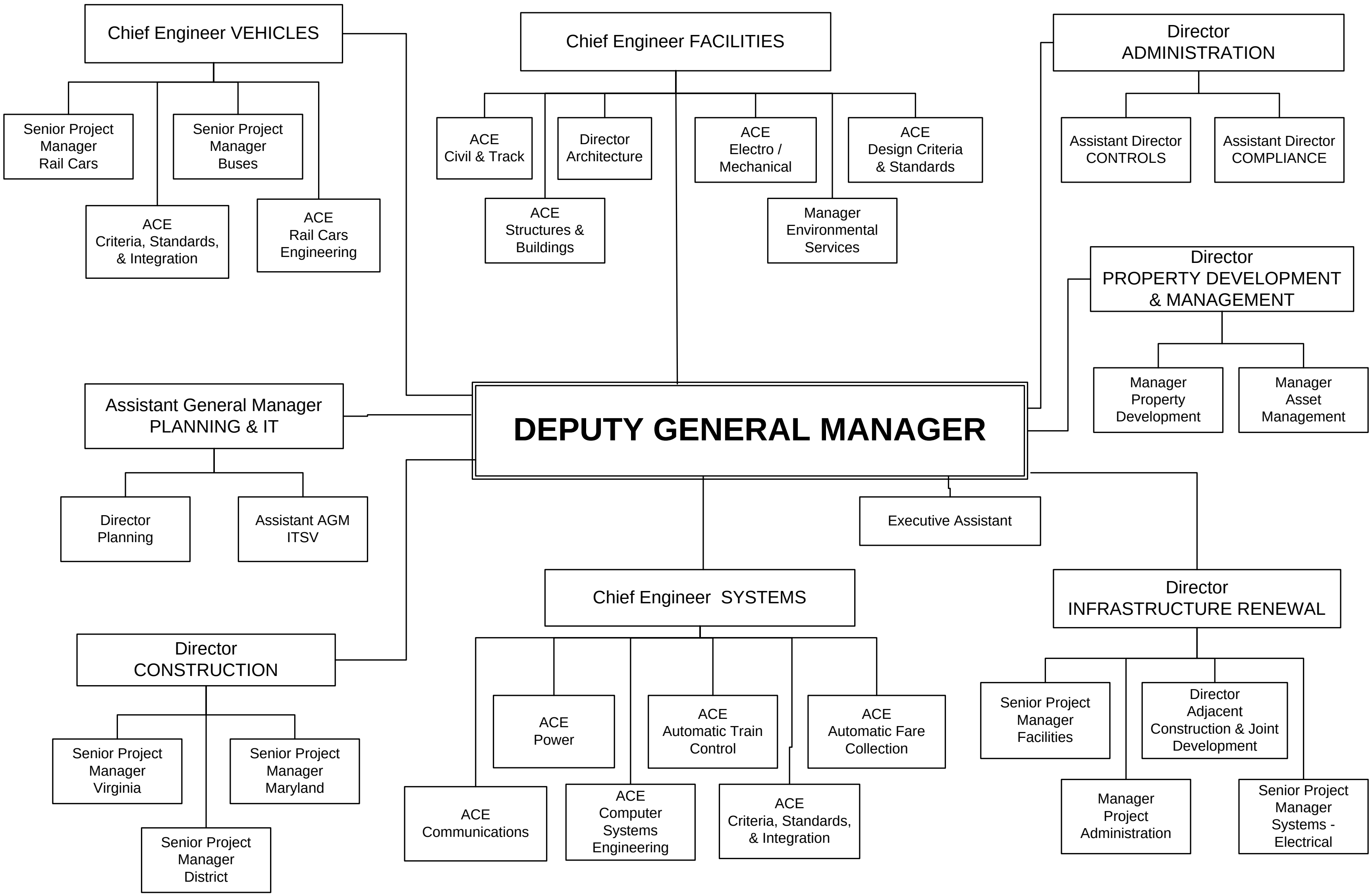
The offices / departments / units within PDEC were:

- Chief Engineer/Facilities
- Chief Engineer/Systems
- Chief Engineer/Vehicles
- Construction
- Infrastructure Renewal Programs
- Administration
- Property Development & Management
- Planning and Information Technology

In many ways, the structure and management of PDEC resembled a private engineering firm. PDEC had a highly refined mission statement, which included performance goals, a core mission, benchmarks, and objectives. In addition, each office generated its own specific goals and objectives, which were refined and presented on a quarterly basis.

The PDEC offices found to be most relevant to MDT field test engineering were those of chief engineer/vehicles and chief engineer/facilities. These offices were described in the following sections.

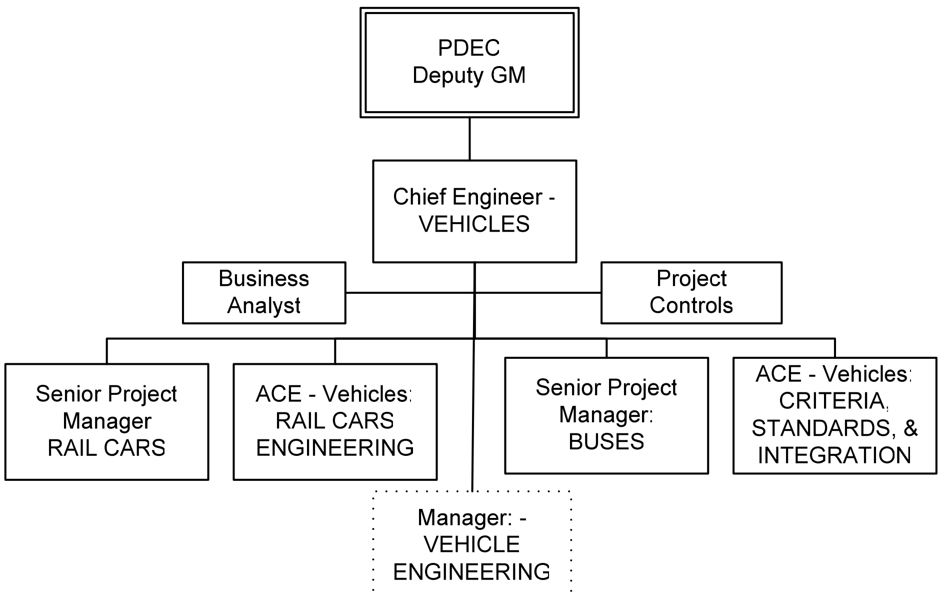
Figure 3.1. Organizational Chart, WMATA: Planning Development Engineering Construction (PDEC)



Chief Engineer: Vehicles (CENV)

The office of chief engineer/vehicles (CENV) was staffed with a total of 46 employees. In addition to the chief, there were 2 assistant chief engineers (ACE). There were also 2 senior project managers, 1 manager/vehicle engineering, 4 project managers, and 36 support staff, which included vehicle engineers, assistant managers, and administrative personnel.

Figure 3.2. Organizational Chart, WMATA: Office of Chief Engineer – Vehicles (CENV)



All assistant chief engineers at WMATA had an educational background in engineering, which included at least a bachelor's degree and were registered P.E.s. An example of the common structure under an ACE was illustrated using the ACE: rail car engineering. Under the ACE was a rail manager that managed a staff of 6 engineers. This group supported procurement and modifications through specification writing, as well as rehab and warranty efforts. For special projects, arrangements were made for maintenance personnel to be transferred to work on a specific project with the engineers.

The chief engineer/vehicles had been with WMATA for less than a year, but had a strong background in both public and private engineering. This level of experience influenced the CENV division to follow a pro-active approach regarding problems and to engage in preventive practices to head off problems before they become too large. In addition, the division used a "front burners" concept to manage priorities. Beyond mere updates, front burners required weekly documentation and status reported at weekly Friday meetings. Every meeting generated an action log for follow-up.

The CENV followed a straightforward management philosophy:

- First, managers must have clear goals and responsibilities, and present them openly.
- In addition, an effective manager should give people the proper tools to do their job.
- Then, management should get out of the way and let them do it.
- Further, trust and cooperation were identified as key elements for a successful engineering management operation.
- Clear and effective communications were also critical. For example, the use of bullet-ized emails was cited as highly effective for quick, clear communications.

The CENV practiced a flattened management structure. Specifically, this was the opposite of a pyramid approach, with the point being to drive down responsibility, rather than push it upwards. Because of excellent communication practices, staff felt empowered. For example, rail and bus engineers combined different forms of communication, such as email and a physical presence in the shop, to have a greater effect. Physical presence was especially critical so engineers had time to listen to concerns on the shop floor. Generally, engineers in the field worked closely with shop superintendents and supervisors.

The WMATA program operation outreach, which put engineers out in shops, was described as a highly effective technique. Engineers were assigned to specific shops and called on them periodically in much the same way that a route salesperson called on clients or customers. In some cases, an engineer might call on a specific maintenance shop 3 or 4 days per week.

The CENV was responsible for 10 rail maintenance facilities and 8 bus maintenance facilities. Ongoing rehabilitation projects included major efforts in both bus and rail. The CENV also oversaw the completion of about 100 major mid-life overhauls per year, which usually involved 7-9 year-old buses. 'Mini' overhauls were also completed every 3 years, especially in response to special conditions such as vehicles coming out of warranty. For example, when a part warranty expired, maintenance installed a better, more durable replacement part.

CENV had very specific methods to handle vendor campaign issues, especially those related to warranty. Specifically, a project engineer was assigned to manage the campaign and was instructed to manage vendors tightly. A work plan was written and submitted to the chief. The plan included the necessary budget, labor, and other needs, and was approved by both operations and PDEC.

> *The "dual approval" requirement was stressed as a key to successful projects because it built a bridge between those providing the service and those receiving the service.*

The work plan method of project management allowed for greater accountability and functioned somewhat like an internal specification. It allowed everyone involved to be aware of the terms of the agreement, and changes or modifications were made in the event that additional problems were found.

The "horizontal action team" (HAT) was a process for maintenance project management. HAT was engaged during design phase through the final acceptance. The HAT team was created from key operations and maintenance personnel. An example of a HAT project was the commissioning program to show rail car builders how they will design and be held accountable for work. HATs worked to minimize variation in contracts, so the supplier knew the detailed contract. A key component was the project acceptance criteria, which as indicated previously, tried to involve operations and maintenance personnel in projects earlier in the process. Specifically, managers wanted maintenance and operations involved in the process as near to specification writing as possible. This practice allowed maintenance and operations personnel to know first hand why specific decisions were made. The alternative was to just allow staff the end product, leaving them puzzled about the rationale for decisions that were made. In addition, having people involved at the front end allowed personnel the chance to step in and assist when they could help make changes or modifications.

Regarding outsourcing, WMATA had increasingly utilized the concept of out-tasking. Specifically, the entire job was not outsourced rather, only the portions of it that the agency might not have the ability or resources to complete were sent out. Examples included smaller jobs like bus painting, for which a small shop may have to contract out the work, or major projects, such as the rail rehabilitation campaign.

WMATA utilized a subjective employee evaluation process. During an employee's annual review, each engineering employee set yearly goals and objectives for him/herself. Managers conducted interviews and handled reporting staff. In some cases, the reviewer might suggest that the employee enroll in additional training. The work plan described earlier was a tool of employee accountability. Overall, 17 points were used to evaluate productivity. Specifically, a manager judged the level of success for a project and determined if extenuating circumstances caused a delay or worse. A personal work plan was also used to examine and to encourage individual growth.

WMATA engaged in innovative training efforts during recent years. For example, a DVD-type disc was produced, which used a game-type situation of repairs and diagnoses. Such enhanced training was a key element, and engineering staff were becoming more involved in the design and development of training. Procurement contracts usually included a training element. Further, a recent procurement contract included a specification for 75 new laptop computers.

WMATA utilized a concept referred to as training by system. Specifically, this method allowed for instruction on the complete package, including process and design, rather than just a solitary component. Although many vendors were involved in a complex, multi-vendor system, the old way was to only train personnel about their own components or materials, rather than on the entire system in which the component is a part. Training-by-system was a more inclusive method. Specifically, rather than referring to operations systems, Systems Operations Manuals forced users to look at entire system. This approach also reflected the complex interaction of market and manufacturers. For example, a rail car might be built in Spain, but brakes came from a different country, software from another, etc.

In vehicle engineering, staffing needs for procurement or capital programs were based largely on the judgment and experience of management personnel. The available project budget usually dictated staffing levels. Further, buy-in was needed from higher level management and board of directors. For specific project personnel needs (smaller projects that don't require hiring personnel) the process involved identifying tasks, establishing a work schedule, possibly engaging a simple spreadsheet analysis, and reporting labor needs. Larger projects frequently engaged in a more detailed analysis of manpower.

As an agency, WMATA valued retaining its own internal core engineering competencies. The CENV reported the difficulty involved with trying to find qualified personnel, especially those qualified with transit engineering experience. Usually, transit engineers had to develop skills and train from within the agency. Some innovative recruitment efforts involved internship/co-op program. Specifically, 6-8 college juniors in an engineering program might be tracked. From this group, 4 or 5 of the most serious students might emerge into the co-op program. The method allows WMATA to find the most interested individuals. The underlying goal was to attract young people and keep them in the transit engineering field for as long as possible.

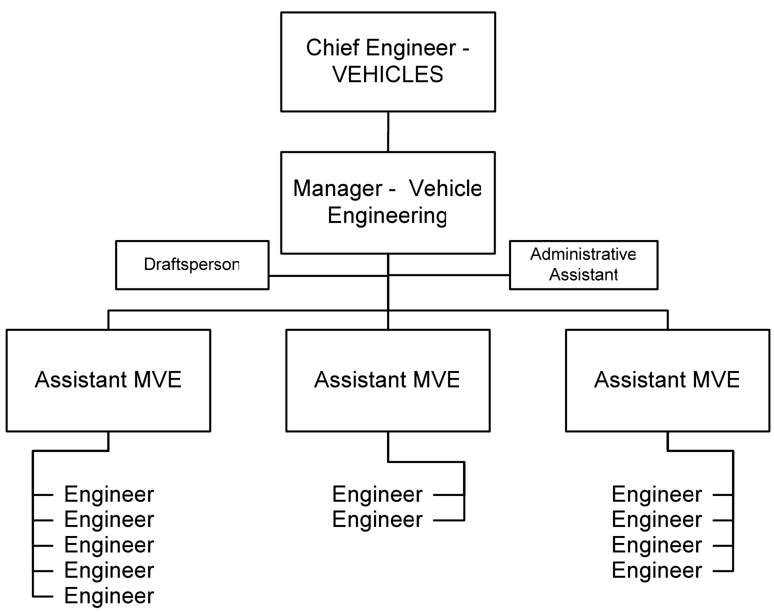
Manager: Vehicle Engineering (MVE)

The manager/vehicle engineering (MVE) position was actively involved at the maintenance shop level. This position held a unique status in that it directly reported to the chief engineer/vehicles, but the position did not show up on the current official PDEC organizational chart. Until recently, the interviewee served as an assistant chief engineer (ACE)/rail cars engineering. As an ACE, the MVE was a member of the chief engineer/vehicle executive group and had oversight of the following projects: HVAC rehabilitation, rail capacity study, AC traction motor rewind, wheel rail interface, and BCV brake overhaul. However, despite 28 years of service at WMATA, the individual was not a college-educated engineer and did not hold a P.E. As such, a degreed P.E. was hired for the ACE position, and the former ACE was reassigned with the title manager/vehicle engineering. WMATA was in the process of creating another senior project manager position and elevating the MVE accordingly.

The MVE worked out of the largest Metrorail maintenance facility and oversaw rail field engineers. Staff included: 3 assistant MVEs, an administrative assistant, a draftsman, and 11 field engineers (see Figure 3.3). Both assistant MVEs and staff engineers were salaried positions however; staff engineers were unionized (*Local 2*). Staff engineer specialties include: wheel/axle/gearbox, brakes, HVAC, train control & propulsion, procedures, electronic documentation, and other general areas. Some staff were involved in special projects, while others are not. The procedures area became a full time job of writing procedures and managing the document to keep it up to date and always ready for referral. Electronic documentation also involved a fulltime effort to keep manuals current. Neither the MVE nor staff performed random audits of preventive maintenance inspections. However, modifications or changes to the inspection sequences were documented when necessary.

The MVE was responsible for small overhaul efforts, which were those projects with less than a $25 million budget. The MVE spent at least 1 hour each day on the shop floor talking to and working with maintenance personnel. The MVE responded to work-related employee issues as necessary. A typical day also involved checking rail status, including reviewing cars out-of-service and looking at ongoing projects to determine what effects the project activities might be having on out-of-service rates. The MVE also spent about a third of the day on administrative and staff issues, such as attending general meetings, conducting project meetings, etc. In addition, the MVE spent part of the day working on assigned projects, including developing work plans and strategies. Oversight of smaller rehab projects was also a responsibility of the MVE.

Figure 3.3. Organizational Chart, WMATA: Manager/ Vehicle Engineering (MVE)



In general, the MVE assigned work according to the needs of rail car maintenance. The guiding principal was that rail car maintenance was the customer of vehicle engineering, so they dictated priorities based on requests for attention to different issues. The MVE also acted as a conduit for upper-level management priorities to shop-level staff. In some cases, selected priorities were "hot issues" with management, so they became priorities with shop staff. When the MVE assigned work, decisions were based on experience and which staff had the best skill set to complete the task. In some cases, the project was assigned to an assistant manager with a directive about which staff should do the work.

The MVE reviewed project status with assistant managers on a bi-weekly basis. Assistant managers generally achieved a high level of production. In cases of staff issues, the MVE talked to the assistant who had direct oversight of the employee in question. Action was taken as necessary. Employee performance was usually reviewed on a bi-annual basis. Direct supervisors met with employees to set goals, discuss work performance, and review project status. Performance criteria included agreed upon assignments and deadlines: were they completed successfully and on time? Fleet performance measures did not have a direct impact on employee evaluations, but the MVE looked at fleet data regularly.

Training was also a part of the review process. Specifically, the reviewer might have mandated training, directing the employee to attend sessions or classes rather than come to work for a certain day or period of time. Areas that were identified to be in need of improved staff expertise included mechanical, electrical, and electronics. Further, WMATA encouraged training. As such, selected staff were encouraged to get more training, and in some cases, employees were being groomed for management positions. The supervisor followed up with an email review of the discussion; this made the review somewhat formal because documentation was created.

The MVE managed contractors when necessary. Work may be contracted out when needed, and the MVE had authority to approve contracts. Contractors were usually engaged if the work at hand was beyond the capability of the shop. For example, the overhaul of specific traction motors was beyond the shop's capability, so the MVE contracted the assignment. It is uncommon for the MVE or other engineers to work beyond their fields of expertise. Although, electronics or the use of unfamiliar software may push knowledge limits at times.

Chief Engineer: Facilities (CENF)

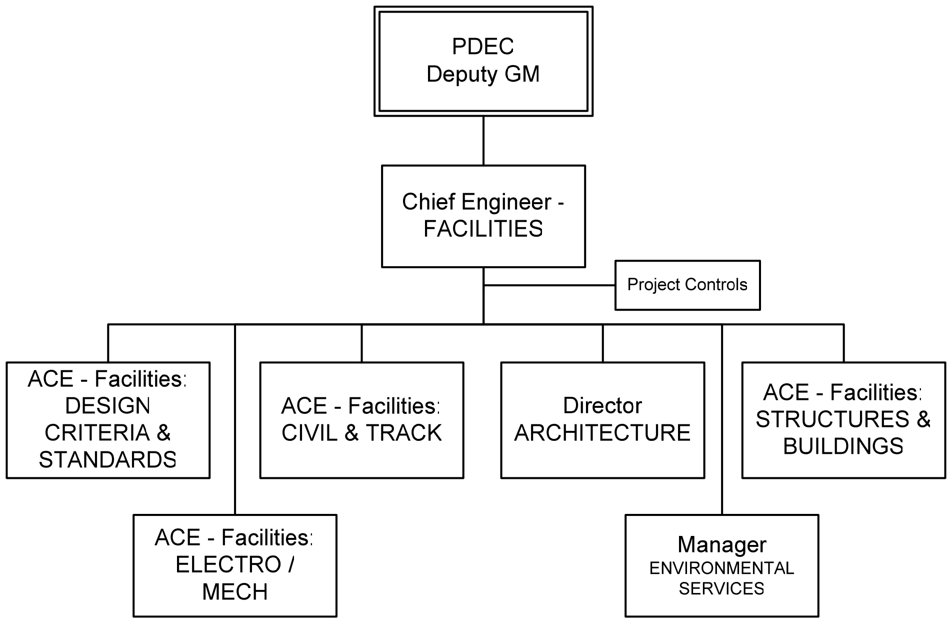
As indicated earlier, the chief engineer/facilities (CENF) resigned from WMATA immediately prior to the scheduled interview with CUTR. Fortunately, an interview had also been scheduled with the assistant chief engineer/facilities: civil & track. In fact, this individual was called into a meeting during the interview with CUTR and appointed acting chief engineer/facilities. As a result, the following section includes information related to both the CENF and ACE positions mentioned above.

The interviewee exemplified the common ACE at WMATA: 28 years engineering experience, including design, planning, consultant, light rail design and track work specialty. Educational background included a bachelor of science in economics, an M.A. in engineering, and a P.E. license. The new acting chief promised to modify the management philosophy in facilities. The former CENF assigned work specifically outside of many engineers' areas of expertise. This was done in an attempt to give people exposure to different tasks. However, the new CENF believed in assigning work according to the area of specialty. Balance had to be found between giving people exposure to different tasks and assigning work according to expertise.

The CENF division was a support division, providing 24/7 engineering support to operations for both Metrobus and Metrorail. CENF also provided WMATA's architect services, supported rail expansion projects, and performed reviews and updates for preventive maintenance procedures. There were 6 areas within CENF: civil & track, architecture, electro/mechanical, design criteria & standards, structures & buildings, and environmental services (see Figure 3.4). The ACE/civil & track oversaw 4 engineers, 1 CAD specialist, and 8 surveyors (WMATA does all its own surveys).

CENF functioned similarly to an engineering consultant organization. CENF did not necessarily manage projects on a daily basis. Rather, other departments, such as maintenance, construction, or infrastructure renewal handled daily project management. Some non-PDEC departments possibly included a staff engineer, but the staff engineer was usually in frequent contact with CENF, and CENF had final approval and oversight on all jobs, tasks, etc., including approval of materials, means, and methods. The CENF division aimed to be proactive; however, staff needs occasionally limited the level of pro-activeness that could be achieved.

Figure 3.4. Organizational Chart, WMATA: Office of Chief Engineer - Facilities (CENF)



As an example of CENF support, the ACE/civil & track signed approval of track equipment procurement and dealt with utilities and right-of-way. The ACE also supported design and construction, including 50% new construction, 25% renewal, and 25% maintenance. Support functions included budget management and construction scheduling.

Another example of the ACE support functions were those provided to operations. In some cases, problems arose that required a quick turn-around. Specifically, 5 rail breaks occurred over a short period of time (within a matter of weeks). CENF addressed the problem and investigated patterns and related problems. Corrective measures were identified, and a list of recommendations was presented. In fact, this investigation is an example of the quick action and results that are made possible by having an extensive in-house engineering resource. Further, no consultant contract is in place to deal with such short-term issues. Regarding engineering in general, it is WMATA policy to hire few consultants, if any. The agency preferred to rely on in-house personnel to perform engineering functions.

The acting CENF reaffirmed that using a subjective approach to measure productivity among engineers was common. Such methods were especially common among public transportation engineering departments because the end product is safe, reliable service rather than a product. It was difficult to measure an engineering department's impact on safe, reliable service, let alone the impact of an individual employee. Further, it was difficult to quantify engineering staff because they are involved in so many varied and different activities. One of the few ways to gauge individual performance was to look at each project and rate employee performance and the overall success level of the project. The idea of retaining an outside firm to rate the overall department was mentioned, but this was not viewed as a feasible or likely method for evaluation.

WMATA utilized a 3-step employee evaluation process. At the beginning of each year, each employee established a performance plan. There was a mid-term review conducted at some point during the year. At year's end, an evaluation was also conducted, which consisted of general questions as well as a specific review of the individual performance plan. Data or fleet performance data were not relevant to individual performance. The final employee rating affected the annual pay raise.

MARTA

Overview

The Metropolitan Atlanta Rapid Transit Authority (MARTA) was recognized as the 9th largest transit system in the US. The service area, with a population of over 1.5 million, covered the city of Atlanta and the counties of Fulton and DeKalb. On any given weekday, an average of over 460,000 people ride MARTA, with over 61% using the system to travel to and from work. MARTA operated 3 modes of transit: bus, rail, and paratransit. The revenue fleet was comprised of 556 buses (441-CNG, 145-Clean Diesel), 338 rail cars, and 110 paratransit lift vans. MARTA rail cars operated almost 23 million annual miles over 48 miles of track through 38 rail stations. The average age of rail cars was 16.5 years. Meanwhile, MARTA buses traveled over 25 million miles per year on 120 routes. The agency also maintained 9 major facilities and employs 4,355 people. For fiscal year 2005, MARTA's capital budget was $445.8 million, operating budget was over $306 million, and total assets valued at $4.7 billion.

MARTA was actively involved in a variety of special programs. Among these were the clean fuel bus program, the small bus program, and planning studies, including the study of bus rapid transit. In addition, MARTA was in the process of a major rail car rehabilitation effort. Specifically, over 200 rail cars will be completely rebuilt. Lastly, MARTA was renovating all 48 miles of rail track under the scope of an $80 million effort.

Peer Selection Criteria & Research Methods - MARTA

CUTR engaged MARTA as a peer agency for comparison based largely on two related criteria. First, MARTA was in the process of a major rail car overhaul project. Specifically, the ongoing project involved the complete rehabilitation of 238 vehicles, which comprised over 70% of its rail car fleet. With a similarly ambitious rail car modernization effort scheduled, MDT field test engineers contacted their counterparts at MARTA and forged a relationship to gain knowledge and insight, especially in the areas of personnel needs and project management. An initial review of field engineering practices at MARTA revealed that further documentation was warranted.

After contracting with CUTR to review its personnel modification plan, MDT field test engineering staff suggested that CUTR utilize the established relationship with MARTA and provided CUTR with preliminary findings and contact information. From there, CUTR initiated contact with MARTA engineering personnel in positions deemed most relevant to the study and most comparable to the responsibilities of the MDT field test engineering section. Availability and accessibility were also determining factors in the selection of specific interviewees.

To collect more detailed information about relevant field test engineering practices, CUTR interviewed the following MARTA engineering management personnel:

- Manager - Rail Car Maintenance Engineering Service & Warranty
- Manager - Bus Maintenance Engineering Service & Warranty

A MARTA rail car maintenance superintendent also attended and participated in the rail car engineering interview.

Organization - MARTA

Engineering functions at MARTA were organized under the deputy general manager. However beyond this level, engineering was decentralized, with responsibilities divided between 2 assistant general manager (AGM) areas (see Figure 3.5).

The first AGM group was engineering & infrastructure, which covered functions related to contract management, program direction, planning, and facilities maintenance.

The second group, AGM/operations, maintained authority over 2 vehicle maintenance engineering sections. Specifically, the manager of bus maintenance engineering reported to the director of bus maintenance. In addition, the manager of rail maintenance engineering reported to the director of rail maintenance. Both the rail and bus maintenance divisions, along with 3 transportation divisions, reported to the AGM/operations through a senior director of operations.

The following sections illustrated the results of the interview process. Each position merited a separate discussion, including specific mentions of the 4 general areas of concern and other relevant topics.

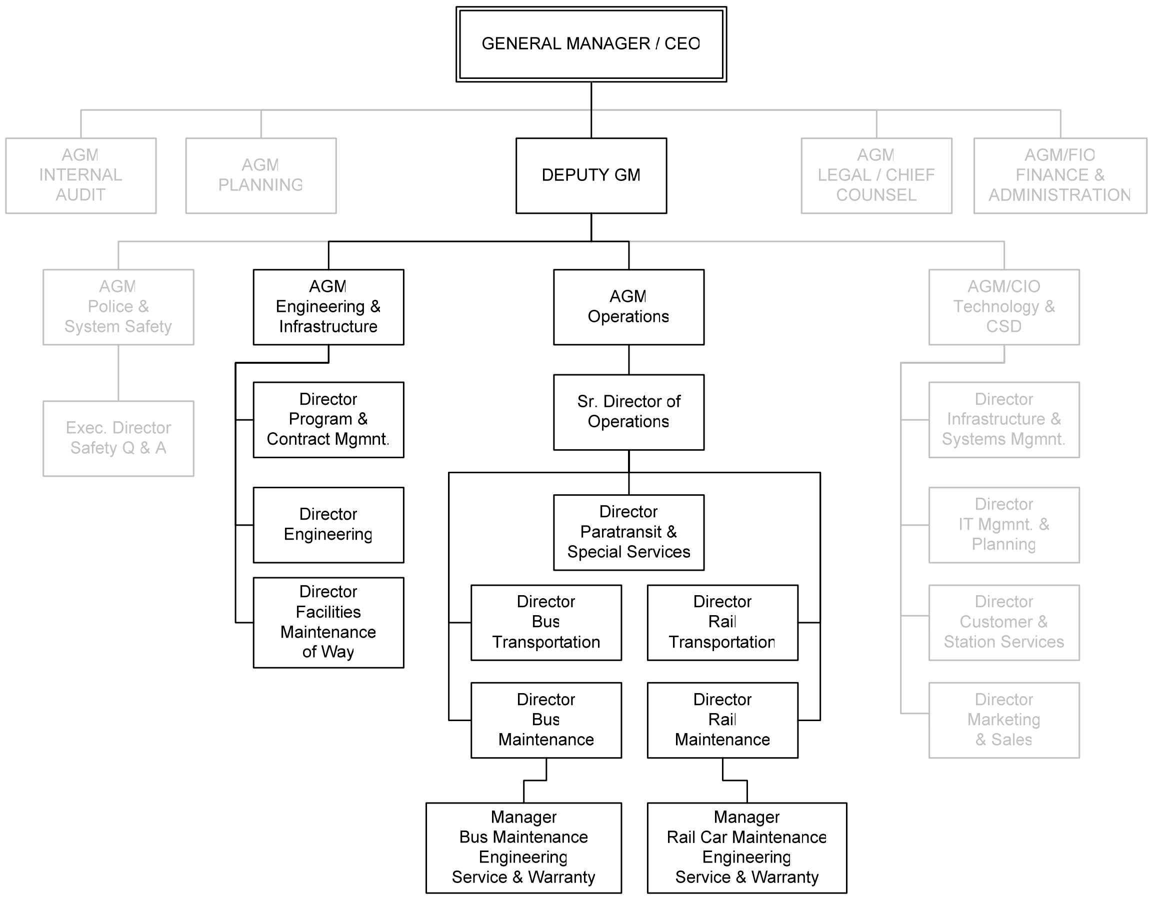
Manager – Rail Car Maintenance Engineering Service & Warranty

The rail car maintenance engineering service and warranty department (RCME) was organized within the rail maintenance division, which was 1 of 5 divisions under operations. The position responsible for oversight of RCME was referred to as manager/RCME; this position reported directly to the director/rail maintenance. The current manager/RCME had a strong background in transit maintenance and engineering. In fact, this individual designed the current structure and organization of the RCME Department.

There were 6 specialized fields within the RCME department: chief of vehicle engineering, electrical engineer IV, mechanical engineer IV, senior engineering technical specialist, contracts administration, and warranty (see Figure 3.6). There were 4 positions within electrical engineer IV, while the remaining fields had 1 staff each. Each of the 9 engineering positions reported directly to the manager/RCME. At the time of writing, there were no vacant positions in RCME however; MARTA was engaged in a policy of passive attrition regarding this department. Specifically, 4 additional engineering positions once existed in the department. As those positions became vacant, they were simply eliminated rather than being re-staffed. This practice allowed MARTA to avoid directly cutting staff. (At the time of this writing, it was unclear whether future vacancies would also result in the elimination of positions.)

Presently, 2 of the 9 staff were licensed professional engineers. Further, the engineering staff maintained official manager oversight authority. This designation was most relevant to the vehicle, electrical, and mechanical engineers because these positions spent a large portion of time working on the rail maintenance facility shop floor. Lastly, the senior engineering technical specialist spent a significant portion of time working with CAD equipment.

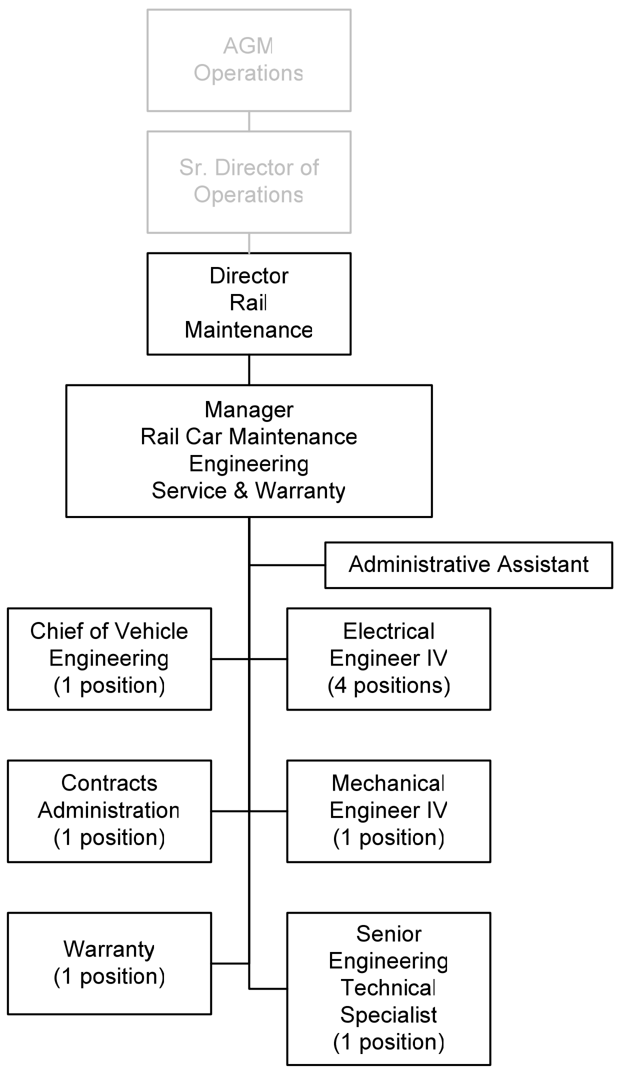
Figure 3.5. Organizational Chart, MARTA: Deputy General Manager / Operations



The overarching management philosophy that drove RCME management and staff was to keep rail car operations running as smoothly as possible. As such, the main role of the department was considered technical support. Staff were responsible to address critical maintenance issues (such as parts), meet requirements, seek quick solutions at all times, and determine the nature of problems as quickly and accurately as possible.

Support and oversight of the rail car rehabilitation effort were among the primary responsibilities of RCME. Specifically, the manager/RCME participated in the review process for the initial rehabilitation contract, and the chief of vehicle engineering officially represented the agency on the project. In addition, the chief dealt with most design and technical issues related to the effort. As mentioned above, the project provided for the complete overhaul of 238 rail cars out of the total 338 in the MARTA fleet. Currently, 46 vehicles were at an offsite location undergoing a total rehabilitation, which included conversion from an AC to a DC power supply. RCME staff were involved with testing freshly rehabbed rail cars and compiling data about new vehicle features.

Figure 3.6. Organizational Chart, MARTA: Rail Car Maintenance Engineering



After rehabilitation was completed, new vehicles re-entered service and were covered under warranty. As such, except for warranty staff, RCME support of freshly rehabbed rail cars tended to be somewhat reduced.

However, RCME was still responsible for maintenance support to all rail cars that had yet to be refurbished. Specifically, engineers commonly developed special programs for vehicle equipment modifications including safety or efficiency enhancements. Such efforts were marginalized by MARTA's policy of deferred maintenance regarding pre-rehab vehicles. As a result, upper level agency management routinely denied (or deferred) special maintenance engineering programs for rail cars such as retrofits, corrective actions, or other special installations. Consequently, RCME actively reduced its involvement in preparing fleet-wide modification programs. However, RCME staff engaged in the practice of developing special packages, which target few but often very specific vehicles for modification. Generally, special packages did not encounter the same level of scrutiny (and the resultant denial) as fleet-wide modifications.

Table 3.3. Peer Agency Operating Characteristics: MARTA – Rail Car Fleet

Rail Car Type	Quantity	# in Rehab	% of Total Rail Car Fleet
CQ310	118	18	35%
CQ311	120	28	35%
CQ312	100	0	30%
TOTAL RAIL CARS	**338**	**46**	**100%**

The practice of deferring rail car maintenance activities was not without risk. Some rail cars will not begin the rehab process anytime soon. As deferred maintenance items accumulated on such vehicles, overall performance may potentially decrease and some rail cars could become unsafe to operate. However, RCME retained the responsibility for development and modification of preventive maintenance program specifications for older rail vehicles. While the possibility of fleet-wide vehicle safety enhancements was not an option, RCME increased the frequency and intensity of inspections conducted on the older rail cars. For example, inspections were now more thorough, and they were conducted at 15,000 miles, 30,000 miles, and 60,000 miles. The additional time required to conduct more scrupulous inspections became available as a result of lightened inspection needs among rehabbed rail cars, but RCME still does not have enough manpower to perform audits of PM inspections.

Beyond vehicle inspections and support to the rehabilitation project, the rail car maintenance engineering service and warranty department had several additional responsibilities at MARTA. For example, the department resolved critical maintenance issues, such as those related to parts. RCME frequently acted as a liaison between vendors and maintenance personnel. Specifically, RCME staff verified and identified appropriate replacement parts, and ensured that procured parts were correct. Department personnel also utilized OEM and other original specifications to develop safety and maintenance plans and bulletins that are easily understood by non-technical staff, including mechanics.

Additional regular tasks performed by RCME included accident investigation and reporting, and inspection of repaired parts to ensure that they are fit to re-enter service. For other relevant problems, the assistance of rail car maintenance engineers may also be requested using the formal, in-house process referred to as the request for engineering assistance (REA.) Through this process, an engineer was specifically assigned to investigate the problem. The effort also involved close coordination with other agency personnel, including technicians and supervisors. Once enough information was compiled, the assigned engineer prepares a report that describes the problem(s) and identifies potential solution(s). RCME personnel assisted in the effort to coordinate the repair.

As mentioned earlier, the chief of vehicle engineering and the mechanical and electrical engineers spent a considerable portion of time working in rail car maintenance facilities. This practice helped engineers gain a more thorough working knowledge of equipment and practical experience with solving problems that may arise. As a result, RCME personnel drew on knowledge and experience to develop maintenance programs as needed. This practice was especially beneficial in regard to the newly rehabilitated rail cars. Specifically, because RCME personnel were not involved in preparing specifications for the rail car rehabilitation effort, their knowledge of and familiarity with the revised vehicles was severely limited. Time spent in the maintenance shop was really the only practical way for RCME personnel to gain insight into the modifications. However, the union collective bargaining agreements expressly forbid any non-union personnel from actively engaging in repairs within the shop. As such, engineering staff were limited to an advisory role when they are onsite. Shop supervisors assigned a rail maintenance technician to work with an engineer in the event that a repairable defect is found.

The manager/RCME reported that engineers were frequently engaged in tasks very much outside their field of engineering expertise or outside the field of engineering in general. The circumstances surrounding this situation were somewhat unconventional. It was a common practice for high-ranking MARTA administrators to bypass the manager/RCME and contact RCME staff directly with work orders and special requests. As a result, work assigned by the manager/RCME lost priority. In addition, RCME staff must inform the department manager about the requests and relay details about the work they were assigned. Further, the manager/RCME was powerless to stop this practice or to reassign staff, regardless of RCME department needs or responsibilities. In addition, while continuing education and strong engineering skills were valued within the RCME department, the manager believed that high-level MARTA administrators had a competing agenda, possibly grooming staff for different, non-engineering jobs.

MARTA actively encouraged department heads to utilize consultants whenever necessary. In fact, the extent to which the agency engaged in contracts with consultants was so great that the manager/RCME put forth the idea that MARTA operated primarily as a "management company" (managing multiple consultants) rather than as a traditional transit agency. The passive attrition policy described earlier supported the notion that MARTA preferred to enlist outside technical expertise rather than to develop such skills internally. Specifically, MARTA retained the RTP group under a $33 million annual contract (FY 2006) to provide general engineering consulting for over 100 separate projects. MARTA paid direct labor and fringe benefits to RTP personnel and provided requisite office space at one of its buildings. MARTA also provided liability insurance to RTP under its wrap-up insurance program. (One of the benefits of contracting for engineering services is that MARTA did not have to directly absorb engineering-related liabilities.) Consequently, RCME was free to seek assistance from RTP at any time when necessary.

Methods used to evaluate productivity among RCME personnel were largely subjective. All MARTA employees are reviewed annually and semi-annually by their immediate supervisor. The results of these reviews were tied to annual raises. Within the field of engineering, managers looked at the overall project performance of their directly-reporting staff. Specific elements of the review included the completion status of assigned tasks. These were measured as a function of the total number of assignments completed over a specific time period. This measure was highly specialized, as one employee may only be engaged in long-term projects (thus completing few overall assignments), while another employee had several completions because assignments are generally short term. No fleet performance data is used in the evaluation of individual performance. Overall, the RCME department was evaluated in terms of the number of failures over a given period of time. Should these prove to be excessive or highly problematic, further investigation could be conducted.

Manager – Bus Maintenance Engineering Service & Warranty

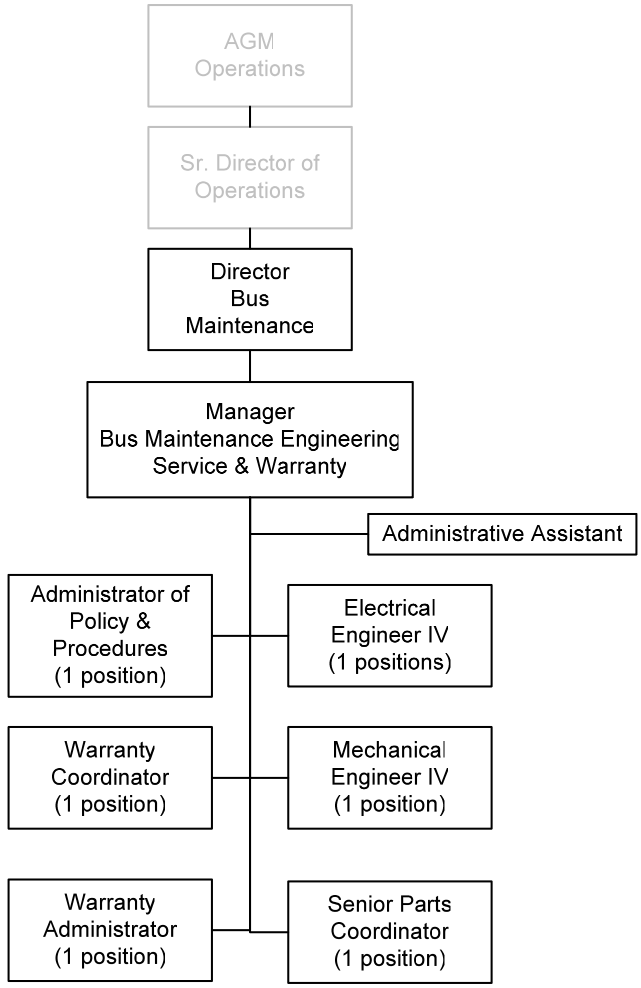
The bus maintenance engineering service and warranty department (BME) was organized under the bus maintenance division, which was 1 of 5 divisions under operations. The position responsible for oversight of BME was referred to as manager/BME; this position reported directly to the director - bus maintenance.

The manager/BME had 7 direct-report staff. Specifically, they were 6 specialized positions within the BME department, plus one clerk. These included: administrator of policy, electrical engineer IV, mechanical engineer IV, senior parts coordinator, warranty administrator, and warranty coordinator (see Figure 3.7). As this list indicated, there were only 2 engineers on staff in bus maintenance engineering.

To facilitate work flow, the manager had informally divided staff into 3 groups, which were focused on different areas of the bus. The power train group was led by the mechanical engineer, while the electrical engineer handled electronics, destination signs, and PLC system. Air brakes/suspension/steering were assigned to the third group. However, the entire reporting staff generally worked as a team.

The warranty staff also worked together frequently. Common tasks included review of maintenance workloads, submission of various warranty requirements, completion of warranty-related administration procedures, and other paper documentation efforts. BME staff used warranty issues as a means of failure analysis. As such, when problems arose, staff considered whether or not it could be handled by BME staff, or whether or not a maintenance campaign was in order. BME warranty staff also determined if a parts upgrade was necessary. Failure analysis sometimes was found to lead to a root-cause analysis. This method involved identifying a problem, then developing a solution for the problem. For part of the solution, BME staff might have developed a service information bulletin to distribute among bus maintenance facilities.

Figure 3.7. Organizational Chart, MARTA: Bus Maintenance Engineering



The MARTA Metrobus fleet consisted of 556 35-40 foot low-floor buses. 145 of these were Orion 7 diesel vehicles, while the other 411were New Flyer CNG buses. Bus maintenance was also responsible for 125 Para-transit vehicles and 300 non-revenue administrative vehicles. MARTA actually reduced the number of buses in its fleet over the past decade.

MARTA BME staff engaged in a decision-making process to determine whether or not items should be repaired in-house or completed by a contractor. Critical elements included whether or not the work can be performed in house, and if so, is the in-house option reliable and cost-effective. If the answers were clearly 'no,' it was more cost-effective to engage a contractor to complete the tasks. This decision-making exercise was also performed on services, such as writing specifications. For example, contracts for fluid acquisition or oil analysis were written in-house by BME, if the contract was greater than $100,000 per year. Other areas where this threshold was in effect were service agreements such as the tire maintenance contract.

Table 3.4. Peer Agency Operating Characteristics: MARTA – Road Vehicle Fleet

Vehicle Type / OEM	Fuel	Quantity	% of Total Road Vehicle Fleet
Buses (35-40 ft., low-floor)			
Orion 7	diesel	145	15%
New Flyer	CNG	411	42%
Total Buses		**556**	**57%**
Paratransit vehicles	various	125	13%
Non-revenue vehicles	various	300	30%
TOTAL VEHICLES		**981**	**100%**

BME managed the technical portions of contracts. All staff, as well as shop maintenance managers, contributed to this responsibility. Of course, bus vehicle purchase specifications and contracts were greater that $100,000, so BME engineers were responsible for their preparation. Further, they participated in an approved equal process. Specifically, exact specifications were put forth based on knowledge of current options within the industry.

At MARTA, the BME group referred to rehabilitation efforts as re-power, which were part of a predictive maintenance effort. Predictive maintenance was described as a scheduled preventive maintenance replacement program. The mechanical engineer wrote predictive maintenance processes and procedures and also wrote contracts for component rebuilds if they needed to be sent out for service. BME engineers wrote or reviewed and modified preventive maintenance procedures annually. New methods or method changes based on different replacement parts were incorporated into the procedures when necessary. BME personnel did not perform random audits of preventive maintenance inspections in bus maintenance facilities.

The manager/BME was responsible for formal evaluations of directly reporting staff. The evaluation process is semi-annual, and reporting staff are measured on their ability to meet goals and maintain standards. An example of a goal is to test 4 new products per year. The testing process involved the testing and reporting results, following up as necessary, and making recommendations. A second example of a goal was to publish 24 service bulletins during the year. Employee contracts stipulated that each employee must engage in at least 40 hours of training per year. Performance for this commitment was also measured in the evaluation process. Training may include continuing education or other approved training courses. Another required performance measure involved maintaining current reading of at least 2 professional journals, and sharing the information at staff meetings or by copying and distributing relevant information to other BME staff. Further, BME employees were evaluated on their responsiveness to field requests and their ability to meet deadlines. Bus maintenance fleet goals were not a factor in engineering personnel evaluations.

Peer Agency Findings

Overview

This research effort relied almost entirely on non-scientific criteria to select peer transit agencies for comparison analysis. Although somewhat uncommon, this approach was nonetheless acceptable in this instance for a number of reasons. First, public transit engineering activities do not generate comparable productivity or performance measure data. As a result, site selection based on statistical similarity or cluster analyses was not possible. Further, many prior transit research studies demonstrated that case study participants are often selected largely because of their availability or their willingness to participate in the effort. In addition, peers are commonly grouped together based on a broad generalization of one or more operating characteristics. For example, agency bus fleet size may be categorized simply as small (less than 100 vehicles), medium (100-500 vehicles), or large (more than 500 vehicles). Other non-scientific factors also influenced the peer selection process.

As mentioned earlier in this chapter, MDT field test engineering personnel initiated contact with peer transit agencies prior to the involvement of CUTR in this project. Specifically, FESM staff obtained preliminary information from public transit agencies in Cleveland, Ohio; Atlanta, Georgia; Washington, D.C.; and New York City, New York. These sites were identified based on similar characteristics including multimodal fleets, heavy rail transportation as one of the modes, planned or ongoing major rail car rehabilitation efforts, and large bus fleets. After CUTR became involved in the research project, the similarities among these criteria were deemed sufficient enough to warrant further investigation. The 4 transit systems were informally classified as large (Atlanta, Cleveland) or very large (New York City, Washington). The New York City agency was all but eliminated from consideration early on because preliminary information on it was light compared to that compiled on the other 3 agencies. In addition, researchers generally felt that 2 peer agencies would suffice for this research effort. From there, availability and willingness to participate in the study were key determinants in the selection and study of peer agencies. As initial contact with the transit agencies in Atlanta (MARTA) and Washington (WMATA) proved successful, these agencies were pursued for further analysis.

Information collected during the site visits verified the choices of MARTA and WMATA as highly appropriate peer transit agencies for comparison to MDT. Each agency's approach toward transit engineering contrasted significantly with the other. As a result, the peer investigation illustrated two very different visions of the capacity in which field test engineers may support transit agency needs. In addition to emulative practices and solutions, the study also illustrated less-than-ideal practices.

Each of the following sections focuses on one of the four major subject areas studied during the site visits and peer review. General categories discussed were management philosophies and management techniques, organizational structure, methods to determine personnel needs, and methods to measure/define employee productivity. Specifically, peer agency responsibilities, and actions taken to meet those responsibilities, were compared and contrasted to form a basis for evaluation of plan #1, which appears in Chapter IV of this document.

Management Philosophy

WMATA and MARTA were ideal peer selections for analysis and comparison to MDT field test engineering. Among the top 10 largest agencies in the United States, each ascribed to several substantially different engineering management ideologies. Some areas of agreement were evident, as each peer was bound by the goal of providing safe, reliable transportation to the public. However, the means of achieving this overall goal were generally very different between the peers.

Overriding management philosophies, and the degree to which they are valued, may be seen in an agency's efforts to publish goals, objectives, and strategies. WMATA engineering management believed that maintaining clear goals and objectives, and effectively communicating these to staff, were fundamental keys to success. Specifically, clear goals were identified for each engineering field, and they were regularly presented and available to staff. Further, executive officers adhered to the belief that engineering staff must be provided with proper tools and resources to meet stated responsibilities. Success in this area was also believed to hinge largely on trust and cooperation between staff and management. WMATA also expressly strove for low supervisory ratios. Engineering managers at MARTA did not have similarly elaborate and outwardly cited policies to work with.

WMATA engineering managers stressed the agency's strong proactive approach to solving problems. This involved engaging preventive practices as much as possible. For example, the "front burners" concept, which included frequent communications and regular follow-up during the project period, allowed engineering personnel to get ahead of many potential problems. Researchers did not see this type of initiative at MARTA. Although rail car engineers were aware of potential negative consequences of inaction, upper level agency management precluded staff from implementing necessary corrective maintenance precautions. This situation was referred to as deferred maintenance. Specifically, only nominal maintenance engineering was authorized for MARTA rail cars that had yet to be refurbished. However, the practice evoked considerable innovation efforts among maintenance engineers. For example, much smaller preventive efforts were developed. Because newly refurbished rail cars were under warranty, rail car engineers did not have to spend as much time attending to them, and thus turned attention to older vehicles. Rail car engineers were also able to enhance safety through more frequent and more intensive inspections of older rail cars.

The degree of specialization among engineering staff was an indication of management philosophy. WMATA staff were highly specialized and rarely, if ever, performed tasks outside their respective fields of expertise. While MARTA engineering personnel were also specialized to a degree, they often participated in work activities that stretched the limits of their expertise. Further, WMATA required specific background and education in engineering, and required each engineering supervisor to be a licensed P.E. Only a limited number of P.E.s were on staff at MARTA. MARTA had allowed engineering staff to dwindle through a policy of passive attrition. Specifically, as vacancies occurred, MARTA simply eliminated positions rather than seeking replacements. On the other hand, WMATA maintained a full complement of engineering staff in all areas of its transit engineering operation. In addition, each specialty engineering group at WMATA was mostly self-sufficient in terms of dedicated support staff. Specifically, each group included all necessary administrative, librarian, and drafter personnel.

The full complement of engineering personnel at WMATA allowed for rapid turn-around on short-term work requests without having to engage contractors. In fact, WMATA engineering preferred to outsource tasks as infrequently as possible, choosing instead to complete the majority of regular work in-house. Engineers generally limited contracting out (also referred to as out-tasking) to smaller jobs or portions of jobs, or for specific tasks that the agency did not have readily available resources to complete. Further, because contracting at WMATA was mostly limited to specialized tasks, engineering managers had oversight authority to contract with consultants directly.

In direct contrast to WMATA, executive management at MARTA encouraged engineering leadership to engage contractors whenever possible. In fact, MARTA maintained a large, open contract with a consulting firm, which included office space at MARTA. At the time of this writing, the MARTA engineering contractor was engaged in over 100 projects. However, the passive attrition policy still precluded MARTA engineers from maintaining a desirable level of responsiveness to engineering problems, especially in regard to short-term requests.

Although WMATA minimized the use of contractual engineers, the agency operated its own engineering services in similar fashion to engineering consultant groups. Specifically, managers assigned work through a formal, written process. These work plans included budgets, labor, and other needs. In some cases, engineers simply oversaw projects rather than maintaining daily involvement. Overall, the engineering management goal was to flatten the management structure, thus driving down responsibilities and empowering staff. WMATA engineers utilized the work plans as a tool of accountability. As such, the work plan must be approved by the operations division (or other relevant division(s) receiving engineering service), in addition to engineering managers. The use of this dual approval method allowed WMATA engineering to build a bridge between itself, as the provider of services, and the customer (operations or other divisions).

Again, methods utilized to assign engineering work at MARTA varied significantly from those at WMATA. Specifically, MARTA field engineers followed no formal structure for scheduling work. In fact, managers reported that upper level management occasionally contacted engineering personnel directly to assign work, effectively bypassing the first level of engineering management. However, both peers reported that in most cases, engineering managers assigned work based on which staff were most capable of completing the tasks at hand. Further, work was prioritized based on the knowledge and experience of the manager, as well as the experience of personnel and the urgency associated with the task.

Not all practices illustrated contrasting management philosophies between the peer transit agencies. Engineering managers at both WMATA and MARTA stressed the importance of strong and effective communications, and each claimed to be engaged in ongoing improvement efforts. Field engineers at the peers strived to maintain a strong presence on the maintenance shop floors. Specifically, this practice allowed for better communications between technicians and engineers, and it afforded engineers ample time to listen to shop concerns and to gain an effective working knowledge of vehicles and equipment. Further, WMATA reported utilizing a special program, operation outreach to encourage engineers to visit shops. Details of this effort included that engineers were assigned a selection of specific maintenance shops to "call on" in much the same say that a route sales person calls on customers.

Multidisciplinary team efforts were also strongly encouraged at both peer agencies. MARTA engineering managers reported that most or all department staff frequently worked together to solve problems or to determine which items should be repaired in-house and which should be contracted. WMATA also valued cross-divisional collaboration. For example, engineers wanted both maintenance and operations personnel to be involved in the preparation of new specifications (early on and throughout the project period.) Managers hoped that this effort would illustrate the reasons behind specific decisions. The work plan dual-approval method described above was also an example of cross-divisional involvement efforts.

MARTA field engineering managers recently identified several improvement possibilities and shared these insights with CUTR. Specifically, engineers wanted to see a 6-month maintenance history appear when a bus was accessed through the data management system. Another suggestion was to make exception reports more available and to make better use of modern technologies and maintenance problem codes. For example, maintenance engineers suggested that warranty claims be generated automatically when specific problems were entered into the system. Engineers also wanted to be automatically notified when new replacement parts were issued. Beyond that, they suggested the agency utilize an internal component-tracking and parts-numbering system rather than relying on the vendor-classified system.

Organizational Structure

The manner in which each peer agency structured its engineering resources provided further indication of the profound differences between their organizational visions. Specifically, WMATA maintained a centralized engineering operation, with all specialty areas managed under one executive engineering official. On the other hand, MARTA dispersed engineering personnel among various areas within the agency.

PDEC, the all-encompassing engineering division, allowed WMATA to maintain a single point of accountability for planning, designing, implementing, and maintaining operational enhancements, system access and expansion, technology, and vehicles. The division also maintained a high-quality, experienced, multi-disciplinary engineering staff for planning, real estate, architecture, construction management and inspection, and information technology. With the broad spectrum of engineering resources in-house, WMATA was able to reach its goal of limiting the need for contractual services. The full complement of engineering personnel also allowed the agency to maintain a proactive, preventive approach to problems that could impact service delivery.

Within PDEC, engineering positions closest in nature to MDT field test engineers were generally concentrated under the offices of the chief engineer/vehicles, chief engineer/facilities, and chief engineer/systems. Total authorized positions under each chief engineer office were 55, 54, and 50, respectively. As such, a simple calculation revealed 1 vehicle engineering staff per every 27 buses and per 16 railcars. The organization of PDEC and the chief engineer offices were such that a 3-tiered management hierarchy existed. Further, sub-groups under the chief were highly specialized. This allowed engineers to focus on duties well within their areas of expertise. Further, the arrangement pushed the average supervisory ratio to be in the range of 6 or fewer engineers per supervisor.

Engineering personnel at MARTA were decentralized, and each field maintained a level of autonomy. In general, oversight of engineers was split between the assistant general managers offices of operations and engineering & infrastructure. The latter group housed 3 areas of engineering, including: program and contract management, engineering, and facilities/maintenance of way. Within operations, groups were categorized according to transit mode and service provided. Specifically, 5 directors under operations oversaw bus transportation, bus maintenance, rail transportation, rail maintenance, and paratransit & special services. Rail car maintenance engineering and bus maintenance engineering groups were a level below the maintenance groups, and each manager of (vehicle) maintenance engineering reported to their respective director/vehicle maintenance.

With the notable exception of 4 electrical engineers housed under rail car maintenance engineering, both vehicle groups had 1 position for each vehicle specialty field. As mentioned earlier, MARTA allowed the ongoing process of passive attrition, and vehicle maintenance engineering managers were unsure whether or not future staff losses would result in the elimination of more positions. While MARTA vehicle maintenance engineering staffs covered various areas of expertise, it was difficult to suggest that this condition was valued by the agency or that this condition will persist into the future. A raw analysis revealed that MARTA currently employed 1 vehicle maintenance engineering staff per 38 rail cars and 1 vehicle maintenance engineering staff per 114 revenue fleet road vehicles.

Employee Productivity

For the most part, engineering practices and management outlook related to employee productivity were similar at WMATA and MARTA. Both peers reported that evaluation of overall performance of a professional position, such as an engineer, was difficult at best. Managers found that a subjective, individualized approach was most useful to measure the progress of engineering personnel. As such, transit fleet data and performance measures did not substantially impact individual engineering evaluations. However, these factors were more commonly used to generally review the engineering department and set performance goals. Specifically, departmental performance measures and goals used at MARTA included fleet mean distance between road calls, established replacement contracts in place at least 4 months prior to expiration, and the goal to reduce the number of buses down for premature failures. MARTA also reported that bus warranty issues were used as a basis for failure analyses.

Managers at both agencies used a multi-step process to evaluate employee performance, including annual and semi-annual reviews conducted by the employee's immediate supervisor. At the beginning of an annual term, the manager and employee met to establish an individualized performance plan for the following year. Specifically, the plan included goals and objectives that were usually related to professional development and project management. Prior performance plans were also reviewed to gauge progress. Supervisors looked at the completion status of previously-assigned tasks, as well as at the total number of assignments completed over a specific time period. The nature and demands of each project varied widely so, the review process was also highly subjective and required generous reliance on the knowledge and experiences of engineering managers. Specifically, MARTA staff were judged on individual ability to meet goals and maintain standards.

At both agencies, the overarching concerns of engineering staff productivity reviews generally focused on the level of success for each project and meeting project deadlines. Managers at MARTA also mentioned the importance of each individual's responsiveness to field requests. Further, WMATA managers used project work plans as an accountability and evaluation tool. For some projects, bi-weekly meetings allowed managers to track staff progress.

Engineering managers identified training as a somewhat unconventional method to measure employee performance. In particular, engineers at MARTA engaged in up to 40 hours per year of continuing education. Managers also compelled staff to stay current with relevant literature and to present such information to other personnel at meetings, or through electronic or hard copies.

Personnel Needs

As a result of their highly dissimilar philosophies toward management and staffing, the peer agencies exhibited vastly different personnel needs and practices. Engaged in a policy of passive attrition, MARTA eliminated engineering staff as positions became vacant. On the other hand, WMATA managers sought to attract and retain a sufficient number of qualified engineering personnel. Agency officials related the difficulty involved in finding and recruiting engineers with specific transit agency experience. As such, WMATA preferred to retain its own personnel by developing skills in-house and training within the agency. WMATA utilized innovative recruitment efforts, including an internship/co-op program with local community colleges and recruitment directly from the ranks of college engineering departments. Managers hoped that engineers could be attracted to the agency early on in their careers, and then remain in the field of transit engineering and with the agency for as long as possible. The full staffing complement of WMATA engineering personnel allowed engineers to maintain the important quick-response capability.

Training efforts were related to personnel needs. Specifically, WMATA utilized innovative training techniques, including the development of a DVD simulation 'game'. The agency followed a training-by-systems philosophy, which marked the conscious effort to train employees about the entire mechanical system that became defective, rather than just providing information about the specific faulty component. WMATA procurement specifications generally included provisions for OEM-sponsored training and acquisition of necessary supporting equipment. Further, WMATA engineering staff began to play a wider role in designing and developing training materials. In some cases, individuals may be trained as part of a grooming process for promotion to manager status.

To determine personnel requirements for specific projects, WMATA engineers sometimes utilized a simple analysis technique. It followed that larger projects involved more complex analyses. Available project budgets also influenced staffing needs at WMATA.

IV. MODIFICATION PLAN REVIEW & MANPOWER NEEDS ANALYSIS

Introduction

Previous chapters of this research report presented current conditions within the MDT field test engineering section and investigated ongoing practices at 2 peer agencies. Specifically, CUTR reviewed and documented the present responsibilities of the MDT field test engineering section, including detailed information obtained through staff interviews and culled from the section modification plan. Researchers also examined the current organization of the field test engineering section and the projected supportive needs of ongoing and forthcoming capital improvement projects. The peer agency review included a detailed look at engineering functions at WMATA and MARTA. Researchers presented the organizational structure in place and compared the management philosophies observed by each agency.

With the preliminary MDT and peer agency data in order, CUTR proceeded to address the chief concern of this research effort: determination of the reasonableness of the proposed modifications to FESM/field test engineering. To accomplish this task, researchers first assembled the suggested augmentations to reflect the likely structure of a new field test engineering division. Then, CUTR compared peer conditions to the current state at MDT and discussed the degree to which the new division would meet current and expected MDT field engineering needs.

After a brief description of the methodology utilized within, the remainder of Chapter IV consisted of 2 overall sections. First, researchers presented an exhaustive review of the MDT field test engineering modification plan. The section described the vision and justifications behind the plan, as well as the distinctive terms of the proposed field test engineering division, including anticipated salary and equipment costs. In the second part of Chapter IV, CUTR documented the processes and results of the manpower needs analysis. Specifically, researchers developed the knowledge gained during the peer and MDT reviews into a discussion of field test engineering personnel needs and the degree to which the proposed modifications adequately met those needs.

Methodology

Similar to the unconventional methods described for selecting peer analysis candidates, a review of labor needs for a division of professional employees proved challenging. While a host of data, time standards, and formulae existed to help determine maintenance technician staffing needs, no such methods or data were available for transit engineers. For example, CUTR intended to review work orders completed over a one-year period. However, this process would be incomplete because the use of work orders was found to be minimal or sporadic, at best. In addition, the search for generally-accepted engineering supervisory ratios went unfulfilled. The best ratios were found to be those determined through various in-practice trials. Specifically, as engineering supervisory personnel gained experience within specialized areas, the ability to best determine specific personnel needs developed. Experienced managers were also best-suited to devise the most beneficial organizational structure and management practices to meet the needs of their agencies. Further, employee productivity in the field of transit maintenance engineering was highly challenging to quantify. Employee performance reviews were highly subjective, and fleet performance data were not a factor in judging engineering staff productivity. In most cases, the most relevant areas of concern were simply: Was the job completed? Was it completed properly?

The situations described above led CUTR to develop a specialized methodology to determine the appropriateness of the MDT field test engineering modification plan. CUTR deconstructed the 4 components of the original modification plan and reassembled them as 1 in order to visualize and evaluate the structure and responsibilities of the proposed field test engineering division. Researchers compared current engineering responsibilities, practices, and organizational structures among MDT and the 2 peer agencies. Then, CUTR looked for emulative practices among the peer agencies and drew conclusions about the terms of the MDT modification plan based on past experiences and current conditions.

Further details about the methodology developed for this review are mentioned throughout the following sections.

Review of Field Test Engineering Modification Plan (Plan #1)

The following section examines plan #1 – field test engineering, which was presented in the 2005 MDT - FESM division document created to address personnel requirements for current service levels and transit growth projects. In general, plan #1 focused on staffing needs and structural modifications necessary to develop a robust, highly esteemed field test engineering program at MDT. While CUTR briefly summarized plan #1 and introduced its 4 original components in chapter ii of this report, greater details are found below. Specifically, overriding goals that drive the most important field test engineering responsibilities are presented. In addition, CUTR described current conditions that FESM managers pinpointed as justification for the proposed modifications. Later, CUTR followed the structural format of the modified division to provide details about each proposed specialty area, including staff needs and specific duties. Lastly, specific elements regarding salary costs and equipment costs were presented.

Field Test Engineering Modification Plan: Vision

The advent of a number of major capital efforts, including the acquisition of several hundred new buses and the rehabilitation of the railcar fleet, spurred MDT field test engineering leadership to outline an ambitious reorganization and modification plan to ensure that all current responsibilities and future challenges were met. Guided by decades of collective transit engineering experience, the management group illustrated a comprehensive vision of an ideal MDT field test engineering division. The plan to successfully realize this goal advocated the ability to retain and utilize a multi-disciplinary staff to provide quality service, effective management, and proper maintenance to all areas of the agency in need of field engineering support.

According to FESM management, the division was bound to provide dedicated engineering support to any MDT system or equipment currently operating without it. An adequate number of specific personnel were an essential component in the effort to fully meet the agency's current and future engineering needs. Further, a high-quality, experienced, and multi-disciplinary field test engineering staff was a cornerstone in the effort to fully meet the technical demands of a growing, technologically-advanced transit fleet. Ideally, the modernized division should retain a full complement of staff with demonstrated expertise in all relevant transit engineering fields. In addition, a comprehensive field test engineering division must also include adequate support staff. Engineers must be allowed to achieve total focus within their specific areas of expertise rather than devoting time to clerical, administrative, drafting, or other supportive, non-engineering tasks.

Through the modification effort, field test engineering leadership sought to successfully manage ongoing and future projects, including successful implementation of new programs, systems, and processes. A properly established division would be able to provide professional quality engineering services through a strong, highly-capable team effort. Field test engineering personnel exemplified the need to work closely with consultants, contractors, and MDT maintenance and operations divisions to ensure that both new and existing agency equipment met high standards for safety, reliability, and maintainability. With a comprehensive field test engineering staff in place, transitions to new technologies and systems would be made as smoothly as possible. Specific services visualized through the modification effort included full support for all current and future Metrorail and Metromover fleet rehabilitations and acquisitions. With regard to acquisitions, engineering managers sought to ensure that MDT received the highest quality vehicles at the lowest achievable cost.

MDT field test engineers were obligated to ensure the protection of all agency investments through the development of highly effective maintenance programs. The vision of a modified and fully staffed field test engineering division included significant consideration of maintenance efforts. Specifically, an outstanding field engineering division should be able to fully meet all bus maintenance engineering needs, including purchases, replacements, warranties, and quality assurance. Engineering staff must also anticipate future needs and ensure that all vehicle projects and vehicle maintenance programs are effectively managed and successfully completed. Of course, this requirement extended to all systems and facilities with field engineering needs.

Field Test Engineering Modification Plan: Current Conditions and Plan Justification

Prior to and during the course of this research project, various conditions at MDT illustrated real and potential consequences of field test engineering personnel deficiencies. Several major long term capital projects had recently gotten under way, with others scheduled to begin shortly thereafter. As a result, demands for field engineering support rapidly approached a level that could not be met by available resources. As work loads increased, engineers were pressed to perform duties well beyond their scope of personal expertise. Further, special requests and project needs began to preclude staff from performing regular maintenance engineering duties.

Managers feared that this combination of circumstances would result in an overall decline in the quality of field engineering services at MDT. Complex transit systems and equipment require experienced engineering staff to develop comprehensive maintenance programs to properly maintain systems once they are in regular daily service operations. In the event that engineers' ability to satisfy fundamental engineering requirements continued to be impeded, safety and maintenance concerns would grow by distressing proportions. In addition, the long term costs to the agency as a result of inadequate engineering oversight on projects and implementations generally end up being far greater than short term savings in personnel costs. As such, FESM management developed the divisional modification plan, which was the focus of this research effort. Within the plan and its 4 field test engineering components, engineering leadership demonstrated that current and future demands were unsustainable and could not be met by existing staff. Specifically, the plan presented several examples of project needs and maintenance requirements, along with staffing and organizational deficiencies; the sum of these warranted the modifications and reorganization put forth by the plan.

Major capital investments, such as the UAFC project and the Metrorail Rehabilitation effort, involved many complex tasks and required strong managerial oversight in order to realize success. However, each project risked significant impacts due to shortfalls of experienced and highly-skilled personnel within the FESM field test engineering section. For example, despite the broad scope and demanding nature of the UAFC project, allotted field test engineering staffing was limited to 1 full time fare collection engineer and part-time contributions from 2 supervisors. However, the fare collection engineer also retained complete oversight of existing fare collection equipment, while both supervisors also retained the responsibilities of their full time positions.

The insufficient complement of FESM personnel precluded any field test engineer from full time assignment to the Metrorail Rehabilitation program. In fact, rail engineering staff consisted of only 1 engineer, whose primary duties required permanent and continual oversight of regular vehicle maintenance engineering efforts. As such, little, if any, time was available for the rail engineer to participate in the extensive Metrorail modernization effort. Specifically, the program involved the complete overhaul of 136

Metrorail cars, as well as the acquisition of 26 new railcars and 12 new Metromover vehicles. Additional rail efforts included construction associated with the north, east-west, and MIC corridors, as well as development of maintenance programs for new vehicles. The schedules for each of the rail elements overlapped, between 2007 and 2012. As a result, appropriate field engineering support to these efforts required several additional staff. As always, maintenance programs associated with these implementations will be required to continue indefinitely once the systems are in service.

Several rail-related areas were found to be entirely deficient of specialized field engineering support. In fact, one individual was charged with oversight of all of the following areas, each of which merited full time support within a transit system the size of MDT. For example, the field test engineering section retained no resident track engineer to perform relevant daily and routine track maintenance activities at MDT. Field test engineering staff also did not include a traction power engineer to provide dedicated engineering support for power distribution systems. Neither electrical nor mechanical facilities engineers were part of the field test engineering staff. In fact, a facilities maintenance plan had only recently been implemented.

Programs to maintain and acquire Metrobuses also experienced considerable shortages of full time field engineering support. Specifically, only 1 vehicle engineer and 1 special projects administrator were dedicated to MDT Metrobus maintenance engineering duties. However, the Metrobus operation included approximately 1,200 buses, 4 maintenance facilities, and 1 support/major overhaul facility. Bus acquisition efforts consumed the majority of time available to the 2 staff mentioned above. For example, the development of a 300-vehicle procurement program (with an option to acquire at least 300 addition vehicles) was under way during the time of this research effort. In addition to the preparation of purchase specifications, vehicle procurement involved site visits to OEM facilities, inspections, and coordination with other MDT divisions. Procurement specifications and methods varied according to vehicle type. As such, little time was available to current bus engineering personnel for maintenance engineering attention to the existing fleet. Current engineering managers predicted that additional staff in this area would positively affect fleet reliability improvement and reduce road calls.

Further engineering staff shortfalls existed in critical support areas. Specifically, field test engineering had never established an official technical library, which is essential for the group to establish official status as a division. As such, field test engineering did not retain a librarian or other maintainer of documents, drawings, manuals, correspondence, and other technical documents. Additional unfilled positions required to complete a full complement of a field test engineering division included administrative and clerical staff, as well as a dedicated field test engineering drafter. These tasks, if left to be completed by engineers, further exacerbate the personnel shortfall because engineers are forced to complete supportive duties, which are clearly outside the specific engineering area of expertise. Further, relying on engineers to complete these tasks is neither cost effective nor an effective utilization of resources.

Whether providing support to special projects, developing ongoing maintenance programs, or responding to special, short-term requests, field test engineers are guided by common project management goals. Specifically, the section continually strived to manage projects effectively and to maintain successful implementations of new programs, systems, and processes. Implementation schedules are purposefully ambitious in order to dedicate staff to the goal of staying on schedule. Field engineers also seek to manage projects without incurring the considerable expenses associated with private consultant assistance. In addition, field engineers labored to minimize complications associated with the implementation of new equipment into revenue service. However, attainment of such goals became increasingly difficult, as efforts were hindered by the incomplete complement of experienced engineering personnel and engineering support staff.

While staff shortages posed specific risks to the successes of capital projects and maintenance efforts, the incomplete allotment of field test engineering personnel at MDT may have an even more profound effect on the section itself. Left unchecked, the condition is likely to cause the overall goals and guiding management philosophies of the field test engineering section to be thoroughly undermined. The resulting decline in employee morale and the potential loss of staff may prove to be catastrophic.

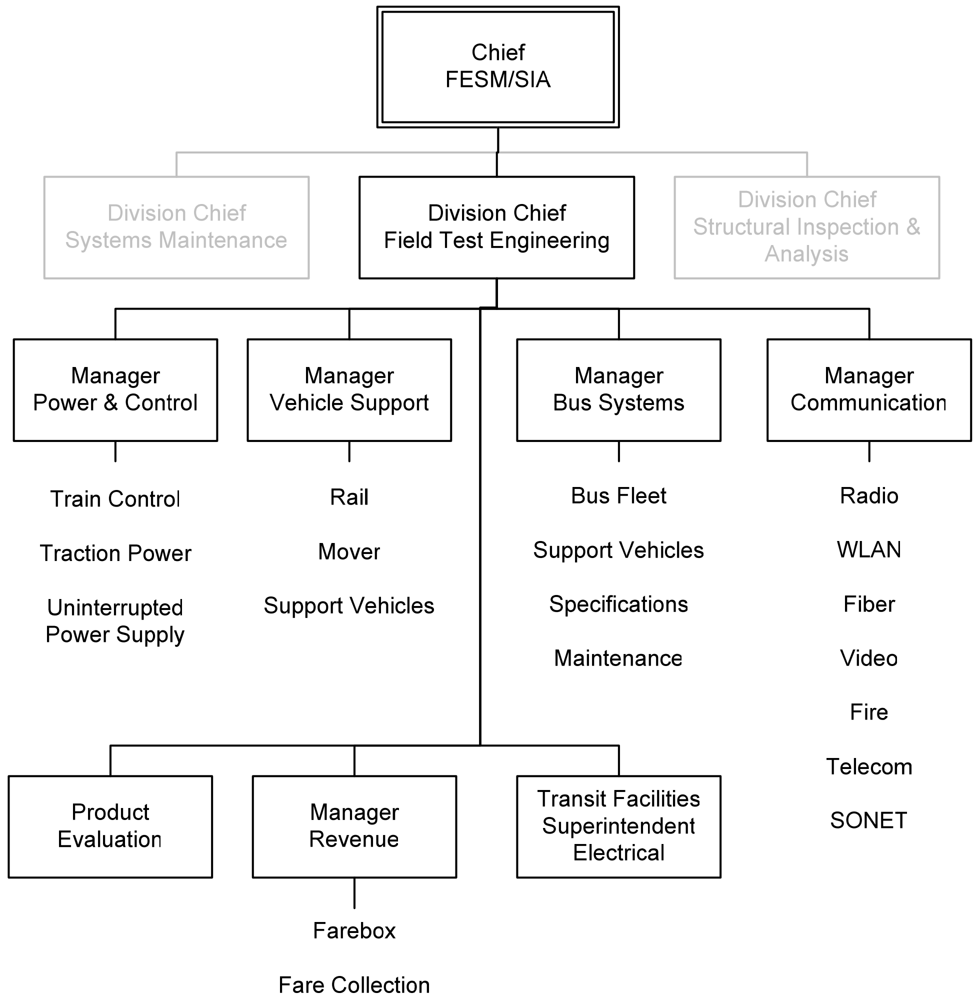
Field Test Engineering Modification Plan: Proposed Division – Personnel and Organization

The overall objective of the MDT field test engineering section modification plan was to acquire specific, experienced personnel, which would provide complete maintenance services across all related field test engineering areas and allow the section to meet division status. The full complement of field test engineering personnel would allow for complete support of all existing systems and for meeting future challenges as necessary. The 4-component plan, requested the addition of 18 field test engineers, including: 6 mechanical engineers, 5 electrical engineers, 3 communications engineers, 2 warranty engineers, 1 track engineer, and 1 traction power engineer. In addition, 2 quality assurance engineers and 2 IT specialists would be added as part of the plan, but would be managed and paid through their respective home divisions (QA, ITSS). The plan also recommended the addition of 5 support personnel, including: 1 office support specialist, 1 administrative specialist, and 1 secretary. field test engineering would also acquire an engineering draftsman. Beyond that, 5 positions were reclassified as manager, and several positions changed as a result of promotion. In addition, the current position of manager/field test engineering would be reclassified as division chief.

The peer agency review demonstrated that a comprehensive transit maintenance engineering operation is highly effective when it is organized into specialized groups. In fact, the proposed MDT organization (a division chief overseeing specialty area managers, who in turn supervise a small group of specialized engineers) closely resembled the WMATA setup of a chief engineer overseeing assistant chief engineers, who subsequently oversee a small group of specialized engineers. This arrangement allowed for efficient management of the complex tasks performed among the various engineering disciplines.

The MDT field test engineering modification plan sought to establish a field test engineering division comprised of 7 specialized areas. These areas included: power & control, communications, vehicle support, bus systems, revenue, product evaluation, and transit facilities (electrical) (see Figure 4.1).

Figure 4.1. Organizational Chart, MDT: Proposed Field Test Engineering Division



Proposed Field Test Engineering Division – Specialty Areas (Sections)

Among the 4 components of the field test engineering modification plan, 3 focused on needs associated with specific, ongoing special projects, while the 4th illustrated general needs, including those necessary to attain divisional status. However, each document included several references to the importance of the proposed division functioning as a team in support of every project. As such, researchers chose to conduct this analysis by looking at the overall plan in a broader perspective. Specifically, this approach allowed for a vision of the entirely revised, 7-section division, as well as its overall needs, to unfold.

The following portions of this document illustrated the staffing elements, responsibilities, and specific duties associated with each proposed specialty area, or section, within the proposed field test engineering division. General administrative needs, intended to support the entire division, were also described. In some cases, a statement was included to indicate the current status of the position described. Where applicable, relevant and comparable conditions among the peer agencies were described.

Power & Control

The proposed POWER & CONTROL field test engineering group will be responsible for train control, traction power, and uninterrupted power supply (UPS) systems. In general, this group will provide these systems with services related to specification and contract development, equipment production and installation, and maintenance. For oversight of this group, the existing lead field test engineer/train control & traction power will be reclassified as manager/power & control. Engineering staff added to this group will include a track systems engineer, a traction power engineer, a mechanical engineer /facilities, and an electrical engineer/facilities. An existing train control engineer will also be part of this group.

Specifically related to contract development, the power & control group will develop requests for proposals (RFPs) and specifications to purchase and install new track equipment, traction power equipment, and facilities mechanical and electrical equipment and systems; as well as for various consulting or maintenance services, as necessary. The group will also support and attend project group meetings and participate and advise management of technical matters in all design reviews.

Power & control personnel will perform various duties related to systems and equipment production and installation, including: testing, inspection, troubleshooting, document management, contractor proposals, claims, and quality assurance. Specifically, power & control staff will monitor component and subsystem qualification tests, material tests, pre- and post-shipment tests, and component, subsystem, and acceptance testing. The group will also perform inspections of equipment at the manufacturing plant, shipments, and equipment installation at MDT; develop inspection forms and reports; and issue non-conformance reports as required. Staff will also troubleshoot (with the assistance of contractor(s), if applicable) all new facilities, power, and track equipment. Further, contractor proposals and/or change orders will be reviewed and approved by power & control, and the group will review and process all related documents from proposals to change proposals to manuals and drawings. The group will also be charged with review of all closeout documents, such as warranties, manuals, and drawings, and approval of final payment. Additional contractor involvement may include reviewing payment requests, recommending payment actions, managing costs and tracking payments, and reviewing and recommending contractual changes, negotiations, and progress reports. Quality assurance at each stage of design, installation, and testing will be another concern of power & control staff, as are coordination of contractor time extension requests, schedule assessments and revisions, and approval of requests as they arise.

Power & control personnel will conduct various maintenance-related tasks. Specifically, the group will develop preventive and corrective maintenance programs for existing and planned facilities, traction power, and train control systems. Short- and long-term maintenance requirements and intervals will be established and revised on a continual basis. New maintenance procedures will be developed, and design changes will be implemented as needed to improve reliability and safety. Further, the group will develop purchase specifications for materials, parts, tools, equipment, and contractor services, as needed. Investigations and troubleshooting of unusual occurrences related to track, facilities, and power will be conducted as necessary; quality inspections will be performed, including review and approval of all maintenance records; and test programs will be developed as needs arise. When needed, power & control personnel will function as liaison between MDT maintenance divisions and contractors or vendors.

The manager, power & control will supervise a minimum of 5 field test engineers. The manager, power & control will also coordinate all relative acquisition, maintenance, and design engineering efforts related to train control, traction power, and UPS systems.

Specific responsibilities of proposed power & control staff are as follows:

- The track systems engineer will oversee maintenance programs, provide redesign, and support track and guideway systems improvements and maintenance. This position would be responsible for maintenance engineering service for all Metrorail track and Metromover guideway, including non-revenue areas in and around maintenance facilities. Further, the track systems engineer would also design or redesign trackwork where necessary and would function as liaison for expansion projects.

Currently, there is no resident track systems engineer at MDT to perform the daily and routine facility systems and maintenance.

- The traction power engineer will largely be responsible for maintenance and repair of power delivery systems from Florida Power & Light to Metrorail and Metromover guideways. Specific systems that this position will be responsible for include substations containing switchgear, transformers, other electronics, power cables, and power rails.

  Currently, there is no resident traction power engineer at MDT to perform the daily and routine facility systems and maintenance.

- The mechanical engineer - facilities and the electrical engineer - facilities will generally oversee respective maintenance programs and implement capital improvements across the system, and they will ensure that all systems requirements are met in support of operations and maintenance divisions. These positions will act as liaisons between Operations and Maintenance divisions, especially for new facilities.

  Currently, there are no resident facilities maintenance engineers at MDT dedicated to facility systems and equipment.

At WMATA, the power and control *services* described above fell under the direction of the office of chief engineer/systems (CENS). Specifically, the responsibilities of the MDT manager, power & control were split between 2 comparable manager positions at WMATA: assistant chief engineer (ACE) systems, automatic train control and ACE systems, power systems. Each ACE in this area oversaw an average staff of 5 engineers. MARTA managed these areas under its assistant general manager engineering & infrastructure, with direct oversight responsible to the director, facilities maintenance of way.

Communications

The proposed COMMUNICATIONS field test engineering group will be responsible for radio, WLAN, fiber, video, fire, telecom, and SONET systems within Metrobus, Metrorail, and Metromover. In general, this group will provide these systems with services related to specification and contract development, equipment production and installation, and maintenance. For oversight of this group, the existing lead field test engineer/communications will be reclassified as manager, communications systems. Engineering staff added to this group will include a communications engineer to replace the position reclassified to manager.

Specifically related to contract development, the communications engineering group will develop RFPs and specifications to purchase and install new radio, WLAN, fiber, video, fire, telecom, and SONET systems; as well as for various consulting or maintenance services, as necessary. The group will also support and attend project group meetings and participate and advise management of technical matters in all design reviews.

Communications personnel will perform various duties related to systems and equipment production and installation, including: testing, inspection, troubleshooting, document management, contractor proposals, claims, and quality assurance. Specifically, communications staff will monitor component and subsystem qualification tests, material tests, pre- and post-shipment tests, and component, subsystem, and acceptance testing. As necessary, the group will also perform inspections of equipment at the manufacturing plant, shipments, and equipment installation at MDT; develop inspection forms and reports; and issue non-conformance reports as required. Staff will also troubleshoot (with the assistance of contractor(s), if applicable) all new communications equipment. Further, contractor proposals and/or change orders will be reviewed and approved by communications, and the group will review and process all related documents from proposals to change proposals to manuals and drawings. The group will also be charged with review of all closeout documents, such as warranties, manuals, and drawings, and approval of final payment. Additional contractor involvement may include reviewing payment requests, recommending payment actions, managing costs and tracking payments, and reviewing and recommending contractual changes, negotiations, and progress reports. Quality assurance at each stage of design, installation, and testing will be another concern of communications staff, as are coordination of contractor time extension requests, schedule assessments and revisions, and approval of requests as they arise.

Communications personnel will conduct various maintenance-related tasks. Specifically, the group will develop preventive and corrective maintenance programs for existing and planned communications systems. Short- and long-term maintenance requirements and intervals will be established and revised on a continual basis. New maintenance procedures will be developed, and design changes will be implemented as needed to improve reliability and safety. Further, the group will develop purchase specifications for materials, parts, tools, equipment, and contractor services, as needed. Investigations and troubleshooting of unusual occurrences related to communications systems will be conducted as necessary; quality inspections will be performed, including review and approval of all maintenance records; and test programs will be developed as needs arise. When needed, communications personnel will function as liaison between MDT maintenance divisions and contractors or vendors.

The manager/communications will supervise all group staff and coordinate all relative acquisition, maintenance, and design engineering efforts related to communications systems within bus, rail, and mover vehicles. Specific responsibilities of proposed staff are as follows:

- The communications engineer will replace the position promoted to manager. This engineer will be responsible for the large and varied array of electronic and optical fiber equipment deployed on MDT buses, rail vehicles, and mover vehicles, as well as at rail stations, central control, parking garages, and other facilities.

At WMATA, the communications services described above fell under the direction of the office of chief engineer/systems (CENS). Specifically, the responsibilities of the MDT manager, communications were mostly performed by the comparable WMATA manager position of assistant chief engineer (ACE) systems, communications. MARTA managed this area under the assistant general manager engineering & infrastructure, with the director, engineering responsible for oversight.

Vehicle Support

The proposed VEHICLE SUPPORT group will be responsible for Metrorail and Metromover vehicles systems, as well as Metrorail support vehicles. In general, this group will support these vehicle systems through services related to specification and contract development, construction, maintenance and warranty. Further, this group would be instrumental in providing electrical, mechanical, and warranty engineering services for MDT programs, including rail rehabilitation, Metrorail north corridor rail fleet purchase, technical warranty administration, and maintenance program development. For oversight of this group, the existing lead field test engineer/vehicles will be reclassified as manager/vehicle support. Engineering staff added to this group through the FESM modification plan will include a mechanical engineer, an electrical engineer, and a warranty engineer.

Specifically related to contract development, the vehicle support group will develop RFPs and technical specifications for equipment acquisitions as well as for various contracted or sub-contracted services, as necessary. The group will also support and attend project group meetings, participate and advise management of technical matters in all design reviews, and participate in the bid process and contractor selection, including service on the technical review committee.

Vehicle support personnel will perform various duties related to equipment production and implementation, including: testing, inspection, troubleshooting, document management, contractor proposals, claims, and quality assurance. Specifically, vehicle support staff will monitor component and subsystem qualification tests, material tests, pre- and post-shipment tests, and component, subsystem, and acceptance testing. The group will also perform inspections of equipment at the manufacturing plant, shipments, and equipment implementation at MDT; develop inspection forms and reports; and issue non-conformance reports as required. Further, contractor proposals and/or change orders will be reviewed and approved by vehicle support, and the group will review and process all related documents from proposals to change proposals to procedure manuals, drawings, schematics, repair parts, and training materials. The group will also be charged with review of all closeout documents, such as warranties, manuals, and drawings, and approval of final payment. Additional contractor involvement may include reviewing payment requests, recommending payment actions, managing costs and tracking payments, and reviewing and recommending contractual changes, negotiations, and progress reports. Quality assurance at each stage of design, installation, and testing will be another concern of vehicle support staff, as are coordination of contractor time extension requests, schedule assessments and revisions, and approval of requests as they arise.

Vehicle support engineering personnel will conduct various maintenance-related tasks. Specifically, the group will develop new preventive and corrective vehicle maintenance programs. Short- and long-term maintenance requirements and maintenance intervals will be established and revised on a continual basis. New maintenance procedures and processes for vehicle repairs will be developed, and design changes will be implemented as needed to improve reliability and safety. Further, the group will develop purchase specifications for materials, parts, tools, machinery, equipment, and contractor services, as needed. Investigations and troubleshooting of unusual occurrences related to track, facilities, and power will be conducted as necessary; quality inspections will be performed, including review and approval of all maintenance records; and test programs will be developed as needs arise. When needed, vehicle support personnel will function as liaison between MDT maintenance divisions and contractors or vendors.

Regarding warranty, services provided by the vehicle support group will include technical and engineering analyses to accurately determine the causes of component or subsystem failures. Staff will resolve disputes surrounding the causes of failures and will work closely with maintenance control divisions and/or contractors to ensure that failure data is collected properly and reported accurately. In addition, vehicle support personnel will monitor and evaluate mean time between failures for vehicles and subsystems. The group will also monitor and evaluate component and subsystem failure rates as related to contractual redesign requirements.

The vehicle support group will support all current and future rail and mover vehicle fleet rehabilitations and acquisitions, and it will ensure that the agency receives the highest quality vehicles at the lowest possible cost. Vehicle support staff will also develop and oversee the necessary maintenance programs to protect new investments. The group will provide electrical, mechanical, and warranty engineering services in support of specific MDT programs. For example, the rail rehabilitation program, which is scheduled to run from 2004 through 2012, involves the complete overhaul and modernization of the 136-vehicle railcar fleet and the purchase of 12 new Metromover vehicles. The north line rail fleet purchase, which includes the purchase of 26 additional Metrorail cars, will also be supported by this group. Vehicle support staff will also be involved in technical warranty administration for both the rail rehab and rail purchase programs. The group will develop specific maintenance programs, maintenance schedules, and maintenance procedures as needed for all additional vehicle procurements. Further, staff will examine maintenance facility needs and capacity, and it will develop specifications for necessary modifications and equipment.

The manager, vehicle support will supervise all group staff and coordinate all relative acquisition, maintenance, and design engineering efforts related to all vehicles, including bus fleet procurements and maintenance. Specific responsibilities of proposed staff are as follows:

- The Mechanical engineer will contribute to vehicle maintenance programs, provide redesign, and support improvements and further maintenance. This position will focus heavily on rail rehabilitation and acquisition efforts.

  Currently, there is no resident mechanical engineer at MDT to perform the daily and routine functions as described here.

- The electrical engineer will assist with development of vehicle maintenance programs, and will provide redesign, and support improvements and further maintenance. This position will focus heavily on the electrical engineering aspect for rail rehabilitation and vehicle acquisition efforts.

  Currently, there is no resident electrical engineer at MDT to perform the daily and routine functions as described here.

- The warranty engineer will generally oversee respective maintenance programs and implement capital improvements across the system, and will ensure that all systems requirements are met in support of operations and maintenance divisions. This position is involved with analysis and proving of failure cases. These positions will act as liaisons between Operations and Maintenance divisions, especially for new facilities.

  Currently, there are no resident warranty engineers at MDT who are dedicated to facility systems and equipment.

At WMATA, the vehicle support *services* described above fell under the direction of the office of chief engineer/vehicles (CENV). Specifically, the responsibilities of the MDT manager, vehicle support were split among 3 comparable manager positions at WMATA: assistant chief engineer (ACE) railcars, senior project manager/railcars, and manager/vehicle engineering. MARTA managed these areas under its assistant general manager operations through the director of rail maintenance, with direct oversight responsible to the manager/rail car maintenance engineering services and warranty.

Bus Systems

The proposed BUS SYSTEMS field test engineering group will be responsible for engineering and maintenance of the Metrobus fleet, including Metrobus support vehicles. In general, this group will support the growing bus fleet through services related to contract specification and development;

production and implementation; and maintenance, quality assurance, and warranty. For oversight of this group, the existing special project administrator will be reclassified as manager, bus systems. Engineering staff added to this group through the FESM modification plan will include 3 mechanical engineers, 2 electrical engineers, and 2 communications engineers. In addition, the existing mechanical engineer on staff will be reclassified to match the status of the new positions, and a quality assurance engineer will be added in conjunction with the MDT quality assurance division.

With respect to contract development, the bus systems group will develop RFPs and technical specifications for the acquisition of new and replacement buses, as well as for various contracted or sub-contracted services, as necessary. The group will also support and attend project group meetings, participate and advise management of technical matters in all design reviews, and participate in the bid process and contractor selection, as needed.

Bus systems personnel will perform various contract management services related to equipment procurement, production, and implementation, including: testing, inspection, troubleshooting, document management, contractor proposals, claims, and quality assurance. Specifically, bus systems staff will monitor component and subsystem qualification tests, material tests, pre- and post-delivery tests, and component, subsystem, and acceptance testing. The group will also perform inspections of vehicles at the manufacturing plant, in shipments, and after implementation at MDT; develop inspection forms and reports; and issue non-conformance reports as required. Further, contractor proposals and/or change orders will be reviewed and approved by bus systems, and the group will review and process all related documents from proposals to change proposals to procedure manuals, drawings, schematics, repair parts, and training materials. The group will also be charged with review of all closeout documents, such as warranties, manuals, and drawings, and approval of final payment. Additional contractor involvement may include reviewing payment requests, recommending payment actions, managing costs and tracking payments, and reviewing and recommending contractual changes, negotiations, and progress reports. Quality assurance at each stage of design, installation, and testing will be another concern of bus systems staff, as are coordination of contractor time extension requests, schedule assessments and revisions, and approval of requests as they arise.

Bus systems engineering personnel will conduct various maintenance-related tasks. Specifically, the group will develop new preventive and corrective bus maintenance programs. Short- and long-term maintenance requirements and maintenance intervals will be established and revised on a continual basis. New maintenance procedures and processes for bus repairs will be developed, and design changes will be implemented as needed to improve reliability and safety. Further, the group will develop purchase specifications for materials, parts, tools, machinery, equipment, and contractor services, as needed. Investigations and troubleshooting of unusual occurrences related to bus systems will be conducted as necessary; quality inspections will be performed, including review and approval of all maintenance records; and test programs will be developed as needs arise. When needed, bus systems personnel will function as liaison between MDT maintenance divisions and contractors or vendors.

Regarding warranty, services provided by the bus systems group will include technical and engineering analyses to accurately determine the causes of component or subsystem failures. Staff will resolve disputes surrounding the causes of failures and will work closely with the MDT bus maintenance control division and/or contractors to ensure that failure data is collected properly and reported accurately. In addition, bus systems personnel will monitor and evaluate mean time between failures for buses and systems. The group will also monitor and evaluate component and subsystem failure rates as related to contractual redesign requirements.

The bus systems group will support all current and future Metrobus acquisitions and program repairs, and it will ensure that the agency receives the highest quality vehicles at the lowest possible cost. Bus systems staff will also develop and oversee the necessary maintenance programs to protect new inventory. The group will provide electrical and mechanical engineering services in support of MDT Metrobus fleet growth and to improve fleet reliability and reduce road calls. Bus systems staff will develop specific maintenance programs, maintenance schedules, and maintenance procedures as needed for all additional vehicle procurements. Further, staff will examine maintenance facility needs and capacity, and will develop specifications for necessary modifications and equipment.

The manager/bus systems will supervise all group staff and coordinate all bus procurement and bus maintenance programs. Specific responsibilities of proposed staff are as follows:

- Mechanical engineers will provide mechanical oversight for all maintenance programs, special projects, and retrofits for all bus fleets. They will also develop procedures for repair consistency among all maintenance facilities. Further, the bus systems mechanical engineers will strive to improve maintenance practices to increase vehicle reliability, which will result in fewer road calls, unusual occurrences, and accidents. Mechanical engineers will also develop specifications for necessary tools and maintenance equipment.

Currently, there is only 1 resident mechanical engineer at MDT to perform the daily and routine bus maintenance functions as described here.

- Electrical engineers will provide electrical engineering oversight for all maintenance programs, special projects, and retrofits for all bus fleets. They will also develop relevant procedures for repair consistency among all maintenance facilities. Further, the bus systems electrical engineers will strive to improve maintenance practices to increase vehicle reliability, which will result in fewer road calls, unusual occurrences, and accidents. Electrical engineers will also develop specifications for related tools and necessary maintenance equipment.

  Currently, there are no resident electrical engineers at MDT to perform the daily and routine bus maintenance functions as described here.

- Communications engineers will adapt new and innovative communications technologies to Metrobus fleets. They will also oversee that all bus communications systems are properly maintained and will assist in troubleshooting and complex problem-solving.

  Currently, there are no resident communications engineers at MDT who are dedicated to bus systems and equipment.

- The Quality Assurance engineer will report to the MDT QA division in order to maintain independent status regarding bus project management. This engineer will ensure that project requirements are developed to meet the needs of all relevant internal and external agencies. The QA engineer will also see to it that equipment and personnel are capable of meeting project quality measures and will document such efforts.

At WMATA, the bus systems services described above fell under the direction of the office of chief engineer/vehicles (CENV). Specifically, the responsibilities of the MDT manager, bus systems were comparable to the WMATA manager position of assistant chief engineer (ACE) buses. MARTA managed this area under the assistant general manager operations through the director of bus maintenance, with direct oversight responsible to the manager/bus maintenance engineering services and warranty.

Revenue

The proposed REVENUE field test engineering group will be responsible for fare collections systems on all MDT revenue vehicles. Specifically, the group will directly manage the acquisition, implementation, and maintenance associated with the universal automated fare collection (UAFC) system. As described earlier in this report, the UAFC is a massive undertaking that will standardize fare collections among MDT Metrobus, Metrorail, and Metromover, as well as with other regional transit systems. In general, the revenue group will oversee the provision of engineering, technical, administrative, warranty, quality assurance, and IT support to the UAFC effort. Specifically, revenue personnel will provide services related to specification and contract development, equipment production and installation, and maintenance. For oversight of this group, the existing lead field test engineer – fare collection will be reclassified as manager, revenue. Engineering staff added to this group will include a mechanical engineer, a warranty engineer, and an electrical engineer. In addition, a quality assurance engineer will be added by the MDT quality assurance division to support the revenue group and the UAFC effort. Also, 2 IT systems analyst positions will be added by the MDT information technology and support division to support the revenue group and the UAFC effort.

In the area of contract development, the revenue group will develop RFPs and technical specifications for the acquisition of required new and replacement equipment, as well as for various contracted or sub-contracted services. The group will also support and attend project group meetings, participate and advise management of technical matters in all design reviews, and participate in the bid process and contractor selection, as needed.

Revenue personnel will perform various required tasks related to systems and equipment production and installation, including: testing, inspection, integration, troubleshooting, alarm management, standards, document management, contractor proposals, warranty, claims, and quality assurance.

Specifically, revenue staff will monitor component and subsystem qualification tests, material tests, pre- and post-shipment tests, and component, subsystem, and network acceptance testing at MDT, including hardware and software integration. As necessary, the group will also perform inspections of equipment at the manufacturing plant, shipments, and network connections. Revenue personnel will provide required Internet connections, network addresses, and communications ports to the contractor, and will provide future support for the regional magnetic and SMART CARD fare collection systems. Staff will also troubleshoot (with the assistance of contractor(s), when necessary) all new network, communications, and other required equipment. The revenue group will also manage all equipment alarms, events, and alerts to the central computer system; the group will also ensure that implemented systems meet proven industry standards and follow FTA ITS guidelines for land networks. Group staff will also ensure that all equipment and systems installations meet applicable Miami-Dade County codes.

The revenue field test engineering group will be responsible for review and approval of contractor proposals and/or change orders, and the group will review and process all related documents, including proposals, change proposals, schematic manuals, parts, procedures, calculations, training materials, and drawings. Revenue will also be charged with review of all closeout documents, such as warranties, manuals, and drawings, and approval of final payments. Additional contractor involvement may include reviewing payment requests, recommending payment actions, managing costs and tracking payments, and reviewing and recommending contractual changes, negotiations, and progress reports. Quality assurance at each stage of design, installation, and testing will be another concern of revenue staff, as are coordination of contractor time extension requests, schedule assessments and revisions, and approval of requests as they arise.

Regarding warranty, services provided by the revenue group will include technical and engineering analyses to accurately determine the causes of component or subsystem failures. Staff will resolve disputes surrounding the causes of failures and will work closely with maintenance control divisions and/or contractors to ensure that failure data is collected properly and reported accurately. In addition, vehicle support personnel will monitor and evaluate mean time between failures for vehicles and subsystems. The group will also monitor and evaluate component and subsystem failure rates as related to contractual redesign requirements.

Revenue personnel will be responsible for various maintenance-related tasks. Specifically, the group will develop preventive and corrective maintenance programs for existing and planned fare collection systems. Short- and long-term maintenance requirements and intervals will be established and revised on a continual basis. New maintenance procedures will be developed, and design changes will be implemented as needed to improve reliability and safety. Further, the group will develop purchase specifications for materials, parts, tools, equipment, and contractor services, as needed. Investigations and troubleshooting of unusual occurrences related to the UAFC systems will be conducted as necessary; quality inspections will be performed, including review and approval of all maintenance records; and test programs will be developed as needs arise. When needed, revenue personnel will function as liaison between MDT maintenance divisions and contractors or vendors.

The manager/revenue will supervise all group staff and coordinate all UAFC efforts. Specific responsibilities of proposed staff are the following:

- The mechanical engineer will provide relevant support for design issues, contractor liaisons, document review, systems installation and testing, and maintenance program development related to mechanical equipment and issues.

- The electrical engineer will provide relevant support for design issues, contractor liaisons, document review, systems installation and testing, and maintenance program development related to electrical equipment and issues.

- The warranty engineer will oversee warranty issues related to UAFC and coordinate with the MDT Materials Management and Maintenance Control Divisions.

- The quality assurance engineer will plan and engage processes necessary to maintain the integrity, timeliness, and progress of the UAFC project. This position will report to the MDT QA division in order to assure independence from project management.

- The IT systems analysts will support the installation and testing of all equipment, connections, and software, including those related to the MDT Real Time and business networks infrastructure.

At WMATA, the revenue services described above fell under the direction of the office of chief engineer/systems (CENS). Specifically, the responsibilities of the MDT manager, revenue were mostly performed by the comparable WMATA manager position of assistant chief engineer (ACE) systems, automatic fare collection. MARTA managed this area under the assistant general manager operations, with the directors rail & bus maintenance engineering services and warranty engineering responsible for direct oversight.

Product Evaluation

The proposed PRODUCT EVALUATION group may not include engineers. However, group staff will provide administrative support to field test engineering projects and contracts, as necessary. Initial responsibilities likely will focus largely on the UAFC project. In fact, the positions in this group were originally identified within the UAFC component of the field test engineering modification plan. An administrative officer will oversee the group, which includes supervision of a production coordinator.

The administrative officer will handle contract management duties, such as correspondence, cost control, and payment tracking. Additional responsibilities will include report writing, documentation, scheduling reviews and assessments, and processing supplemental agreements and change orders. The officer will monitor and assess contractors' schedules, process extension requests, and approve revised schedules. This position will also coordinate issues and prepare items that must come before county commissioners or county managers. The administrative officer will also participate in meetings with the county attorney to negotiate and interpret contracts and to resolve disputes.

Among the first orders of business of the production coordinator will be to establish and operate a document library for the UAFC program. Specifically, documents, manuals, drawings, correspondence, and other technical materials will be cataloged to facilitate their use and reference to by revenue and other field test engineering staff. The coordinator will serve at the direction of the administrative officer and provide assistance as needed. Additional duties may include maintenance scheduling, manual distribution, updating library documents, and other administrative functions.

Transit Facilities Superintendent - Electrical

Under the reorganized field test engineering division, the transit facilities superintendent/electrical will continue to function in much the same way as described earlier in this report. One position will remain in place for this area. A primary responsibility of the position is oversight of all electrical code compliance issues related to field test engineering, as well as to various systems throughout MDT. The superintendent is also charged with directing MDT maintenance shift supervisors on code enforcement, fire alarm systems, power, lighting, grounding, and lightning protection. Further, this position holds a Master Electrician License, which qualifies the FESM division as an electrical contractor.

Support Personnel
In order for a section to be recognized as a division at MDT, adequate support staff must be in place. Currently as a section, Field test engineering retains 1 administrative staff position. As a result, the modification plan provides for 2 additional clerical positions and 1 drafter position. New support staff, which would report to the proposed chief/field test engineering position, are described below:

- The engineering drafter II would support all field test engineering sections by providing required drawings for various projects. Specifically, this position would be responsible for revisions to drawings and diagrams, and would provide revisions to manuals, studies, and designs. In addition, the drafter would organize and coordinate project drawings for engineering review of new construction and new systems. Acquisition of this position would free field test engineers from these non-engineer responsibilities.

- The office support specialist III would provide specific clerical support to all field test engineering groups. Specifically, this position would maintain a library of technical documents, including: change control documents, engineering logs, reports, requests for service, investigations, and other reports. This position would also provide support related to personnel and budget matters.

- The secretary would perform clerical duties and administrative duties, including: correspondence, filing, payroll, time sheets, and budget support.

Field Test Engineering Modification Plan: Costs

The following section illustrated salary cost data and anticipated equipment requirements and costs associated with the field test engineering modification plan.

Salary Costs

Collectively, the MDT field test engineering modification plan called for 27 new positions and 8 reclassified positions. For each new position, the plan included a total cost figure that represented annual salary plus fringe benefits. Each reclassified position involved a 5% increase in annual salary, based on expanded responsibilities. Total personnel compensation costs to fully implement the plan were slightly over $2.2 million.

Annual salary plus fringe costs for each of the 27 new positions added by the MDT field test engineering modification plan ranged from $42,071 for the secretary position to $87,294 for each of the 18 new field test engineer (engineer iv) positions (see Table 4.1). Specifically, the plan added 5 electrical engineers, 6 mechanical engineers, 2 warranty engineers, 3 communications engineers, 1 traction power engineer, and 1 track systems engineer. Annual cost figures for 2 quality assurance engineers ($86,107) and 2 it specialists ($73,866) are included in the plan, but these positions were to be paid through the MDT QA and IT divisions, respectively. Additional support positions budgeted in the plan included: 1 administrative officer iii ($75,068), 1 production coordinator ($69,853), 1 engineering drafter ii ($55,848), and 1 office support specialist III ($45,604).

Salaries of existing personnel were adjusted to meet the additional responsibilities associated with each reclassification. Specifically, 1 chief position and 5 manager positions were created from among existing field test engineers and lead field test engineers. Current annual salaries, which varied slightly, were increased by 5%. In addition, 1 engineer iii was elevated to engineer IV in order to be in line with newly acquired engineer positions. The plan also allotted a 5% salary increase to the transit facilities superintendent.

Table 4.1. Projected Salary Costs: MDT Field Test Engineering Modification Plan

Position	Quantity	Unit Cost	Total Cost	Notes
Reclassified as Chief	1	$ -	$ -	
Reclassified as Manager	5	$ 5,789	$ 28,945	· Unit cost is average increase per reclassification · Individual 5% increases vary, but total cost is accurate
Reclassified as Engineer IV	1	$ 3,525	$ 3,525	· Represents a 5% increase in current salary
Reclassified as Superintendent	1	$ 3,786	$ 3,786	· Represents a 5% increase in current salary
Engineer IV	18	$ 87,294	$ 1,571,292	· Inc. (5) electrical, (6) mechanical, (2) warranty, (3) communications, (1) traction power, (1) track systems
QA Engineer III	2	$ 86,107	$ 172,214	· Will report to/be paid through MDT QA Div
IT Specialist (Systems Analyst II)	2	$ 73,866	$ 147,732	· Will report to/be paid through MDT ITSS Div
Administrative Officer III	1	$ 75,068	$ 75,068	· Will support entire FTE Division
Production Coordinator	1	$ 69,853	$ 69,853	· Will support entire FTE Division
Engineer Drafter II	1	$ 55,848	$ 55,848	· Will support entire FTE Division
Office Support Specialist III	1	$ 45,604	$ 45,604	· Will support entire FTE Division
Secretary	1	$ 42,071	$ 42,071	· Will support entire FTE Division
TOTALS	**35**		**$2,215,938**	

Equipment Costs

The MDT field test engineering modification plan outlined specific equipment and supplies costs associated with the 27 new positions created within it. For each new position, the plan allowed for the purchase of a desktop computer ($1,500) and office furniture ($1,200) (see Table 4.2). To meet computing needs in the field, all but 3 new staff would also receive a laptop computer ($1,500). Except for the 3 communications engineers, the plan allowed for an automobile to be acquired for use by each new field test engineer position. All new staff with in-field responsibilities would be issued a county radio ($1,200). The plan also included the cost of almost 2,000 square feet of additional office space ($235,200). Other office equipment, as well as travel associated with the UAFC project, was included in the plan. In total, equipment costs were slightly more than $776,000.

Table 4.2. Projected Equipment Costs: MDT Field Test Engineering Modification Plan

Item	Quantity	Unit Cost	Total Cost	Notes
Desktop computer	27	$ 1,500	$ 40,500	· Provided for all new staff
Laptop computer	24	$ 1,500	$ 36,000	· Provided for all new field test & QA engineers, IT specialists, administrative officer, & new production coordinator
Office furniture set	27	$ 1,200	$ 32,400	· Inc. desk, chairs, file cabinets, bookshelves, etc.
Automobile	17	$ 20,000	$ 340,000	· Provided to new field test engineers, except communications engineers (15), new admin. officer (1), new prod. coordinator (1)
County radio	20	$ 1,200	$ 24,000	· Provided to new field test engineers, (18), new admin. officer (1), new prod. coordinator (1)
Copy machine	1	$ 8,000	$ 8,000	
Miscellaneous items	-	$ 600	$ 600	
Office space	1960 ft^2	$ 120	$ 235,200	
Travel		$ 60,000	$ 60,000	· Provided to support UAFC project factory testing
TOTAL COSTS			**$ 776,700**	

MANPOWER NEEDS ANALYSIS

Overview

CUTR had previously completed manpower analyses for MDT, as well as for other transit agencies. For example, a bus mechanic manpower analysis was completed for MDT in 2003. Although researchers for that study noted the lack of industry-wide work standards in this (and most other) transit vocation, several types of data were maintained by MDT and made available to CUTR for the investigation. Researchers used the available vehicle performance data, mechanic work hours, and projected vehicle mileage data to devise a methodology for predicting maintenance staffing levels. A sample calculation from this effort was the number of mechanic work hours per mile calculated from total work hours and total miles. Further, a figure for the required number of full time mechanics was determined through a function of total vehicle miles and the number of miles per mechanic. Unfortunately for the study at hand, such data were either not available for or not relevant to transit engineering.

Personnel needs for professional positions such as engineers are historically difficult to determine through standard manpower calculations. Frequently, performance data were not tracked for these positions. As a result, work time standards often did not exist and few, if any, data sources were available for comparison. In addition, the nature of engineering positions usually required that multiple, ongoing tasks be completed, with individuals also frequently responding to immediate needs. For example, an extraordinary situation may arise that required an individual to completely reprioritize one or many planned work days. Further, work logs were usually not maintained, especially among transit engineers, where quick responses and rapid turn-around times are commonly required. In general, the nature and urgency of engineering services requests precluded accurate, detailed documentation of completed work efforts.

> It should be noted that as mentioned earlier, researchers did identify the practice of written work planning at WMATA. However, the agency did not compile data from the work plans into cumulative statistics that were readily available to and usable by CUTR. As researchers were able to use only existing data, compilation and documentation of raw peer agency data was beyond the scope of this study.

The nature of responsibilities assigned to transit engineers also dictated that engineers rarely adhered to strict work time boundaries. As described earlier in this report, a significant portion of maintenance engineering effort was completed during non-revenue hours. In addition, most transit engineers were not bound by organized labor contracts that specified work hours, break times, days off, etc. Further, few tasks were repetitive, and many assignments extended over long periods of time. Often, engineering personnel were required to devise new methods and to develop innovative work plans for completing projects. Although some tasks may finish quickly, others proved to be much more time intensive. Again, there were few, if any, means to quantify the expending of work time on such endeavors.

Comparison of one transit engineer to another was difficult because each individual generally maintained highly specific responsibilities. It followed that each position may require the use of totally different methods to reach successful outcomes. As such, employee evaluations were subjective and highly specialized to the individual. While this condition may confound a supervisor at one specific agency, comparisons made between agencies were even more difficult. Further, supervisory styles and priorities may also influence employee production in ways that were all but impossible to analyze statistically.

As a result of the unconventional characteristics surrounding transit engineering work processes and evaluation, CUTR developed a methodology to specifically address the manpower analysis needs of the project at hand. Proper execution of this research effort required CUTR to establish a substantial foundation of information. Specifically, prior to assessing the reasonableness of the field test engineering modification plan, researchers compiled, reviewed, and documented the following information:

- Current responsibilities of MDT field test engineering personnel
- Current organizational structure of the MDT field test engineering section
- Details of ongoing and future MDT projects that demanded support from the MDT field test engineering section
- Anticipated future responsibilities of the MDT field test engineering section, especially areas likely to require dedicated support
- Details of the FESM division modification plan, which included a plan to modify the field test engineering section
- Suggested personnel acquisitions and modifications to the organizational structure of the MDT field test engineering section
- Anticipated labor and equipment costs associated with implementation of the field test engineering modification plan
- Relevant field test engineering practices, structures, responsibilities, and philosophies currently employed at 2 peer transit agencies

Once gathered, CUTR utilized the preliminary data as the basis for analysis of the field test engineering section modification plan. Specifically, researchers compared the current state of MDT field test engineering to conditions at the peer agencies. Additional focus areas of the analysis included in the MDT plan considered similarities among the peers, and determined which, if any, offered emulative practices. Further areas of interest involved management philosophies, organizational structures, methods utilized to measure employee productivity, and techniques involved in determining engineering personnel needs.

Throughout the following sections, current practices at MDT are discussed, compared, and contrasted to those in effect at the peer agencies. Later, relevant findings stemming from the discussion, as well as emulative practices and general lessons learned, are presented.

Discussion of Current State: Field Test Engineering at MDT & Peer Agencies

The goal of this analysis was to determine the reasonableness of proposed modifications to MDT field test engineering without using conventional manpower needs analysis methods or standard transit performance data. In the absence of these common tools, CUTR looked closely at current conditions and field test engineering practices among the peer transit agencies (WMATA and MARTA.) The comparison was extensive, and researchers documented several notable similarities. In addition, the investigation yielded many differences among the agencies. First, general similarities were briefly noted, followed by a summary presentation of overall differences. Subsequent portions of this discussion section included a more detailed presentation of both similarities and differences.

Regarding similarities among MDT, WMATA, and MARTA, each agency was actively engaged in a number of improvement projects that relied on substantial field engineering involvement. In addition, vehicle maintenance engineering services were among the most important responsibilities of each field engineering operation. Each engineering group serviced a multi-modal transit system and faced challenges associated with rapidly advancing transit technologies. None of the agencies adhered to a strict ratio of engineering managers to staff, but management representatives from each were consciously aware of the benefits of maintaining a low number. Managers at each agency also recognized the potential for negative outcomes associated with overworked engineering personnel, understaffed or incomplete engineering groups, and engineers compelled to work outside of their fields of expertise. Further, each engineering leadership official stressed the importance of strong communications between management and staff, as well as between higher level agency management and engineering groups (although communications were stronger at some agencies than others). While practices often differed, each engineering group expressed the desire for maintenance engineers to spend a significant amount of time in the maintenance facilities working and communicating with maintenance technicians frequently.

Researchers also observed a variety of differences among field engineering operations at each of the 3 transit agencies studied. For example, wide variation existed among the organizational structures of engineering. Agency views also differed on required qualifications, especially licensure and education. Further, the amount of effort engineers expended on tasks outside their fields of expertise varied among the transit systems. Other differences were found related to management philosophies, work methods, determining personnel needs, and overall goals and priorities.

The differences in engineering organizational structure at WMATA, MARTA, and MDT illustrated a wide spectrum of possibilities in this area. As described in Chapter III, WMATA centralized its engineering functions under the PDEC division. This method allowed for a highly specialized engineering workforce to focus on specific responsibilities. A number of levels existed within the WMATA arrangement, which facilitated the management of engineering personnel and projects. In contrast, MARTA dispersed engineering personnel across 3 groups. While MARTA vehicle maintenance engineers were specialized and organized into small groups, each served under the direction of vehicle maintenance divisions and was isolated from other engineering operations. At MDT, field test engineers were grouped together within 1 section, while engineering tasks related to construction, planning, design, and land acquisition were organized in a separate area. The field test engineering section faced the dilemma of a broad scope of responsibilities (vehicles, facilities, and infrastructure) but deficiencies among staff needed to meet such needs. Further, MDT did not utilize specialized, individually-managed engineering groups, such as bus vehicle maintenance, railcar vehicle maintenance, automatic train control, or bus procurement.

Chapter III identified similarities and several differences in overriding management philosophies between MARTA and WMATA. Guiding principles at MDT aligned somewhere in between the peers. In general, WMATA desired to keep most engineering functions in-house, limiting the involvement of contractors to areas beyond its capabilities. MDT engineering leaders generally echoed this sentiment. MDT field test engineers sought to preempt the need for additional contracting by devising an ambitious plan to retain necessary personnel. At the other end of the spectrum, MARTA streamlined its engineering staff to a point where contractors were required in order to meet the general engineering needs of the agency. WMATA stood out among the 3 agencies as the only one to strongly value education and professional licensure among the majority of its engineering staff (particularly among engineering managers). At WMATA, non-P.E.s could only attain certain levels of management status and were not able to reach the assistant chief position or higher. In this area, MARTA and MDT preferred to have fewer PEs on staff, citing the potential for liability issues to confound the regular output of engineers in the field. WMATA maintained a strong, proactive approach to problems by prioritizing preventive maintenance and retaining a sufficient complement of staff. MARTA engineers were prevented from performing preventive retrofits on vehicles, which prompted managers to engage creative means to accomplish such tasks. Again engineering personnel at MDT faced a dilemma. A proactive approach was desired, but personnel limitations restrained MDT engineers from engaging in as many preventive actions as they preferred. For example, random audits of preventive maintenance inspections were highly valued, but they could not be completed with existing staff numbers.

CUTR found that methods used to gauge engineering employee productivity were generally similar among WMATA, MARTA, and MDT. Each agency followed a subjective approach and conducted annual and semi-annual one-on-one employee meetings to review progress. In addition, the agencies generally encouraged engineering staff to improve skills through training, setting performance goals, and/or devising personal plans for the coming review period. Individual goals were used as milestones and employees rarely had similar plans. In addition, employees were judged on their individual progress on projects. Neither fleet performance data nor any other transit data impacted individual employee reviews at any agency.

Field test engineering groups at all 3 agencies faced similar challenges related to the delivery of effective and efficient engineering services to the agency. MDT field test engineering representatives did not hesitate to point out that its services were available to (and at least occasionally utilized by) every division within the agency. In fact, meeting diverse agency-wide needs in a timely fashion proved to be one of the engineering group's most important challenges. Engineers at WMATA had the benefit of an elaborate mission statement, which described in detail the challenges to be met. Because engineering services were organized under one deputy general manager group, WMATA engineering personnel maintained a number of tools at their immediate disposal in the effort to meet challenges. Under a decentralized structure, MARTA engineers maintained a high degree of focus within specifically assigned fields. Though minimally staffed, MARTA engineering personnel were generally able to meet challenges, especially by enlisting the assistance of the engineering contractors.

As described in previous sections, the peer agencies were selected in large part due to the fact that field engineers at each agency were engaged in large-scale improvement projects. MDT, MARTA, and WMATA were all in the midst of extensive railcar rehabilitation efforts. Each agency also reported varying status on other rail-related projects, including: system expansions, new rail line implementations, technology systems upgrades, and other general improvements and modernization efforts. A variety of expansive bus projects were in progress at each of the agencies. Specifically, MDT and WMATA were in the midst of major vehicle procurement efforts, WMATA and MARTA were involved in cleaner fueled bus projects (conversions and/or acquisitions), MDT was anticipating the implementation of a bus rapid transit system, and all 3 agencies were at varying stages of expanding their complement of bus maintenance facilities. In addition, each agency reported a number of facility improvement and upgrade efforts, especially in the areas of fare collection, HVAC, and security.

One of the more important comparisons in this analysis involved the overall workloads and responsibilities of engineering personnel. Not surprisingly, the factors mentioned earlier in this section had some level of direct influence on engineering work assignments and how they were managed at WMATA, MARTA, and MDT. Workloads were also impacted by the specific area of expertise involved, as well as the number of active projects and amount of available staff to complete them. With a high degree of specialization, a generally full complement of experienced staff, and less reliance on contracted services, WMATA engineering personnel maintained reasonable work assignments and expectations of work output. This was generally the case for each level (from chief to manager/assistant chief engineer (ACE) to staff engineer) within the WMATA engineering group. For example, the chief engineer/vehicles (CENV) was responsible for leadership and technical support to ensure safety, reliability, and best maintenance practices for WMATA railcars and buses. Assistants to the CENV (including second tier supervisors and ACEs) had specific vehicle-related responsibilities, including: railcar rehabilitation and procurement, railcar vehicle systems engineering, buses, and criteria, standards, and integration. Front line supervisors were further specialized, and they assigned even more specific tasks to staff engineers. As mentioned earlier, sufficient numbers of personnel allowed WMATA engineers to focus on tasks at hand within their area of expertise.

Engineering workloads at MARTA were somewhat alleviated by the agency's aforementioned heavy reliance on contractors. However, the field test engineering/vehicle maintenance groups were specialized, including engineering staff with various fields of expertise. In most cases, more than 1 MARTA engineer or division staff contributed to projects assigned to an engineering group. For each of the 2 vehicle maintenance engineering groups, 1 manager maintained oversight of the entire group. Again, the diversity in the structure of engineering groups (split between 2 divisions in the case of MARTA) allowed groups to focus on specific areas of interest and prevented individuals or groups from being overloaded with work.

Compared to similar groups within the peer agencies, the MDT field test engineering section had a much wider range of responsibilities, but far fewer staff to complete all required tasks. For example, the number of MARTA staff dedicated to railcar vehicle maintenance engineering was close to the number of personnel allotted for all field test engineering functions at MDT. Further, MDT had 1 chief to oversee 3 field engineering/systems maintenance areas, and only 1 section manager to oversee all field test engineering functions. MDT also had 4 lead field test engineers to act in a management capacity. However, the lead positions had no official manager oversight authority and were generally overwhelmed with tasks and responsibilities. On the other hand, WMATA had entirely separate engineering groups dedicated to vehicle maintenance, facilities maintenance, and systems maintenance, and each group had a separate chief, as well as a full complement of assistants, managers, etc. Clearly, this condition represented a very difficult situation for MDT engineering managers and personnel. Further compounding the situation at MDT was the lack of adequate support staff. As a result, MDT field test engineers' work responsibilities also included clerical and administrative tasks. (This condition was not seen at MARTA or WMATA).

General and other factors also affected engineering workloads among the agencies. For example, newer technologies were rapidly replacing older methods. This condition existed for large items, such as buses and railcars, and for systems within the vehicles, such as fare collection, security, and data collection. Field engineers at each agency were involved in every modernization effort, and these responsibilities continued for the foreseeable future. However, field engineers must continue to provide support to older systems until such time as they are no longer in place on any agency resources. As such, an adequate quantity of personnel must be available to meet the needs of these implementations. Because field engineers at MDT were responsible for a wide range of duties, the risk of encountering several interruptions throughout the work period was high. With a full schedule already, distraction for information or other special requests further hindered progress. There was no way to quantify the effect of each interruption; however, each unplanned break in concentration certainly had some degree of impact on productivity and work flow.

Field test engineering leadership at MDT expressed grave concern that personnel deficiencies, combined with intense, expanded workloads, forced staff to frequently engage in tasks outside of their individual areas of engineering expertise. Exacerbating the situation at MDT, field engineering position titles were non-specific and no formally-designated engineering specialty groups existed. This created the illusion that field test engineers were generalized. Because field test engineers frequently responded to peripheral requests, a self-perpetuating cycle quickly became entrenched. However, engineering fields, especially those within the public transit industry, involved highly specialized responsibilities.

> In fact, the total compensation analysis, which appears later in this chapter, warrants mention at this point because although the ERI software package used for the analysis contained over 5,700 position titles, it did not include a generic engineer position. All ERI engineering titles were associated with a specific area of expertise, including electrical, mechanical, physical, power systems, reliability, and transportation.

Peer agencies agreed that the situation of engineers operating outside their specialty areas was highly undesirable and even potentially dangerous. Due to dwindling staff numbers and greater reliance on contractors, MARTA also experienced this dilemma. However, MARTA maintained descriptive engineering position titles to indicate the appropriate field of engineering expertise required for each job. Sufficient personnel numbers, descriptive position titles, and highly specialized engineering groups precluded WMATA from this challenge.

The ways in which each agency managed personnel requirements and determined personnel needs varied considerably at each agency. In fact, variations among the underlying goals and objectives driving each engineering group likely had the greatest impact on personnel decisions. WMATA took great pride in its large and comprehensive engineering division, which allowed the agency to meet most engineering needs in-house. In addition, WMATA chief engineers stressed the need for goals and objectives and that these drive most decisions. While some personnel vacancies existed at WMATA, these were generally caused by a lack of qualified applicants rather than unwillingness to fill the positions.

As documented earlier in this report, engineering personnel numbers at MARTA were allowed to dwindle through a policy of passive attrition. Regardless of managers' desire for additional staff, MARTA maintenance engineering groups were precluded from acquiring or expanding the workforce. In the event that engineers were not able to meet demands, the agency encouraged managers to enlist the assistance of contractors or to parse the tasks out entirely.

Engineering personnel deficiencies existed at MDT and reflected different issues. In some cases, engineering positions were vacant. In addition, many personnel needs could not be addressed until the engineering group was augmented by the creation of required positions and the reorganization of staff. Clearly, MDT field test engineering management desired additional engineering personnel. Based on current and anticipated agency demands for technical services, MDT field test engineering management presented the detailed plan to address personnel needs, which is the focus of this research effort. Further, WMATA and MARTA maintained sufficient non-engineer support staff, while a case may be made that the value of support staff had be overlooked by MDT agency management. The plan presented by field engineering leadership identified specific administrative, clerical, and engineering support staff needs.

Findings: Manpower Needs Analysis

At this point, CUTR had gathered, reviewed, and documented all necessary and available information related to field test engineering responsibilities and operations at MDT and at the 2 peer agencies, WMATA and MARTA. The final task was to illustrate whether or not the terms of the MDT field test engineering section modification plan (plan #1) were reasonable, given the lessons learned and the current and forthcoming challenges faced by MDT engineers. The following section provides a general indication of the practicality of plan #1. Further, researchers discussed portions of the proposed MDT field test engineering division and presented findings to support or deny its acceptance.

The section becomes a division. One of the fundamental modifications proposed by plan #1 was the transformation of MDT field test engineering from a generalized, imprecise section with limited first-tier manager oversight into a specialized, highly-manageable division. Specifically, the plan created several engineering positions and identified desirable qualifications for each. Further, the existing allotment of field test engineers, along with newly-acquired personnel, would be reorganized into 5 distinct engineering groups, each of which would maintain precise responsibilities and be guided by an experienced manager. 2 other specialty groups were also part of the planned division.

> Based on the outcome of this research effort, CUTR believed the vision of a specialized, comprehensive field test engineering division to be reasonable and worthy of consideration for implementation by MDT.
>
> Under the terms of plan #1, field test engineering at MDT would more closely resemble peer agencies in terms of management style and organizational philosophy. Although the peer analysis revealed that agencies structured field engineering operations differently from each other, (centralized at WMATA, dispersed within MARTA) both maintained a number of specialized field engineering personnel groups. In addition, qualified managers were positioned to oversee engineers' efforts. In the majority of instances, first-, second-, and sometimes third-line engineering managers maintained precise titles and areas of responsibility. Further, this method allowed supervisory ratios to be kept low and helped managers to be more intimately familiar with ongoing staff projects.

A full complement of engineering personnel. Terms of the field test engineering modification plan were largely based on anticipated needs associated with planned agency growth and modernization efforts for existing systems. Engineering personnel were responsible not only to support the initial development and implementation of special projects, but also to indefinitely maintain new and modernized systems and acquired resources. With existing staff expending an exorbitant amount of effort just to meet current demands for technical services, it was entirely unreasonable to believe that additional large-scale responsibilities could be absorbed without any significant augmentation to staffing levels. In fact, engineering personnel were forced to continuously adjust individual task priorities so the most vital areas would be sure to receive attention. In response to existing personnel deficiencies and the looming engineering staffing crisis, plan #1 identified critical areas of need and organized personnel to most effectively meet all needs.

Based on the findings and observations experienced as a result of this research effort, CUTR maintained that the concept of an adequately staffed field test engineering division that followed the specific organizational structure and personnel augmentations outlined in the modification plan and included specialized managers for each area of responsibility, was sound and reasonable.

The peer agency comparison illuminated many factors that supported this finding. The effort allowed CUTR to gain perspective on the workload faced by MDT field test engineering personnel. For example, MDT had 9 field test engineers and 1 special project administrator that were officially responsible for all necessary development, maintenance, and technical services related to (but not limited to): communications, fare collections, train control, traction power, Metrobus vehicles, Metrorail vehicles, Metromover vehicles, security and fire systems, procurements, etc. In contrast, MARTA dedicated 9 staff specifically to rail car maintenance engineering service and warranty, and MARTA dedicated 7 staff to bus maintenance engineering service and warranty. Of further interest, MARTA maintained less than 1,000 total road vehicles and fewer than 600 buses. In addition, the MARTA Metrobus fleet consisted of only 2 types of buses, compared to more than 6 different types within the MDT fleet.

Another interesting comparison from the peer agency analysis further justified CUTR's stance. At WMATA, the manager/vehicle engineering (MVE) was one of 5 specialty areas within the office of the chief engineer/vehicles (CENV). Briefly, the MVE was mainly responsible for rail vehicle maintenance and rehabilitation, and for "small" projects valued at less than $25 million. To meet all required responsibilities, the MVE maintained a staff of 3 assistant MVEs and 11 field engineers. In addition, the MVE oversaw a draftsperson and an administrative assistant, both of whom were 100% dedicated to the MVE. It is significant to note that in addition to the MVE, the CENV also oversaw an assistant chief of rail cars engineering and an assistant chief of criteria, standards, & integration, both of whom had different rail-related responsibilities from those assigned to the MVE.

Addition of Support Staff. As mentioned above, retaining a capable, diverse, and experienced complement of staff was a critical aspect of the MDT field test engineering section modification plan. Continually increasing demands for services further strained the ability of the existing field test engineering group to keep pace. The dubious situation was exacerbated by a lack of clerical, administrative, and other support personnel, forcing engineers to perform such tasks on their own. In addition, in order for a section to be reclassified as a division, a full complement of staff, including support personnel, must be in place. As a result, plan #1included provisions to acquire 2 clerical support staff and 1 engineering drafter.

> **Based on observations and findings resulting from this research effort, CUTR believed the provision to acquire adequate support personnel was REASONABLE and warranted strong consideration for action by MDT.**
>
> CUTR found that engineering groups at the peer agencies retained all necessary support personnel in place. In fact, peer agency representatives seemed puzzled at the idea of an engineering group not maintaining adequate clerical, administrative, etc., resources. With every major project that unfolded at MDT and demanded greater involvement from field test engineers, less and less time was available for non-engineering tasks.

The Title of Manager. As indicated above, the MDT field test engineering management group presented a plan to create 5 separate areas of engineering responsibility. The plan intended for comparable existing lead field test engineers to be reclassified as "manager/(_specialty area_)". This title was purposefully chosen because of its non-descriptive nature. For example the existing position of communications engineer could be given oversight authority and re-titled as manager/communications systems. The field test engineering leadership group felt that use of the term "engineer" in the management position title would imply that the position holder had to be an engineer. They feared that this condition would preclude potentially qualified personnel from seeking or holding the position. The leadership group was motivated to this action because the priority for highly developed management skills in the position exceeded the need for engineering skills in the position.

> Based on research findings garnered for this study, CUTR was skeptical about the motivations behind this decision. Researchers

believed that this decision may be somewhat competitive with other objectives of the plan. As a result the field test engineering leadership group may want to reconsider this title, or it may want to include a provision to augment the title in the event that an engineer is selected for the position.

One of the intended outcomes of the overall modification effort was to improve the status of field test engineering at MDT. Specifically, section leadership desired to attain division status and increase the number of specialized engineers on staff. However, the action of assigning generalized titles to positions of management seemed to contradict the preceding goals. For comparison, WMATA utilized a somewhat elaborate system of manager titles. The peer assigned supervisory titles based on educational background and licensure. Further, WMATA reserved its highest status manager titles for individuals with the highest educational credentials. The agency felt that this system maintained a specific image of high status for the agency. As such, MDT should consider management positions that outwardly signify educational qualifications.

Another point to consider related to potential applicants and position holders. MDT engineers sought to raise the status of the field test engineering section, but considered awarding oversight authority to non-engineers. Another option might be to consider different fields of engineering for manager positions. Specifically, systems engineers are highly skilled in management techniques and are highly adaptable to most industries. As such, the modification effort should strongly consider systems engineers for field test engineering management positions, while other specialty engineers would retain responsibility for applied project involvement.

TOTAL COMPENSATION ANALYSIS

Proposed Field Test Engineering Division Positions

One of the main objectives of the field test engineering modification plan was to acquire necessary resources for the section to reach division status. Specifically, in order to gain recognition as a division, the field test engineering section had to formally request and establish the required positions through standard county procedures then, retain the full complement of staff. For each new position, the modification plan included a detailed job description, required skills and experience, and an annual salary figure (which represented costs for labor and fringe). In order to ensure the external competitiveness of the proposed positions, researchers determined that an examination of the transit engineering labor market was warranted. Through this analysis, CUTR provided MDT with comparison data to ensure that wages were set high enough to attract, motivate, and retain necessary labor resources, but not too high so that labor costs disproportionately exceeded those of competitors.

Methodology: Total Compensation Analysis

Based on MDT salary figures and job descriptions, CUTR utilized a commercial salary survey produced by the Economic Research Institute (ERI) to conduct a salary comparison analysis of the proposed field test engineering division positions, including the reclassified manager positions. CUTR previously achieved successful results with ERI products as a current and accurate source of salary data. ERI conducted surveys and other research on salaries, benefits, and compensation. ERI also gathered compensation data from official government sources and collected human resources data. The ERI database included regional salary and cost of living data, as well as job responsibility descriptions, for over 5,700 position titles in 298 US and Canadian cities. The database was updated quarterly; CUTR used the most recent update, April 2006, for this analysis.

For the salary analysis, CUTR used the Salary Assessor, an ERI software tool that worked with the salary and cost-of-living databases, to generate compensation details and comparative analyses. The ERI package included 3 salary figures: base salaries, total compensation, and incentives. Because labor cost figures in plan #1 were presented as salary-plus-fringe amounts, CUTR reported only the ERI total compensation figures for this analysis. The Salary Assessor calculated the mean and median for salary figures. The mean was the overall average salary, while the median was the average salary that occurred at the 50^{th} percentile. Because the mean annual total compensation figures were sometimes found to be slightly skewed, CUTR used the median annual total compensation figures for the analysis.

ERI allowed the user to adjust compensation data based on geographic location. Unadjusted compensation figures were based on a national average, which weight each location in the database equally. However, users were able to input a specific location of interest (Miami, Florida) that automatically adjusted the figures based on city size (larger cities' data weighted more heavily than smaller towns) and cost-of-living, which included home costs and taxes.

ERI avoided duplication of position titles and descriptions in the database. Database entries accounted for slight name variations. For example, the entry for communications engineer included alternate titles such as engineer – telecommunications and telecommunications engineer. As a result, job functions and overview descriptions were the same regardless of minor differences in syntax.

For this analysis, CUTR reviewed the ERI list of position titles and compared them to current and proposed MDT field engineering positions. Researchers also searched the database and compared positions according to descriptions and educational requirements. Based on these factors, CUTR selected the most applicable titles and added them to the Salary Assessor Benchmark List. Researchers entered MDT compensation data for each position, and the assessor calculated the market index for each position.

The *market index* provided a quick look at the agency's competitive pay position within the marketplace. The index was figured by dividing the MDT compensation amount by the overall ERI median annual compensation (this figure included all levels of experience). The resulting raw figure indicated the percentage of the median total compensation that MDT offered for that position. Figures above 100 indicated that MDT paid more than the overall median compensation for that position, while figures under 100 indicated the amount under the median that the agency paid. CUTR adjusted the figure to represent the percentage difference between MDT compensation and the ERI figure. Positive figures indicated the percent over the ERI median total compensation and negative figures indicated the percent under the median.

The Salary Assessor also presented compensation data according to years of experience. The maximum years of experience for each position varied according to the availability of salary data. For example, salary data for electrical engineer 4 were available for 1-16 years of experience, while salary data for communications engineer were available for 1-20 years of experience. Data were presented in chart form, with a low percentile, the survey median (or mean), and a high percentile. The percentiles were adjustable, so researchers were able to determine which percentile MDT compensation fell into. For this analysis, CUTR used either the year closest to the existing (to be reclassified) position holder's years of experience, or the total minimum years of experience required according to the MDT request for position form.

Findings: Total Compensation Analysis

The following sections provided the total compensation analysis for each position established under the proposed MDT field test engineering division.

Division Chief – Field Test Engineering
Researchers found the ERI database position of "manager, engineering" to be most similar to the proposed division chief/field test engineering position at MDT. According to ERI, the "manager, engineering" managed and coordinated activities of an engineering department to design, produce, improve, and test components, products, systems, and services. This position was typically the 2nd level of management, with 1st level supervisors reporting to it. The "manager, engineering" also administered personnel functions, including recruitment, hiring, performance evaluations, and salary adjustments. The position directed department activities, through subordinate managers, to design, modify, improve, test, and implement processes, as necessary. Other duties involved assembly of cost control and statistical data, development of material selection standards, preparation of annual budgets, and recommendation of new policies and procedures, as necessary.

For this position, survey compensation data were available for up to 18 years of experience. ERI reported that the median annual total compensation of "manager, engineering" positions with 18 years of experience was $137,762 (see Table 4.3). 90% of these positions reported total annual compensation to be greater than $114,343, while only 10% earned more than $168,208. The overall median figure for all years of experience was $106,392.

Manager – Field Test Engineering
CUTR found the ERI database position of "engineering specialist" (also referred to as "engineering supervisor/generic") to be most similar to the various proposed manager/field test engineering positions at MDT. According to ERI, the "engineering specialist" was the first line of supervision and management of engineering personnel. This position analyzed and resolved work problems, assisted employees in solving problems as needed, and may recruit, hire, and train staff, evaluate employee performance, and recommend promotions, transfers, or disciplinary action. The "engineering specialist" oversaw systems, procedures, and technical services, and provided planning, direction, and coordination for all technical activities. Further, the position was responsible to investigate costs, initiate cost reduction actions,

and devise plans, policies, and proposals regarding specific technical services.
The MDT compensation figure used for the analysis of the proposed manager – field test engineering positions was $93,083 (see Table 4.3). This figure represented the MDT engineer IV salary plus the average amount of salary increases associated with the 5 requested reclassifications to manager ($87,294 + $5,789). For this position, survey compensation data were available for up to 18 years of experience. ERI reported that the median annual total compensation for "engineering specialist" positions with 18 years of experience was $112,377. 90% of the 18-year positions reported total annual compensation to be greater than $94,397, while only 10% earned more than $135,752. The overall median total compensation figure across all years of experience was $94,853.

It is important to note that ERI did not report the engineering specialist position in levels or grades (such as "1", "2", "3", or "4"). For comparative purposes, the approximated salary for the proposed MDT manager – field test engineering position ($93,083) was just slightly below the ERI 10th percentile mark for an "engineering specialist" with 18 years of experience. In addition, the market index for MDT related to this position was 102.8.

Communications Engineer IV
Researchers found the ERI database position of "communications engineer" to be most similar to the proposed communications engineer IV positions at MDT. According to ERI, the "communications engineer" researched, developed, designed, and tested communications systems and equipment. S/he also conducted studies on communications systems and equipment, such as projected volume, system effectiveness and adequacy, and estimated costs. The position also analyzed reports, records, and recommendations to determine whether equipment should be repaired or replaced, additional equipment installed, or newly developed equipment acquired. Other responsibilities included: to prepare specifications and recommendations for acquisition of equipment, to coordinate equipment installations and maintenance activities, to approve purchases, and to work with contractors.

For this position, survey compensation data were available for up to 20 years of experience. ERI reported that the median annual total compensation for "communications engineer" positions with 20 years of experience was $96,679 (see Table 4.3). 90% of the 20-year positions reported total annual compensation to be greater than $81,210, while only 10% earned more than $113,018. The overall median total compensation figure across all years of experience was $74,739. At 10 years of experience, the total salary compensation figures were $62,781 (10th percentile), $74,739 (median), and $87,370 (90th percentile) (see Table 4.3).

It is important to note that ERI did not report the "communications engineer" position in levels or grades (such as "1," "2," "3," or "4"). For comparative purposes, the salary for the proposed MDT communications engineer iv position ($87,294) was just slightly below the ERI 85th percentile mark for a "communications engineer" with 10 years of experience ($87,370). In addition, the market index for MDT related to this position was 121.1.

Electrical Engineer IV

Researchers found the ERI database position of "electrical engineer 4" to be most similar to the proposed electrical engineer IV positions at MDT. According to ERI, the "electrical engineer 4" planned, scheduled, conducted, or coordinated detailed phases of electrical engineering work in major projects. The position may also devise new approaches to problems and offer technical guidance on unusual or complex problems and approval for project plans. The work required a broad knowledge of precedents in the specialty area and a good knowledge of principles and practices of related specialties. The position may supervise other staff on project tasks and works independently on many other tasks.

For this position, survey compensation data were available for up to 16 years of experience. ERI reported that the median annual total compensation for "electrical engineer 4" positions with 16 years of experience was $96,681. 90% of the 16-year positions reported total annual compensation to be greater than $81,212, while only 10% earned more than $116,791. The overall median total compensation figure for all years of experience was $81,770. At 7 years of experience, the total salary compensation figures were $66,760 (10th percentile), $79,476 (median), and $96,007 (90th percentile) (see Table 4.3).

It is important to note that the electrical engineer position was the only field of engineering that ERI reported in levels or grades (such as "1," "2," "3," or "4"). For comparative purposes, the salary for the proposed MDT electrical engineer IV position ($87,294) was just slightly below the ERI 75th percentile mark for an "electrical engineer 4" with 7 years of experience. In addition, the market index for MDT related to this position was 110.2.

Table 4.3. Proposed Staff Acquisitions: Total Compensation Comparative Analysis

MDT Position Title	MDT Salary	ERI Position Title	ERI Years of Experience	ERI Total Annual Compensation (10th percentile)	ERI Total Annual Compensation Median	ERI Total Annual Compensation (90th percentile)	MDT Percentile	ERI Market Index** (adjusted)
Division Chief, Field Test Engineering		Manager, Engineering	18	$ 114,343	$ 137,762	$ 168,208		
Manager (Engineering)	$ 93,083*	Engineering Specialist	18	$ 94,397	$ 112,377	$ 135,752	< 10th	+ 2.8%
Communications Engineer IV	$ 87,294	Communications Engineer	10	$ 62,781	$ 74,739	$ 90,285	85th	+ 21.1%
Electrical Engineer IV	$ 87,294	Electrical Engineer 4	7	$ 66,760	$ 79,476	$ 96,007	75th	+ 10.2%
Mechanical Engineer IV	$ 87,294	Mechanical Engineer	7	$ 54,389	$ 64,749	$ 78,217	> 90th	+ 30.2%
Engineer IV – Facilities	$ 87,294	Engineer Facilities	10	$ 57,179	$ 68,070	$ 82,229	> 90th	+ 31.8%
Track Systems Engineer IV	$ 87,294	Value Engineer	10	$ 59,442	$ 70,764	$ 85,483	> 90th	+ 23.2%
Traction Power Engineer IV	$ 87,294	Power Systems Engineer	10	$ 67,624	$ 80,504	$ 97,249	70th	+ 12.7%
Warranty Engineer IV	$ 87,294	Reliability Engineer	7	$ 54,574	$ 63,458	$ 75,008	> 90th	+ 26.7%
QA Engineer III	$ 86,107	QA Manager	7	$ 67,524	$ 80,386	$ 97,107	65th - 70th	+ 5.6%
Transit Facilities Superintendent (Electrical)	$ 67,778*	Superintendent - Utilities	7	$ 52,862	$ 63,689	$ 77,765	65th	+ 7.8%
IT Specialist (Systems Analyst II)	$ 73,866	IT Systems Administrator	7	$ 56,816	$ 67,638	$ 81,707	70th	+ 5.2%
Administrative Officer III	$ 75,068	Production Control & Planning Manager	7	$ 61,790	$ 73,560	$ 88,860	50th	+ 3.7%
Production Coordinator	$ 69,853	Documentation Engineer	5	$ 44,295	$ 52,732	$ 63,700	>90th	+ 13.7%
Engineer Drafter II	$ 55,848	Drafter CAD 2	3	$ 35,767	$ 42,078	$ 50,284	>90th	+ 14.2%
Office Support Specialist III	$ 45,604	Office Supervisor	3	$ 32,663	$ 38,884	$ 46,972	85th	+ 2.1%
Secretary	$ 42,071	Secretary 3	1	$ 29,677	$ 34,914	$ 41,722	>90th	- 2.9%

* - estimated. ** - adjusted index figure equaled the % difference between the ERI market figure and MDT figure. I.E. the MDT total compensation amount for the Secretary was 2.9% less than the ERI median.

Mechanical Engineer IV
Researchers found the ERI database position of "mechanical engineer" to be most similar to the proposed mechanical engineer IV positions at MDT. According to ERI, the "mechanical engineer" researched, developed, planned, and designed mechanical systems and required a degree in mechanical engineering. Other duties included installation to ensure systems conformed to engineering design and customer specifications, operation, maintenance, and repair activities to obtain optimal function of machines and equipment. The "mechanical engineer" may also design systems interfaces, evaluate field installations, and recommend design modifications to minimize malfunctions.

For this position, survey compensation data were available for up to 18 years of experience. ERI reported that the median annual total compensation for "mechanical engineer" positions with 18 years of experience was $84,385. 90% of the 18-year positions reported total annual compensation to be greater than $70,884, while only 10% earned more than $101,938. The overall median total compensation figure for all years of experience was $69,025. At 7 years of experience, the total salary compensation figures are $54,389 ($10^{th}$ percentile), $64,749 (median), and $78,217 ($90^{th}$ percentile) (see Table 4.3).

It is important to note that ERI did not report levels or grades (such as "1," "2," "3," or "4") for the "mechanical engineer" position. For comparative purposes, the salary for the proposed MDT mechanical engineer IV ($87,294) position was very close to the ERI 90^{th} percentile mark for a mechanical engineer with 11 years of experience. In addition, the market index for MDT related to this position was 130.2.

Engineer IV- Facilities
The field test engineering modification plan included requests for facilities engineers in both mechanical and electrical specialty areas. While the specific fields were included in this analysis, the ERI tools also provided compensation data for facilities engineer positions. As such, CUTR included this information for additional comparative purposes. According to ERI, the "facilities engineer" conducted research and development activities concerned with design, construction, and production of facilities and systems. Typically, this position determined the feasibility of designing new or modifying existing facilities considering costs, available space, time limitations, and other economic and technical factors. Further, this position may design, modify, or develop facilities, testing, machines, equipment, or processes, and it is usually provided technical information concerning

materials, properties, and process advantages and limitations that affect long range operations. The position may also involve coordinating maintenance and repair activities or field installations of equipment and systems.

For the "facilities engineer" position, ERI survey compensation data were available for up to 20 years of experience. ERI reported that the median annual total compensation for "facilities engineer" positions with 20 years of experience was $81,491. 90% of the 20-year positions reported total annual compensation to be greater than $68,452, while only 10% earned more than $98,441. The overall median total compensation figure for all years of experience was $68,070. At 10 years of experience, the total salary compensation figures are $57,179 (10th percentile), $68,070 (median), and $82,229 (90th percentile) (see Table 4.3).

It is important to note that ERI did not report levels or grades (such as "1," "2," "3," or "4") for the "facilities engineer" position. For comparative purposes, the salary for the proposed MDT facilities engineer IV ($87,294) position was very close to the ERI 90th percentile mark for a facilities engineer with 12 years of experience. In addition, the market index for MDT related to the "facilities engineer" position was 131.8.

Track Systems Engineer IV

There were few positions in the ERI database that were highly similar to the proposed specialized position of track systems engineer IV at MDT. Based on general common duties, researchers selected the ERI database position of "value engineer" for comparison. According to ERI, the "value engineer" analyzed design data to determine conformance to established design criteria, use of standardized parts and equipment, and design-to-cost ratio. Further, this position involved approval of initial designs and recommended modifications, coordinated testing of new parts and equipment, evaluated test results, and approved or rejected use based on test results. Additional responsibilities included working with staff technicians, improving procedures, parts, and required technologies. The position is also charged with developing maintenance programs, as well as programs to predict, track, and report operating costs, and looking for ways to improve performance and reduce cost.

For this position, survey compensation data were available for up to 22 years of experience. ERI reported that the median annual total compensation for "value engineer" positions with 22 years of experience was $89,233. 90% of the 22-year positions reported total annual compensation to be greater than $74,956, while only 10% earned more than $107,793. The overall median total compensation figure for all years of experience was $72,873. At 10 years of experience, the total salary compensation figures are $59,442 (10th percentile), $70,764 (median), and $85,483 (90th percentile) (see Table 4.3).

It is important to note that ERI did not report levels or grades (such as “1”, “2”, “3”, or “4”) for the “value engineer” position. For comparative purposes, the salary for the proposed MDT track systems engineer IV ($87,294) position was slightly higher than the ERI 90th percentile mark for a “value engineer” with 10 years of experience. In addition, the market index for MDT related to this position was 123.2.

Traction Power Engineer IV
Researchers found two ERI database positions, “power systems engineer” and “power distribution engineer,” to be most similar to the proposed traction power engineer IV position at MDT. As both positions were similar to each other in the ERI database, CUTR selected the position closer in salary to the MDT position. According to ERI, the “power systems engineer” designed and maintained power system facilities and equipment, and coordinated construction, operation, and maintenance of electric power generating, receiving, and distribution stations, systems, and equipment. The position also prepared drawings, estimated labor costs, and inspected completed installations for compliance with design and equipment specifications and safety standards. This position also responded to situations as they arise, and sought to optimize power facilities to meet demands.

For this position, survey compensation data were available for up to 20 years of experience. ERI reported that the median annual total compensation for a “power systems engineer” position with 20 years of experience was $100,779. 90% of the 20-year positions reported total annual compensation to be greater than $84,654, while only 10% earned more than $121,741. The overall median total compensation figure for all years of experience was $80,504. At 10 years of experience, the total salary compensation figures are $67,624 (10th percentile), $80,504 (median), and $97,249 (90th percentile) (see Table 4.3).

It is important to note that ERI did not report levels or grades (such as “1,” “2,” “3,” or “4”) for the “power systems engineer” position. For comparative purposes, the salary for the proposed MDT traction power engineer IV ($87,294) position was close to the ERI 70th percentile mark for a “power systems engineer" with 10 years of experience. In addition, the market index for MDT related to this position was 112.7.

Warranty Engineer IV

Researchers found the ERI database position of "reliability engineer" to be most similar to the proposed warranty engineer IV positions at MDT. According to ERI, the "reliability engineer" designed and developed programs to achieve reliability objectives and support proposed changes in design. The position was also involved in analyzing performance and calculating effects of proposed modifications on systems or individual components. In addition, this engineer looked at failure mode and effect analyses to identify units with greatest potential for failure, predicted performance, and conferred information in design review meetings. The position monitored failures, reviewed specifications and modifications for potential causes and effects, analyzed data, and may work with vendors or suppliers to determine methods to improve performance and reliability.

For this position, survey compensation data were available for up to 20 years of experience. ERI reported that the median annual total compensation for a "reliability engineer" position with 20 years of experience was $88,964. 90% of the 20-year positions reported total annual compensation to be greater than $76,509, while only 10% earned more than $105,155. The overall median total compensation figure for all years of experience was $71,680. At 7 years of experience, the total salary compensation figures were $54,574 (10th percentile), $63,458 (median), and $75,008 (90th percentile) (see Table 4.3).

It is important to note that ERI did not report levels or grades (such as "1," "2," "3," or "4") for the "reliability engineer" position. For comparative purposes, the salary for the proposed MDT warranty engineer IV ($87,294) position was close to the median total compensation for a "reliability engineer" with 18 years of experience. In addition, the market index for MDT related to this position was 126.7.

QA Engineer III

Researchers found the ERI database position of "quality assurance manager" to be most similar to the proposed QA engineer III position at MDT. According to ERI, the "quality assurance manager" planned, coordinated, and directed quality control programs to ensure standards are maintained. This position managed the development and analysis of statistical data and specifications to determine present standards and establish proposed quality and reliability expectancy. The "quality assurance manager" also formulated and maintained quality control objectives and inspected practices and procedures to maximize quality and reliability and to minimize costs. Further, the position may develop and implement methods and procedures for monitoring work activities, and plan, promote, and organize training related to quality and reliability. The manager also interpreted company policy to employees and enforced policy and practices.

For this position, survey compensation data were available for up to 18 years of experience. ERI reported that the median annual total compensation for a "quality assurance manager" position with 18 years of experience was $101,071. 90% of the 20-year positions reported total annual compensation to be greater than $84,900, while only 10% earned more than $122,094. The overall median total compensation figure for all years of experience was $84,782. At 7 years of experience, the total salary compensation figures were $67,524 (10th percentile), $80,286 (median), and $97,107 (90th percentile) (see Table 4.3).

It is important to note that ERI did not report levels or grades (such as "1," "2," "3," or "4") for the "quality assurance manager" position. For comparative purposes, the salary for the proposed MDT quality assurance engineer III ($86,107) position fell between the 65th and 70th percentiles for a "quality assurance manager" with 7 years of experience. In addition, the market index for MDT related to this position was 105.6.

Transit Facilities Superintendent - Electrical

Researchers found the ERI database position of "superintendent-utilities" to be most similar to the upgraded transit facilities superintendent/electrical position at MDT. According to ERI, the "superintendent-utilities" supervised and coordinated activities of workers engaged in maintaining building utility systems, including electrical wiring and control systems and fire alarm and emergency systems. Additional functions were studying schedules and estimating worker-hour requirements for completion of assigned tasks, as well as interpreting policies, specifications, blueprints, and work orders, and enforcing safety regulations. The holder of this position may also be involved in making recommendations to improve methods, performance, and quality of services provided, and may inspect systems to determine preventive maintenance needs. Changes in working conditions, equipment use, and scheduling might also be necessary, and the position may train maintenance workers, perform evaluations, help solve problems, and recommend personnel actions.

CUTR did not have a total annual compensation figure available for the transit facilities superintendent-electrical position at MDT. However, the field test engineering modification plan provided for a slight increase in pay grade for the position ($3,786). CUTR added the salary increase amount to the average compensation for the position ($63,992) to arrive at a working total compensation estimate of $67,778 (see Table 4.3). (For this estimate, the salary amount was determined by taking the average of the Miami-Dade County minimum and maximum annual salary figures for the position.)

Again, ERI did not report levels or grades (such as "1," "2," "3," or "4") for the "superintendent-utilities" position. For this position, survey compensation data were available for up to 16 years of experience. ERI reported that the median annual total compensation for a "superintendent-utilities" position with 16 years of experience was $81,319. 90% of the 16-year positions reported total annual compensation to be greater than $67,495, while only 10% earned more than $99,291. The overall median total compensation figure for all years of experience was $65,684. At 7 years of experience, the total salary compensation figures were $52,862 ($10^{th}$ percentile), $63,689 (median), and $77,765 ($90^{th}$ percentile).

For comparative purposes, the increased salary total for the transit facilities superintendent/electrical position at MDT position was very close to the 65^{th} percentile for a "superintendent-utilities" position with 7 years of experience. In addition, the market index for MDT related to this position was 107.8.

IT Specialist (Systems Analyst II)

Although several positions seemed applicable for comparison, researchers determined the ERI database position of "IT Systems Administrator" to be most similar to the proposed it specialist (systems analyst ii) positions at MDT. According to ERI, the "IT Systems Administrator" developed, tested, implemented, and maintained operating systems and related network software. While this position generally was not involved with writing or altering operating system software codes, it did configure software and hardware specific to the organization. The "IT Systems Administrator" also established and implemented standards for computer equipment operations to maintain compatibility between hardware and software according to predetermined specifications. Further, the position holder scheduled, performed, and monitored systems maintenance, backups, upgrades, and growth. Technical support was also provided, and new equipment specifications were reviewed and recommended.

For this position, survey compensation data were available for up to 18 years of experience. ERI reported that the median annual total compensation for an "IT Systems Administrator" position with 18 years of experience was $89,921. 90% of the 18-year positions reported total annual compensation to be greater than $75,534, while only 10% earned more than $108,624. The overall median total compensation figure for all years of experience was $73,043. At 7 years of experience, the total salary compensation figures were $56,816 (10th percentile), $67,638 (median), and $81,707 (90th percentile) (see Table 4.3).

ERI did not report levels or grades (such as "1," "2," "3," or "4") for the "IT Systems Administrator" position. For comparative purposes, the salary for the proposed MDT it specialist (systems analyst ii) position ($73,866) was closest to the 70th percentile for an "IT Systems Administrator" with 7 years of experience. In addition, the market index for MDT related to this position was 105.2.

Administrative Officer III

Researchers found the ERI database position of "production control & planning manager" to be most similar to the proposed administrative officer iii position proposed at MDT. According to ERI, the "production control & planning manager" managed and coordinated work assignments, including staffing and scheduling. This was typically a first line supervisor position that usually was assigned various, specialized aspects of the organization's operation. Other duties may involve recommending new policies or procedures, administering personnel functions, and planning project schedules and following up on performance estimates. This position may also be involved with design specifications, establishing standards, preparing and/or controlling budgets, and managing cost control and statistical data.

For this position, survey compensation data were available for up to 16 years of experience. ERI reported that the median annual total compensation for a "production control & planning manager" position with 16 years of experience was $93,438. 90% of the 16-year positions reported total annual compensation to be greater than $78,488, while only 10% earned more than $112,874. The overall median total compensation figure for all years of experience was $76,114. At 7 years of experience, the total salary compensation figures were $61,790 (10th percentile), $73,560 (median), and $88,860 (90th percentile) (see Table 4.3).

ERI did not report levels or grades (such as "1," "2," "3," or "4") for the "production control & planning manager" position. For comparative purposes, the salary for the proposed MDT administrative officer III position ($75,068) was slightly below the 50th percentile point for a "production control & planning manager" with 7 years of experience. In addition, the market index for MDT related to this position was 103.7.

Production Coordinator

According to the field test engineering modification plan, the proposed position of production coordinator will be largely responsible for managing field test engineering documents and establishing a field test engineering library. Plan #1 also called for this position to report directly to the proposed administrative officer III position. Within the ERI database, two positions seemed directly comparable to the MDT production coordinator position however, deeper investigation revealed a third position to be most applicable. Specifically, the ERI position of "engineering librarian" included similar responsibilities to the MDT production coordinator, but managerial control and maintenance scheduling were not among these. In addition, the ERI position of "production control & planning supervisor" was a direct report to the "production control & planning manager" (the position chosen for comparison to the administrative officer III position, which will have direct oversight of the production coordinator); however, the ERI position had only limited documentation responsibilities. As a result, CUTR found the ERI database position of "documentation engineer" to be most similar to the proposed production coordinator position at MDT.

According to ERI, the "documentation engineer" planned, directed, coordinated, and prepared project documentation, such as engineering drawings, specifications, schedules, modifications, contracts, and manuals. This position reviewed contracts to determine documentation required at each stage of a project, including drawings, software, technical details, and other documents, as necessary. The "documentation engineer" also monitored project status to ensure that required documentation is handled according to schedule. This position reviewed and verified project documents for completeness, format, and compliance, and retains necessary information. Further, the "production control & planning manager" submitted project documentation for managerial approval, transmitted and maintained documents, and prepared or modified contracts as required.

For this position, survey compensation data were available for up to 20 years of experience. ERI reported that the median annual total compensation for a "production control & planning manager" position with 20 years of experience was $75,352. 90% of the 20-year positions reported total annual compensation to be greater than $63,296, while only 10% earned more than $91,025. The overall median total compensation figure for all years of experience was $63,155. At 5 years of experience, the total salary compensation figures were $44,295 (10th percentile), $52,732 (median), and $63,700 (90th percentile) (see Table 4.3).

ERI did not report levels or grades (such as "1," "2," "3," or "4") for the "production control & planning manager" position. For comparative purposes, the total compensation for the proposed MDT production coordinator position ($69,853) was very close to the median amount for a "production control & planning manager" with 14 years of experience. In addition, the market index for MDT related to this position was 113.7.

Engineering Drafter II
Researchers found the ERI database position of "drafter CAD 2" to be most similar to the proposed engineering drafter II position at MDT. According to ERI, the "drafter CAD 2" was often highly specialized and had greater involvement with software programs involving computer-aided drafting. The position may also be responsible to develop specialized program applications, complete project or product designs, analyze data, and deal with software vendors. This position provided specialty drafting as needed by the organization.

For this position, survey compensation data were available for up to 14 years of experience. ERI reported that the median annual total compensation for a "drafter CAD 2" position with 14 years of experience was $60,628. 90% of the 14-year positions reported total annual compensation to be greater than $51,534, while only 10% earned more than $72,451. The overall median total compensation figure for all years of experience was $49,812. At 3 years of experience, the total salary compensation figures were $35,767 (10th percentile), $42,078 (median), and $50,284 (90th percentile) (see Table 4.3).

For comparative purposes, the total compensation for the proposed MDT engineering drafter II position ($55,848) was very close to the median amount for a "drafter CAD 2" with 14 years of experience. In addition, the market index for MDT related to this position was 114.2.

Office Support Specialist III
Researchers found the ERI database position of "office supervisor" to be most similar to the proposed office support specialist III position at MDT. According to ERI, the "office supervisor" coordinated and supervised

administrative, clerical, and support functions. The position was a first level supervisor of office staff, which were involved in a variety of office tasks. Specific responsibilities of the "office supervisor" included preparing work schedules and assigning duties to personnel; auditing accounts, records, and certifications to ensure compliance with established work standards; compiling required documentation and special reports; and formulating office procedures and establishing uniform correspondence procedures and practices. The position also reviewed clerical and personnel records to ensure completeness, accuracy, and timeliness. It may also involve preparing budgets and periodic financial reports. Further, the position may require directing employee training and conducting staff meetings and conferring with associates to deal with specific issues.

For this position, survey compensation data were available for up to 14 years of experience. ERI reported that the median annual total compensation for an "office supervisor" position with 14 years of experience was $54,106. 90% of the 14-year positions reported total annual compensation to be greater than $45,449, while only 10% earned more than $63,250. The overall median total compensation figure for all years of experience was $45,417. At 3 years of experience, the total salary compensation figures were $32,663 (10th percentile), $38,884 (median), and $46,972 (90th percentile) (see Table 4.3).

For comparative purposes, the total compensation for the proposed MDT office support specialist III position ($45,604) was between the 85th and 90th percentile total compensation for an "office supervisor" with 3 years of experience. In addition, the market index for MDT related to this position was 102.1.

Secretary

Researchers found the ERI database position of "secretary 3" to be most similar to the proposed secretary position at MDT. According to ERI, the "secretary 3" position handled a variety of complex situations involving the clerical or administrative function of the office that should not be brought to the attention of an executive official. The position involved most general clerical functions, including scheduling appointments, receiving and delivering mail, preparing correspondence, and responding to inquiries. Further, the "secretary 3" worked with professional staff in a supportive role to prepare reports, summaries, and information gathering. Additional responsibilities included answering and directing telephone calls, greeting and directing visitors, and placing calls as necessary.

For this position, survey compensation data were available for up to 14 years of experience. ERI reported that the median annual total compensation for the "secretary 3" position with 14 years of experience was $52,843. 90% of the 14-year positions reported total annual compensation to be greater than $44,916, while only 10% earned more than $63,147. The overall median total compensation figure for all years of experience was $44,094. At 1 year of experience, the total salary compensation figures were $29,677 (10th percentile), $34,914 (median), and $41,722 (90th percentile) (see Table 4.3).

For comparative purposes, the total compensation for the proposed MDT secretary position ($42,071) was slightly higher than the 90th percentile total compensation for a "secretary 3" with 1 year of experience. Further, the MDT total compensation was similar to the median level of a "secretary 3" with 6 years of experience. In addition, the market index for MDT related to this position was 97.1.

Peer Agency Comparison: Total Compensation Analysis

After review of the initial draft report, FESM managers asked CUTR to investigate engineering compensation rates among the peer agencies. Although direct comparison of salary data is generally considered invalid, especially among employers in such geographically diverse areas as Miami, Atlanta, and Washington D.C., researchers responded to the request and reported findings in the following paragraphs. FESM managers and other MDT agents are advised to consider peer agency compensation data on a "for your information only" basis. In addition, the following information should not be used as the basis for compensation decision-making purposes.

CUTR asked compensation specialists and payroll administrators at MARTA and WMATA for salary data related to the engineering positions requested by plan #1. Specifically, researchers provided a brief summary of each position and asked peer officials to select the positions within their agency that most closely resembled the MDT position. Peer officials returned this information to CUTR. In some cases, the peer offered minimal data in return.

MARTA officials informed CUTR that many of the positions requested in plan #1 had no comparable position at MARTA. In fact, the compensation specialist responded with salary data for only 3 positions. MARTA claimed that due to their overwhelming use of general engineering consultants, they did not directly retain positions comparable to MDT. In addition, MARTA would only provide midpoint compensation data for the following engineering positions: electrical engineer IV, mechanical engineer IV, and manager/quality assurance (see Table 4.4).

Table 4.4. Peer Agency Engineering Position Compensation Data: MARTA

Position	Description	Salary Amount
Electrical Engineer IV	Midpoint	$ 59,148
Mechanical Engineer IV	Midpoint	$ 59,148
Manager/Quality Assurance	Midpoint	$ 81,735

Payroll officials at WMATA provided CUTR with salary range data for 13 comparable engineering positions. The positions and salaries are listed in Table 4.5.

Table 4.5. Peer Agency Engineering Position Compensation Data: WMATA

Position	Description	Salary Amount
Chief Engineer	Salary range	$70,476 - $105,662
Assistant Chief Engineer	Salary range	$87,652 - $131,582
Senior Project Manager	Salary range	$87,652 - $131,582
Manager, Engineering	Salary range	$76,409 - $114,718
Communications Engineer	Salary range	$60,284 - $ 91,056
Senior Electrical Engineer	Salary range	$60,284 - $ 91,056
Senior Communications Engineer	Salary range	$70,476 - $105,662
Software Engineer	Salary range	$63,995 - $ 96,766
IT Project Manager	Salary range	$70,476 - $105,662
Manager/Quality Assurance	Salary range	$70,476 - $105,662
Secretary III	Salary range	$31,677 - $ 47,515
Engineering CAD Technician	Salary range	$42,222 - $ 63,771

V. CONCLUSIONS & RECOMMENDATIONS

This research effort was designed to address a number of key questions regarding the modification and improvement of field test engineering services at Miami-Dade Transit. Specifically, CUTR conducted a multi-step investigation to determine the reasonableness of the FESM plan to address field test engineering personnel deficiencies and other challenges associated with ongoing and planned agency growth. For this study, researchers examined the current state and organizational structure of the MDT field test engineering section, reviewed practices at peer transit agencies, assessed the modification proposal, devised a research process, and conducted manpower-needs and total compensation analyses.

The following chapter is organized into 2 general areas. First, CUTR presented a series of conclusions based on each step completed during the investigation of MDT field test engineering. Later, researchers concluded the chapter with a series of recommended actions based on the overall findings and results of this study effort.

CONCLUSIONS

CUTR drew several conclusions based on this research endeavor, the most significant being that the current state of field test engineering at MDT cannot meet existing or anticipated demands for services. Without the acquisition of additional personnel, a presently frustrating situation will only continue to worsen.

An all-inclusive set of conclusions generated by this study is cataloged below.

1. Background

1.1. The original scope of responsibilities for FESM/field test engineering personnel was generally limited to maintenance of existing equipment and systems. Responsibilities increased significantly over time.

1.2. Any MDT division may request FESM/field test engineering services. Most divisions received at least minimal support from the group.

1.3. Prior to 1999, field test engineers reported to 1 of the 3 various MDT vehicle maintenance divisions. After 1999, field test engineers reported to the MDT FESM division.

1.4. Prior to 1999, field test engineers performed mostly maintenance engineering services and played a supportive role in small projects. After 1999, the responsibilities of field test engineers expanded to also include developmental engineering services, large-scale projects and implementation, and other various field engineering duties.

2. Current MDT Field Test Engineering Responsibilities

2.1. Field test engineers provided support to MDT divisions in 5 key transit areas, including: vehicles, train control, traction power, systems, and facilities.

2.2. Field test engineers were responsible for engineering support to 136 Metrorail railcars, 29 Metromover vehicles, and over 1,000 Metrobus vehicles. Field test engineering personnel also supported the 22.5-mile Metrorail track system and the 4.4-mile automated Metromover guideway system.

2.3. Overall, the field test engineering section scope of services involved: maintenance programs, development of specifications, implementation support to small- and large-scale improvement projects, various studies, and feasibility analyses.

2.4. The field test engineering section was responsible for developmental services related to the following areas: contracts and specifications, project management, project implementation, feasibility studies, and code compliance.

2.5. Field test engineering duties related to contracts and specifications involved preparing the proper documentation, complete oversight of vehicle and equipment acquisitions, participation in the bid and selection process, organization of contractor design review meetings, and revisions to documents, as necessary.

2.6. Field test engineers managed both small and large improvement projects, including entire system modifications or replacements. Specific duties involved a variety of testing and inspection throughout the design, production, delivery, and implementation phases. Field test engineers also reviewed and approved payment requests, claims, and change orders. Further, they maintained frequent contact with contractors and acted as liaison between contractors and other MDT divisions.

2.7. Project implementation tasks completed by field test engineers supported large- and small-scale efforts to improve existing systems. Specific responsibilities included the development and implementation of new maintenance programs for new systems, which frequently involved the design of new processes and methods, as well as providing training to maintenance personnel.

2.8. The field test engineering section was responsible for maintenance engineering services related to the following areas: development of preventive maintenance programs, capital enhancements, technical components replacement, various modifications, accident and malfunction investigation, implementation of corrective measures, and quality control.

2.9. Field test engineering duties related to preventive maintenance programs involved program development, implementation, modification, and scheduling for all three vehicle modes operated by MDT. Engineers may be required to work with original equipment manufacturers to devise corrective measures or modifications, such as in cases of obsolescence or unusual occurrences (repeated accidents, fires, or other chronic malfunctions).

2.10. Field test engineers were responsible for completion of written documentation and analysis of unusual occurrences and providing results to relevant MDT divisions, including operations, maintenance, and safety.

2.11. MDT did not retain quality control inspectors, so field test engineers were responsible for this activity. Related duties involved random maintenance inspections, technician observations, and corrective instruction, as required.

2.12. Field test engineers were involved in a variety of non-engineering functions, including administrative, clerical, human resources, drafting, and other supporting tasks.

3. Current Organization of MDT Field Test Engineering Section

3.1. The field test engineering section was one of 3 areas within the MDT FESM division, which also included systems maintenance and structural inspection & analysis.

3.2. Section oversight was the responsibility of the manager/field test engineering, who reported directly to the chief/FESM.

3.3. 3 groups exist within the current field test engineering section: Field/Maintenance Engineers, Fire & Burglar Alarms, and the Electronic Repair Facility.

3.4. Current section staff included 7 field test engineers, 4 of whom were classified as lead field test engineers. Additional personnel included 2 engineer (III) positions, 1 special project administrator, and 1 transit facilities superintendent – electrical.

3.5. Each lead field test engineer position focused on one of the following areas: communications, vehicles, fare collection, and train control & traction power.

3.6. Staff at the electronic repair facility consisted of 1 electronic technician supervisor and 11 transit electronic technician/lab positions.

4. MDT FESM Division Modification Plan

4.1. FESM division leadership created the modification plan in response to continued growth in the demand for FESM/field test engineering services and the expansion of division responsibilities. Management personnel recognized the potential for a significant decline in engineering service effectiveness if the current state of the division was left unchanged.

4.2. The FESM division modification plan consisted of 3 phases, each of which addressed personnel deficiencies and service inadequacies for 1 of the 3 areas of FESM: field test engineering, systems maintenance, and structural inspection & analysis.

4.3. Each plan phase served as a responsive solution to existing personnel shortages and offered proactive solutions to meet future staffing and management challenges related to upcoming MDT projects.

4.4. Among the 3 phases of the FESM divisional plan, the effort to modify the field test engineer section was clearly the most ambitious in terms of overall structural changes, personnel acquisitions, and augmentations of responsibilities.

4.5. Under the terms of the overall plan, oversight of the electronic repair facility would be removed from the field test engineering area to the systems maintenance area

5. MDT Field Test Engineering: Personnel Deficiencies

5.1. Overall, 5 official positions within the existing field test engineering section were vacant.

5.2. Overall, only 2 official clerical staff positions existed to serve the entire FESM division. There were no official clerical staff positions dedicated to the existing field test engineering section.

5.3. Lack of support personnel in the existing field test engineering section forced field test engineers to perform a considerable amount of non-engineering tasks, including clerical and administrative duties.

5.4. Lack of adequate numbers of specialized engineering personnel in the existing field test engineering section forced existing engineers to perform duties beyond their areas of expertise.

5.5. The existing field test engineering section had no resident track systems engineer specifically responsible for track maintenance programs, redesign, and support to track and guideway systems improvements and maintenance.

5.6. The existing field test engineering section had no resident traction power engineer responsible for maintenance and repair of power delivery systems to Metrorail and Metromover guideways.

5.7. The existing field test engineering section had no resident facilities maintenance engineers specifically dedicated to daily, routine facility systems and equipment.

5.8. The existing field test engineering section had no resident mechanical engineers specifically dedicated to daily, routine rail vehicle maintenance engineering needs.

5.9. The existing field test engineering section had no resident electrical engineers specifically dedicated to serve daily, routine rail vehicle maintenance engineering needs.

5.10. The existing field test engineering section had no resident warranty engineers specifically dedicated to daily, routine rail vehicle maintenance engineering.

5.11. The existing field test engineering section had only one resident mechanical engineer specifically dedicated to daily, routine Metrobus vehicle maintenance engineering.

5.12. The existing field test engineering section had no resident electrical engineers specifically dedicated to daily, routine Metrobus vehicle maintenance engineering.

5.13. The existing field test engineering section had no resident communications engineers specifically dedicated to meet relevant Metrobus vehicle maintenance engineering needs.

5.14. The existing field test engineering section had no resident quality assurance engineers specifically dedicated to meet relevant Metrobus vehicle needs.

5.15. In the area of fare collections, the existing field test engineering section retained only 1 full time engineer specifically dedicated to meet relevant fare collection and revenue needs. 2 staff assisted on a part time basis however, both had full time positions elsewhere with the agency.

5.16. In the area of fare collections, the existing field test engineering section retained no dedicated fare collection engineering staff in any of the following areas: mechanical, warranty, quality assurance, or warranty. In addition, no IT specialists were dedicated to support fare collections.

5.17. The existing field test engineering section had no resident librarian or other staff positions specifically dedicated to maintaining a current library of technical documents.

5.18. The existing field test engineering section had no resident draftsperson to design, create, study, or provide technical engineering drawings.

6. MDT Field Test Engineering (Section) Modification Plan (Plan #1)

6.1. The modification effort developed for the field test engineering section was originally organized into 4 distinct components: 1) support for the Metrorail rehabilitation project; 2) management of the universal automated fare collection (UAFC) project; 3) support for Metrobus vehicle acquisition and maintenance efforts; and 4) miscellaneous general requirements.

6.2. For each of the 4 distinct components, plan #1 identified specific personnel needs, costs, justifications, and services to be provided. In total, 27 new positions were identified and 8 existing positions were reclassified.

6.3. Staff acquisitions and reclassifications described in plan #1 necessitated the development of a thorough reorganization plan for the field test engineering section. The plan included measures to organize engineers into more focused and more easily managed work groups. Specifically, plan #1 remade the section into a full-fledged division organized into 7 specialty areas: power & control, vehicle support, bus systems, communications, revenue, product evaluation, and transit facilities.

6.4. Among the primary motivations for the development of plan #1 was to realize improvements in the effectiveness and efficiency of field test engineering management. As such, the plan stipulated that 5 of the modified field test engineering specialty areas be overseen by a specialized engineering manager.

6.5. The Metrorail rehabilitation effort involved the complete overhaul of the entire existing railcar fleet, the purchases of 26 new rail cars and 12 new Metromover vehicles, and the extension of 2 rail lines. Field test engineers were obligated to support these activities, as well as to play a key role in the development of maintenance plans and to provide other technical support services associated with the Metrorail plan.

6.6. In response to expected workload increases generated by the Metrorail rehabilitation effort, plan #1 identified the following field test engineering staff augmentations: reclassify an existing lead field test engineer to manager/vehicle support and acquire 1 mechanical engineer, 1 electrical engineer, and 1 warranty engineer.

6.7. The UAFC project was an ambitious effort to modernize all fare collection equipment on MDT vehicles. Further, the project created a regional system that would be implemented by several neighboring transit systems. Field test engineers were obligated to support these activities, as well as to play a key role in the development of equipment maintenance plans and to provide other technical support services as necessary. Until the entire new system was implemented, field test engineers also would continue to support existing fare collection equipment.

6.8. In response to expected workload increases generated by the UAFC effort, plan #1 identified the following adjustments to field test engineering staff: reclassify an existing lead field test engineer to manager/communications & revenue; and acquire 1 mechanical engineer, 1 electrical engineer, 1 warranty engineer, 1 QA engineer, 2 IT specialists, 1 administrative officer, and 1 production coordinator.

6.9. The Metrobus acquisitions and maintenance effort involved providing additional support for the expanded fleet. Current field test engineering staff focused mostly on bus procurement. Additional support was required in the areas of maintenance program development, quality assurance, warranties, and replacements.

6.10. In response to personnel deficiencies and expected workload increases generated by Metrobus acquisition and maintenance efforts, plan #1 included the following field test engineering staff modifications: reclassify the existing special project administrator to manager/bus systems; and acquire 3 mechanical engineers, 2 electrical engineers, 1 communications engineer, and 1 QA engineer.

6.11. The 4th portion of plan #1 covered several general modifications necessary for the section to be fully recognized as an all-inclusive field test engineering division. Staff adjustments required by this area included the addition of 8 personnel: 1 mechanical engineer, 1 electrical engineer, 1 communications engineer, 1 track systems engineer, 1 traction power engineer, 1 engineering drafter, 1 office support specialist, and 1 secretary. In addition, an existing communications engineer would be elevated to manager/communications, and an existing lead field test engineer would be elevated to manager/power & control.

7. MDT Field Test Engineering Modification Plan: Costs

7.1. The MDT field test engineering modification plan included total compensation cost figures (annual salary plus fringe benefits) for each new or reclassified position. Overall, the total compensation costs associated with full implementation of the 27 new positions and 8 reclassified positions were approximately $2.22 million.

7.2. Each new engineer IV position had a total compensation figure of $87,294.

7.3. For the 8 reclassified positions, the plan only allotted for requisite 5% salary increases, not the total annual compensation costs.

7.4. Although total compensation figures for the QA engineers and the IT specialists were included in plan #1, these positions were most likely to be paid through their respective divisions at MDT.

7.5. The MDT field test engineering modification plan included costs for required equipment associated with each new or reclassified position. Overall, equipment costs totaled approximately $777,000.

7.6. Plan #1 identified the acquisition of following equipment as necessary for additional or reclassified field test engineering personnel: desktop computers, laptop computers, office furniture, automobiles, county radios, office space, miscellaneous items, and 1 copy machine. The UAFC component included travel costs necessary to complete factory testing.

8. Peer Agency Review

8.1. The peer agency review focused on 4 general areas of interest: management philosophy, determining personnel needs, organizational structure, and evaluation techniques for employee productivity.

8.2. This research effort used WMATA (Washington, D.C.) and MARTA (Atlanta, Ga.) as peer agencies for comparison to MDT.

8.3. WMATA operated 2 modes, Metrobus and Metrorail, with close to 1,500 buses and over 900 railcars in service. The rail system included 106 miles of track and 86 stations.

8.4. The MARTA revenue fleet included over 550 buses and 338 railcars, which operated on 48 miles of track through 38 rail stations.

8.5. The mix of vehicle types and OEMs among the WMATA Metrobus fleet was generally similar to the MDT Metrobus fleet.

8.6. MARTA operated 2 types of buses, close to 75% of which were CNG vehicles.

8.7. MARTA and WMATA were both engaged in major railcar rehabilitation efforts.

8.8. Engineering functions at WMATA were consolidated under one division, collectively referred to as Planning, Development, Engineering, and Construction (PDEC).

8.9. A deputy general manager (DGM) had oversight of PDEC. 8 offices were subordinate to the DGM, including 3 chief engineer offices: vehicles, facilities, and systems. Most field test engineering responsibilities at WMATA were overseen by one of the 3 chief engineers.

8.10. All engineering areas at WMATA included a full complement of support staff.

8.11. PDEC followed a detailed mission statement, which included performance goals, a core mission, benchmarks, and objectives. Each subordinate office area also produced these tools. They were refined as necessary, on a quarterly basis.

8.12. The hierarchy within each WMATA chief engineer office was such that several assistant chiefs, managers, and/or directors were in place to closely manage specific areas of engineering. These positions reported directly to the chief engineer and often had subordinate supervisors or assistants reporting to them.

8.13. At the time of writing, the WMATA chief engineer: vehicles oversaw a total staff of 46 employees. Vehicle engineering oversight was organized into the following areas: rail cars, rail car engineering, vehicle engineering, buses, and criteria, standards, & integration.

8.14. WMATA highly valued education and professional licensure among its engineering staff. Specifically, the assistant chief engineer position required an engineering degree and a licensed P.E. The agency also observed a policy of training from within. The agency also created programs to recruit recent college graduates with the intent of offering an appealing career in transit engineering.

8.15. WMATA engineering managers actively practiced a proactive, preventive approach to problems. They also maintained strong communication efforts with subordinates within engineering and with other agency divisions.

8.16. WMATA engineering managers observed a policy of driving responsibilities down, thus empowering employees to take ownership of their work requirements.

8.17. For effective project management, engineers at WMATA were required to use written work plans for most major efforts. The plan included all project needs and required approval of engineering managers and managers from other involved divisions. The work plan was also used as a tool of accountability, especially during the annual review process.

8.18. WMATA resisted the use of engineering contractors. Rather, the agency preferred to handle most tasks in-house. Engineering managers followed a policy of out-tasking, which allowed for the limiting of contracting to specific tasks that could not be completed within the agency.

8.19. Regarding the process of procurement, WMATA engineering sought the participation of in-agency end-users in order to afford them the opportunity to contribute personal expertise and to gain greater insight into the rationale for decisions made.

8.20. WMATA practices a training-by-systems approach. This involved educating technicians on the workings of component parts within an entire system, rather than focusing on a specific part out of context of its role in the overall function.

8.21. To determine staffing needs, WMATA engineering managers relied mostly on personal judgment and experience. Most staff needs were met at the time of this research, and WMATA engineers were not found to work outside of their areas of expertise.

8.22. Engineering managers at WMATA relied mostly on a subjective approach to measure employee productivity. Specifically, one-on-one meetings were conducted on a bi-annual basis to set goals, review progress, and discuss work performance. Fleet performance measures were not used during the process of individual evaluations.

8.23. Engineering functions at MARTA were dispersed between operations and engineering & infrastructure. Specifically, vehicle maintenance engineering service and warranty responsibilities were organized under operations, while all other engineering needs were handled by the latter.

8.24. The most prominent mission of MARTA vehicle maintenance engineering groups was to provide technical support. Other responsibilities included solving critical parts issues, developing safety and maintenance plans, accident investigation, and other maintenance procedures development.

8.25. At MARTA, the bus maintenance engineering service and warranty group had a staff of 8 (including 1 manager) and was organized under the director of bus maintenance. The railcar maintenance engineering service and warranty group had a staff of 11 (including 1 manager) and was organized under the director of rail maintenance.

8.26. Vehicle maintenance engineering at MARTA followed a policy of passive attrition. Although no staff were cut, as engineers left positions, the positions were eliminated rather than refilled. As a result, engineers engaged in work outside of their areas of expertise.

8.27. At MARTA, professional engineering licensure was not a priority among vehicle engineering.

8.28. MARTA utilized engineering consultants whenever possible. An engineering consultant group maintained office space on MARTA property and was actively engaged in over 100 separate projects.

8.29. Engineering managers at MARTA relied mainly on a subjective approach to evaluate employee productivity. Specifically, one-on-one meetings were conducted on a bi-annual basis to set goals, review progress, and discuss work performance. Fleet performance measures were not used during the process of individual evaluations.

9. Manpower Needs Analysis: Current State of MDT & Peer Agencies

9.1. Data typically used for a manpower-type analysis were not available for engineering positions, and work-time standards did not exist. In addition, fleet performance data were not directly relevant to an engineering staff comparison.

9.2. Quantifying engineering employee output and performance was difficult because of the nature of the work duties and working conditions, such as: long, non-traditional hours (many tasks completed outside of revenue hours); rapid responses or brief investigations often requested with little advance notice; several different tasks ongoing simultaneously; and lack of documented work logs.

9.3. It was difficult to compare performance among individual transit engineers within an agency, and even more challenging to compare engineer performance among several different agencies.

9.4. Based on the factors described above, CUTR developed a methodology to evaluate the section modification plan through comparison of MDT to conditions and practices at the 2 peer agencies (MARTA & WMATA.) Specifically, CUTR compared the current state of MDT field test engineering to conditions at the peer agencies. Among the specific factors that the investigation looked at among engineering operations at the 3 transit agencies were: current workloads of field test engineers, the degree to which engineers worked outside of their areas of expertise, and whether or not conditions warranted additional staff. CUTR also examined goals, objectives, and visions, and compared management philosophies, organizational structures, personnel needs, and employee productivity.

9.5. Among WMATA, MARTA, and MDT, general similarities in engineering operations and philosophies included: several large-scale ongoing or imminent improvement projects which counted on critical engineering support; overall, engineering services were provided to a multi-modal transit system; engineering managers were conscious of hazards associated with overwhelming workload per engineer; high value placed on strong communications; desire for field engineers to spend significant amount of time in maintenance shops; and challenged to keep pace with rapidly advancing technologies.

9.6. Among WMATA, MARTA, and MDT, general differences in engineering operations and philosophies were found to include: organizational structure, licensure/educational background (especially for manager positions), use of contractual engineering services, degree to which engineers worked outside their fields of expertise, work methods, determining personnel needs, and some goals and priorities.

9.7. Regarding organizational structure and management of engineering operations: WMATA had an all-inclusive, centralized structure with a high degree of specialization among engineering positions; MARTA maintained a decentralized structure that included specialized engineering positions; MDT had a semi-centralized field engineering structure with generalized engineering positions. Specific management structures for the 3 agencies were as follows:

9.7.1. WMATA engineering management structure had multiple layers: 1 deputy general manager oversaw the entire engineering operation through a small group specialized chiefs, groups of further specialized second level managers and assistant chiefs, and many highly specialized assistant first level managers.

9.7.2. MARTA engineering management structure involved operations under 2 different assistant general managers (AGM): 1 engineering group focused on infrastructure, facilities maintenance of way, and program & contract management. Under a different AGM, vehicle maintenance engineering was structured under respective vehicle maintenance directors, with a specialized vehicle engineering manager that oversaw a specific group of engineering staff. MARTA did not utilize an advanced system of direct engineering oversight (such as multiple layers of engineering chiefs, assistant chiefs, managers, and assistant managers).

9.7.3. MDT engineering management structure involved operations under 2 different deputy directors: The engineering group under the deputy director for planning & development was responsible for construction, planning, design, land acquisition, and project controls. Field test engineering operations were structured under the deputy director for operations, and the group was responsible for vehicle maintenance engineering, fare collections, power & control systems, communications systems, facilities electrical systems, and product evaluation. MDT did not utilize an advanced engineering oversight system that included multiple layers of engineering chiefs, assistant chiefs, managers, and assistant managers.

9.8. Engineering staff make-up and degree of consultant involvement among the three agencies was as follows:

9.8.1. WMATA maintained a full complement of engineering staff with minimal reliance on engineering consultants.

9.8.2. MARTA maintained a basic complement of engineering staff with heavy reliance on engineering consultants.

9.8.3. MDT maintained a basic complement of field engineering staff but lacked basic field engineering support personnel. MDT field engineering tried to limit its reliance on engineering consultants.

9.9. WMATA required P.E. licensure and specific academic engineering education credentials for all levels of engineering managers. MDT and MARTA limited the number of P.E. licensure among engineering staff.

9.10. None of the 3 agencies adhered to strict supervisory ratios, but all saw value in maintaining as low a ratio as possible.

9.11. The modification plan, which was the subject of this study, explicitly described areas with the greatest staffing needs and detailed measures to address personnel deficiencies. Current MDT field engineering leadership promoted this research effort with the expectation that the results of an independent study would reinforce their appeal for an enhanced workforce. At WMATA, engineering managers were mostly satisfied with current staffing levels. Given the combination of a passive attrition policy (described earlier in this report) and a strong reliance on engineering consultants, engineering management at MARTA had little hope of increasing personnel, regardless of their desires to do so.

9.12. The full complement of engineering staff allowed WMATA to effectively engage in a host of preventive and proactive practices. Dwindling staff at MARTA and staff deficiencies at MDT precluded these agencies from maintaining an ideal program of problem avoidance.

10. Manpower Needs Analysis: Findings

10.1. CUTR determined that the overall intention of the MDT field test engineering modification plan to reorganize the section into an official division was REASONABLE. The actions would emulate field engineering organizations at the peer transit agencies. Specifically, both peers maintained specialized engineering groups, which were limited in their focus and their areas of responsibility. Specialized managers and multiple levels of oversight within a specialty area were also methods put into practice by peer agencies, which would be adopted by MDT along with the implementation of plan #1.

10.2. CUTR concluded that maintaining the status quo within the MDT field test engineering section would be an invitation to crisis. Current responsibilities pushed existing engineering staff to the limits of their abilities to meet agency demands. Additional personnel were required if forthcoming projects had any hope of being truly successful.

10.3. CUTR found that the proposed organizational structure and expanded complement of engineering personnel were SOUND and REASONABLE. Peer agencies arranged engineering groups in a way that allowed for highly efficient oversight. The peers also maintained a sufficient complement of staff among each engineering specialty area, which allowed personnel to maintain focus on their specific areas of responsibility. These practices would be emulated by MDT upon the acceptance of plan #1.

10.4. According to CUTR, the provision within the MDT field test engineering section modification plan to acquire additional support staff was reasonable. CUTR found that both peers maintained various support personnel within specialized sections. In addition, to maintain division status, the field test engineering section had to acquire a proper support staff.

11. Total Compensation Analysis

11.1. CUTR used data and software tools produced by the Economic Research Institute (ERI) to conduct a total compensation analysis for each position allotted through the field test engineering modification plan.

11.2. The ERI analysis tool generated a market index figure for each position, which represented a simple comparison of MDT total compensation figures to the median amount for all similar positions among all other employers. In general, a score greater than 100.0 indicated that compensation for that position at MDT was higher than the overall median. A score lower than 100.0 indicated that MDT total compensation for that position was lower than the overall median figure.

11.3. Among the 17 classes of positions created or reclassified by the MDT field test engineering modification plan, all but 1 (secretary, 97.1) earned a positive ERI market index score. As such, MDT total compensation amounts for new or reclassified positions can be considered generally competitive.

11.4. The total annual compensation amounts offered by MDT for several proposed positions were generally found to be at or above the 90th percentile mark, especially when years of experience were acknowledged.

11.5. CUTR found all salaries to be competitive when studied using the ERI tools. The salary for the manager/(x) position was in a low percentile, but CUTR used an estimated salary figure, which might have been much lower than the specific manager salary figure.

11.6. Transit engineering positions were highly specialized in terms of responsibilities, required skills, and work experience. While CUTR was able to cull generally similar positions from the ERI database for comparison to MDT positions, few transit-specific engineering positions were found. As such, the results of the ERI total compensation analysis should be seen mainly as a guide. Most comparable positions were highly generalized in order to appeal to a wide array of industries that might use the analysis tools.

RECOMMENDATIONS

The MDT field test engineering modification plan presented a strong, proactive approach to the challenges associated with ongoing and imminent agency growth, modernization efforts for current systems, and implementations of advanced technologies. Specifically, the plan sought to reshape the existing section into a full-fledged division by addressing personnel deficiencies, modifying the organizational structure, and revising the overriding management philosophies. MDT field test engineering managers engaged CUTR to review the modification plan and to determine the reasonableness of the provisions within. Afterwards, CUTR was asked to suggest actions and recommend next steps in the effort to facilitate implementation of the plan.

The following section provided a series of recommendations derived by CUTR as a result of the effort expended to complete phase 1 of this research project.

1. The MDT field test engineering modification plan represented a clear attempt by engineering managers to head off potential problems likely to result from insufficient field test engineering personnel levels. At this juncture, any attempt to maintain the status quo within MDT field test engineering should not be considered an option; ignoring the current staffing dilemma could result in a crisis situation.

2. Based on the lessons learned and the knowledge gained throughout the study period, CUTR recommended that the following modifications be enacted immediately:

    2.1. Grant lead field test engineers official manager oversight authority.

    2.2. Reorganize the MDT field test engineering section to reflect the organizational structure illustrated on page 73 of this report.

    In the event that these actions are not immediately allowable, the required standard processes for affecting these changes should be initiated as soon as possible.

3. Prior to formal implementation of the field test engineering modification plan, the field test engineering management group should convene to determine specific goals and objectives and to develop a clear mission statement for the new division. Goals, objectives, and a mission statement will dictate the structure and organization of the

group, and they will serve as a tool of common guidance for staff. The divisional management group should also consider using the strategic planning process close to develop these and other guiding principals for the new engineering division.

4. Consider utilization of a formal strategic planning process to engage upper level MDT management and to set formal goals for the current/future field test engineering section/division goals. Among the many benefits of this process is the ability to establish performance goals and performance measures for the task at hand, and to track achievements throughout the process. If utilized prior to implementation of the proposed modification plan, the effort could dramatically improve the process.

5. Field test engineering management representatives should make a strong effort to elicit specific buy-in from the MDT director and deputy director/operations. The value of establishing and maintaining a strong transit field engineering program should be conveyed to leadership bodies. Fully informed about the vital role played by an internal field engineering group, agency decision-makers are likely to reach more informed decisions, which lead to more favorable outcomes relevant to the future of the group.

6. The process of recruiting and hiring additional field test engineering staff should begin as soon as possible. Impending major projects had overlapping needs and overlapping project schedules. These will exponentially impact time demands on field test engineers. With workloads already at a maximum, a staffing crisis could be looming, which may result in undesirable consequences.

7. The need for and benefits of strong and effective communications were consistently mentioned as vital to the effectiveness of transit engineering operations. The importance of clear and effective communications should be continually reinforced by engineering managers at MDT. Further, many techniques described in this study, such as *Operation Outreach,* the HAT team, and the use of work plans, should be considered for implementation in coordination with the divisional modification effort.

8. Through the modification plan, field test engineering leaders clearly expressed their vision for a strong, comprehensive division, which would serve as an in-house resource of engineering expertise. The

plan identified very specific criteria, including personnel needs, equipment needs, and administrative needs, that should be met if a prominent and effective division is to be established.

9. When making a case in favor of building a strong field test engineering division, FESM managers should argue for the benefits of retaining control over sensitive transit engineering materials. With effective in-house field test engineering capabilities, the agency maintains a high degree of control and direction over sensitive, highly technical functions. Furthermore, the agency can use the resource at its own discretion, rather than consistently relying on contractors, who will likely serve other clients. The benefits and potential rewards of maintaining an in-house engineering operation should be continually reinforced.

10. Another argument to use in support of in-house engineering capabilities is that transit engineers are motivated by agency goals, such as providing excellent transit service to customers. In contrast, the goals of engineering contractors are to earn a profit and to perpetuate its contract for as long as possible.

11. Field test engineering managers should revisit the list of projected equipment needs and address the redundancies contained therein.

    11.1. For example, equipment needs identified by the original modification plan included 27 desktop computers and 24 laptop computers. Although potential savings do not represent a high percentage of total anticipated costs, researchers wondered whether both a portable computer and a stationary desktop computer were necessary for 24 newly-hired individuals. The plan could potentially realize savings by purchasing only the laptop computer along with sufficient peripheral equipment to make the laptop as fully capable as a desktop computer.

    11.2. If laptop computers are to be used by engineers in the field and the plan to purchase desktops is abandoned, MDT may want to consider applying cost savings to purchase hardened laptop machines that are specifically designed to withstand the rigors of use in the field.

    11.3. CUTR was unsure why travel costs for 1 special project were included in the plan, while these costs were not discussed for other projects.

11.4. Researchers also questioned whether there were potential costs associated with the draftsperson positions, such as special equipment, modified computers, special software, etc that may have been inadvertently omitted from the plan.

12. MDT is urged to consider a significant modernization of current field test engineering office facilities. Engineering is a professional position associated with a high level of status. The modification plan goes a long way toward reestablishing a significant degree of professionalism within the division. However, existing field test engineering office space is sorely in need of revamping. Specifically, there is limited office and meeting space, minimal storage space, and little area for visitor waiting. In addition, space for a document library was unavailable. As such, CUTR recommended that in association with the modification plan, field test engineering facilities be remodeled and modernized. Not only will an updated work environment have a positive impact on employees' well-being, but it may also facilitate improvements in communication, work output, and collaborations. The equipment plan allotted for minimal additional space for selected new employees. Researchers wondered if this was a standard allotment or if additional space was necessary.

13. When touting the benefits of the modification plan, engineering staff should promote the idea that the public is investing in its own agency. Further, county residents would be directly investing in a local, effective transportation solution. This investment in agency engineering and its associated benefits can also be referred to as a source of public pride.

14. Another benefit of establishing a strong in-house field test engineering division is that it will be more attractive to the brightest engineering graduates. It is common knowledge that experienced transit engineers are difficult to acquire. As such, WMATA developed several innovative recruitment efforts. MDT could utilize its highly-developed engineering division as an internship laboratory or in other ways that develop partnerships with Florida Universities' engineering schools. One or more internship or post-doctorate engineering positions could also be established within the division.

15. MDT should consider devising an outreach effort related to systems engineering, which is an emerging field of engineering. The transit agency environment provides a good example for the discipline.

Further, the manager positions devised for the new division structure are potentially a good fit for systems engineers.

16. Field test engineering management staff should prepare a contingency plan for use in the unfortunate event that no structural or staffing modifications are accepted by the agency.

17. Prior research, as well as the extensive review of engineering practices at peer transit agencies, indicated that the best determinants of engineering personnel needs were usually divisional engineering chiefs, managers, assistants, or other supervisory staff that regularly faced personnel deficiency challenges. As such, the insights, knowledge, and experiences of field test engineering management personnel should be relied upon heavily by non-engineering personnel who have a stake in the decision-making process.

18. Past research suggested that a highly effective method for modifying an organizational section involved viewing the entire operation as a system. Clearly, the field test engineering divisional modification plan, especially the portions aimed at reorganizing the divisional structure and management philosophy, was an example of a systems approach.

19. Consider adopting the WMATA work plan method described in this report. The work plan is often used as an internal specifications tool and as a means to involve department 'clients' within the agency. It provides a level of accountability that usually does not exist among internal projects.

20. When necessary, consider the utilization of out-tasking, which involved only smaller, specialized tasks for which an agency did not have the available resources to complete. MDT field test engineering should maintain its stance on contracting out engineering work: limit the practice to only when absolutely necessary or to jobs that absolutely cannot be performed in-house. During the site visit to MARTA, engineering managers implied that engaging consultants can become a slippery slope: The more frequently they are utilized, the more dependent the agency becomes on their services. While there is no statistical evidence to draw on, the fact that MARTA practiced a policy of passive attrition (i.e., as engineers left the agency, they were not replaced and the vacant positions were quietly eliminated) was indication enough that some danger did exist.

21. MDT should consider adoption of a policy that involves operations and maintenance staff early in the procurement process. This operating practice was touted by WMATA engineering managers as having strong benefits throughout the service life of the item being procured.

22. Consider use of the Horizontal Action Team (HAT) approach for management of special maintenance projects. The team is initialized during the design phase of a project and remains in place through final acceptance of the deliverables. While difficult to quantify, the benefits of this practice seem to be favorable and would likely outweigh any opportunity costs.

MIAMI-DADE TRANSIT

FIELD ENGINEERING, SYSTEMS MAINTENANCE, and STRUCTURAL INSPECTION & ANALYSIS DIVISION (FESM)

Divisional Modification Plan Review & Recommendations:

PHASE TWO REPORT – SYSTEMS MAINTENANCE

MARCH 2007

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I. INTRODUCTION

This research project intended to assist Miami-Dade Transit (MDT) in documenting current internal processes, planned growth, personnel needs, and available resources within the Field Engineering, Systems Maintenance, and Structural Inspection & Analysis division (FESM) and to develop recommendations for the plan to address them. This assessment, completed by the Center for Urban Transportation Research (CUTR) at the University of South Florida (USF), included a review of the current practices within the division, a comparison with similar divisions at peer transit agencies, and recommendations for a division improvement plan. This project was performed under the existing inter-local agreement between Miami-Dade County and USF.

The overall research effort completed by CUTR was organized around 3 phases that correspond with each area of the FESM division. This report represents the completion of the SYSTEMS MAINTENANCE portion of the project, which was the second phase of the project.

Background

MDT remained committed to providing safe and reliable transportation systems to the people of south Florida. Nonetheless, demands on the present systems continued to grow. With the passage of the People's Transportation Plan (PTP) in 2002, MDT became legally obligated to improve and expand its service. For example, planned growth among the Metrobus fleet will more than double the number of buses serving the citizens of Miami-Dade.

While such improvements were certainly welcomed, the rapid pace of expansion and the large number of newly acquired vehicles presented major challenges to most divisions within MDT. Specifically, divisions originally conceived, staffed, and managed to accommodate a 500-vehicle Metrobus fleet were compelled to meet the greater demands associated with a significantly larger fleet. Because of the high volume of additional responsibilities within the FESM division, staff were increasingly pressed to the limits of their specific areas of expertise.

At the inception of this project, FESM consisted of one division and two sections. To address challenges posed by MDT expansion plans and improvement projects, the FESM management team drafted an organizational modification proposal. Among the proposed changes were elevating the two sections to division status. This proposed modification allowed for greater authority and oversight within the specific fields of engineering, systems maintenance, and structural inspection and analysis. The proposal also addressed personnel shortages and established a more detailed hierarchy of management.

Phase Two Overview

For the second phase of this project, CUTR reviewed the proposed acquisitions of personnel and equipment by the FESM/Systems Maintenance section (FESM/SM). CUTR also documented the scope of systems maintenance responsibilities, current staff positions and organization, and ongoing involvement in major projects. Researchers gathered information from staff interviews, observations, agency documentation, data analyses (when available), and interviews with peer transit agency officials. CUTR examined systems maintenance management techniques, supervisory ratios, and common systems maintenance practices. Specifically, transit-related systems management styles and organizational goals and objectives were compared and contrasted. In addition, CUTR performed a regional compensation analysis for systems maintenance positions in south Florida. Lastly, this research presented recommended actions for FESM/SM.

Report Organization

This research project involved 4 areas of effort, which are detailed throughout the 4 remaining chapters of this report. Chapter II described the current state of FESM/SM, including major responsibilities, a review of staff positions, and presentation of the in-house divisional modification plan. Chapter III presented information compiled from peer transit agencies and provided a comparative analysis of peer agency practices. Chapter IV included an analysis of the divisional modification plan, a salary comparison analysis for systems maintenance positions, and a discussion of systems maintenance staff productivity. The fifth and final chapter presented conclusions and recommendations to improve FESM/SM.

II. CURRENT STATE:
FESM/SYSTEMS MAINTENANCE SECTION

Introduction

This chapter described the current state of the systems maintenance section (FESM/SM), which is one component of the Field Engineering, Systems Maintenance, and Structural Inspection & Analysis division (FESM) at Miami-Dade Transit. Specifically, the chapter presented areas of responsibility and discussed the organizational structure. Further documentation focused on the functions and responsibilities of specific positions within systems maintenance. Later portions of the chapter summarized the FESM/SM modification proposal (plan #2).

This review demonstrated the scope of FESM/SM responsibilities. Further, the review showed the degree to which the group was able to meet its responsibilities with current staffing levels. Recent and anticipated growth in demand for systems maintenance services proved to be a critical factor. This documentation served as the basis for an analysis of the feasibility and appropriateness of the FESM/SM modification plan.

To complete this section, CUTR documented the history, organizational structure, current internal processes, workload, and resource allocation within FESM/SM. Information sources included available reports, staff and management interviews, and field visits. Researchers also noted the effects of recent and future system expansions on the section.

FESM/Systems Maintenance Organization and Responsibilities

Overview

Upon its inception, FESM focused on tasks necessary to maintain existing equipment and systems. Over time, the scope of services expanded, division responsibilities increased, and each area, including systems maintenance, assumed additional responsibilities. Numerous advancements in systems-related technologies also placed greater demands on the FESM groups.

Overall, the systems maintenance section was responsible for the installation, repair, and preventive maintenance of vital electronic equipment. The section provided maintenance support to many MDT assets, including:

- Metrorail vehicle and station operations;
- Metromover vehicle and station operations;
- Metrobus operations;
- Metrobus maintenance;
- Transit revenue department;
- Facilities maintenance department;
- Transit office of safety/security;
- Information technology services.

To meet its objectives, the systems maintenance section was organized into 5 work areas: farebox, fare collection, radio, video/TELCOM, and electronics repair lab. This tally reflected modifications to systems maintenance work areas that occurred during the course of the project (video and TELCOM merged). However, these changes were not to the extent proposed by the modification plan. Each work area is described in greater detail later in this chapter.

The general classification for technical staff within the systems maintenance section was transit electronic technician (TET). Three specialty areas for TETs existed; they were TET/radio, TET/systems, and TET/lab. At the time of this writing, the systems maintenance section employed 57 TET positions, with another 11 technicians in training. Technicians were union-represented, so the positions were "pick positions" (at periodic line-ups, high seniority union employees from other areas of MDT had the opportunity to select into a TET position). This provision had the potential to impact maintenance quality as inexperienced staff could achieve the technical position. However, many TETs had earned high levels of seniority. The responsibilities, similarities, and differences among these positions were noted throughout the remaining sections of this chapter. Technician issues, such as those related to recruitment, training, retention, advancement, and evaluation, were also discussed.

FESM/Systems Maintenance Support to MDT Divisions

FESM/systems maintenance held an extensive area of responsibility. The section provided technical electronics maintenance services to revenue and non-revenue vehicles, rail and mover stations, facilities, and other MDT departments. Systems maintenance staff also serviced agency-assigned personal equipment, such as handheld radios. Specific support tasks commonly involved installation, repair, and maintenance of systems and components. Other problem-solving and support activities were engaged when necessary.

Overall, systems maintenance operated 24 hours per day, 7 days per week to support Metrorail, Metromover, Metrobus, and transit revenue. Specifically, systems maintenance personnel serviced technical electronics within 136 Metrorail railcars, which operated on a 22.5-mile system. The section also provided support to 29 Metromover vehicles, which operated on a 4.4-mile automated guideway system. In addition the systems maintenance group serviced electronic equipment in 44 rail and mover stations. The section was also responsible for vital electronics equipment on the over 1,000 buses in the fleet from a variety of manufacturers. By area served, Table 2.1 lists the specific electronics systems maintained and repaired by the FESM/SM.

FESM/SM supported a host of specific electrical systems and a variety of electronic equipment. The following is an explicit list of maintained items:

- 49 intrusion panels
- 31 Halon panels
- 70 fire panels
- 49 uninterruptible power supply (UPS)
- 60 emergency trip stations
- 100 elevator telephones
- 120 emergency telephones
- 84 passenger-assisted telephones
- 9 console telephones
- 4 radio base stations
- 1130 mobile radios
- 678 handheld radios
- 916 vehicle logic units
- 994 transit control heads
- 136 communication controller units
- 19 CAD/AVL consoles
- 15 Maestro consoles
- 1042 DC-DC converters
- 2798 vehicle destination signs
- 610 vehicle closed circuit TVs
- 46 station signs
- 125 station closed circuit TVs
- 46 station PA systems
- 7 voice recorders
- 643 automated voice announcers
- 2 fiber networks
- 1 network of 25 SONET boxes
- 22 Metrorail fare collection systems
- 22 Metromover counter systems
- 916 Metrobus farebox systems
- 4 bus island farebox equipment systems

Table 2.1. MDT Departments & Assets Serviced by Systems Maintenance

System maintained	Service(s) provided	Notes
Metrorail & Metromover Vehicle and Station Operations		
Consoles / Monitors	Maintenance & repair	
Destination signs	Maintenance & repair	44 Rail & Mover station locations
Dictaphone recorders	Maintenance & repair	
Dispatch PA system	Maintenance & repair	44 Rail & Mover station locations
Elevator telephones	Maintenance & repair	100 locations
Emergency telephones	Maintenance & repair	44 Rail & Mover station locations
Fiber optic cable	Installation, maintenance, & repair	Mover, Omni & Brickell extensions
Fire alarm panels	Installation, maintenance, & repair	44 Rail & Mover station locations
Halon panels	Maintenance & repair	47 locations
Handheld radios	Maintenance & repair	Over 200 units
Hurricane preparations	Systems shut downs & restorations	When necessary
Intrusion panels	Maintenance & repair	44 Rail & Mover station locations
Passenger assist telephones	Maintenance & repair	44 Rail & Mover station locations
Programmable Logic Controller (PLC)	Maintenance & repair	Metrorail stations
Radio base stations	Maintenance & repair	Interama, SPCC, Richmond
Radios	Maintenance & repair	All Metromover & Metrorail cars
Synchronous Optic Network (SONET)	Installation, maintenance, & repair	Metrorail stations
Video monitors & cameras	Installation, maintenance, & repair	44 Rail & Mover station locations
Metrobus Operations		
Bus-mounted destination signs	Maintenance & repair	3 units per bus
Bus-mounted fareboxes	Installation, maintenance, & repair	
Bus-mounted radio CAD/AVL	Installation, maintenance, & repair	
Bus-mounted video system	Maintenance, & repair	Currently placed in 524 vehicles
Dictaphone recorders	Installation, maintenance, & repair	
Dispatch consoles	Maintenance & repair	
Dispatch PA systems	Maintenance & repair	
Handheld radios	Maintenance & repair	Over 200 units
Hurricane preparations	Shutdowns & restorations	When necessary
Non-revenue vehicle beacon lights	Installation, maintenance, & repair	
Non-revenue vehicle radios	Installation, maintenance, & repair	
Video recording units	Data extraction & disc creation	Upon request
Voice enunciator	Installation, maintenance, & repair	
Transit Office of Safety & Security		
Disabled-access gates	Maintenance, & repair	63 locations
Entry gates	Maintenance & repair	238 locations
Exit gates	Maintenance, & repair	102 locations
Facilities Maintenance Department		
Handheld radios	Maintenance & repair	Over 25 units
Information Technology Services		
Handheld radios	Maintenance & repair	Over 25 units

(Table 2.1. continued)

System maintained	Service(s) provided	Notes
Transit Revenue Department		
Bill & coin changers	Maintenance & repair	63 locations
Cashboxes	Installation, maintenance, & repair	985 units
Disabled-access gates	Maintenance, & repair	63 locations
Entry gates	Maintenance & repair	238 locations
Exit gates	Maintenance, & repair	102 locations
Handheld radios	Maintenance & repair	Over 25 units
Hurricane preparations	Shutdowns & restorations	When necessary
Mobile safes	Installation, maintenance, & repair	26 units
Parking dispensers	Maintenance, & repair	39 locations
Probes		18 units
Receivers	Installation, maintenance, & repair	14 units
Ticket encoder	Maintenance & repair	2 units
Transfer dispensers	Maintenance, & repair	95 locations
Metrobus Maintenance Department		
DC/DC converters	Maintenance & repair	
Fire alarm panels	Maintenance & repair	All bus maintenance facilities
Handheld radios	Maintenance & repair	Over 25 units

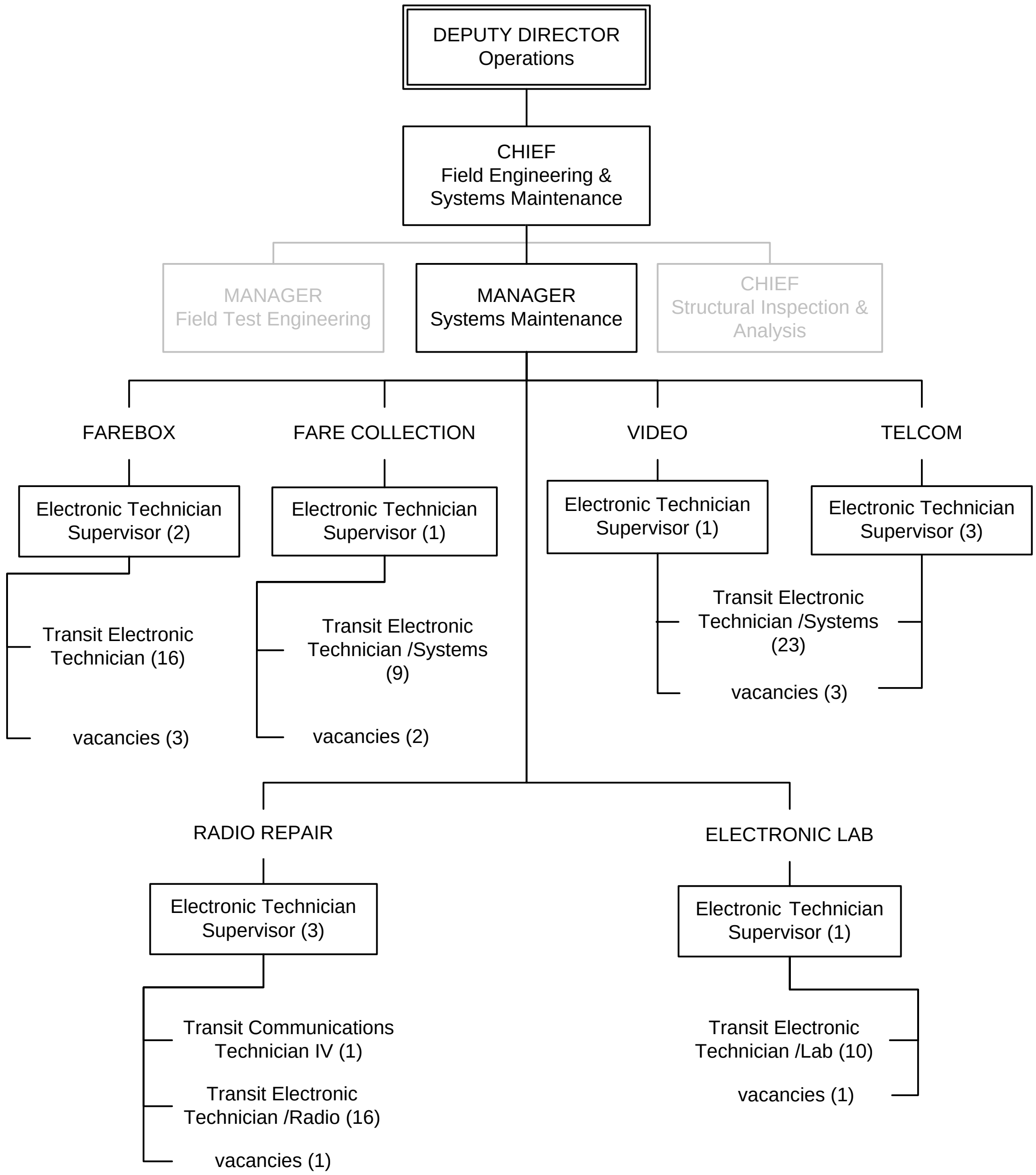
In addition, the current organization of the FESM/SM assigned the section direct responsibility for the electronics lab, which provided component repairs for onboard revenue equipment and related items deployed on Metrorail, Metrobus, and Metromover vehicles.

Organization – FESM/Systems Maintenance

FESM was one of 4 divisions under MDT Operations. The main divisional oversight position was chief/FESM, which managed 2 sections and 1 division and reported directly to the deputy director of operations. One of the sections, systems maintenance, was headed by the manager/systems maintenance (see Figure 2.1). The manager/SM reported directly to the chief/FESM. Overall, the manager/SM managed 11 supervisors and 75 technicians among 5 systems maintenance groups: radio, video/TELCOM, fare collection, farebox, and the electronic repair facility.

At the time of this data collection effort, the radio group consisted of 3 technical supervisors and 18 technician positions, one of which was vacant. The video and TELCOM groups were merged after the start of this research effort. The groups shared 23 active technician positions, 3 technician vacancies, and 4 technical supervisors. Two supervisors oversaw 16 technicians in the farebox group; 3 vacant technician positions were also reported. The fare collection group included 9 technicians along with 2 technician vacancies and 1 supervisor. Eleven technicians were allotted to the electronic repair facility. One supervisor managed this shop, which had 1 vacant technician position. Each supervisor mentioned above reported directly to the manager/systems maintenance.

Figure 2.1 Current Organizational Chart, MDT: FESM/SM Section



Work Groups – FESM/Systems Maintenance

The following sections described FESM/SM repair groups. In many cases, repair groups faced similar challenges, such as retaining adequately trained technical staff, complying with preventive maintenance inspection schedules, maintaining obsolete equipment, acquiring acceptable replacement parts and refurbishing existing components, and responding to specific work order requests. The rapid pace that systems technologies advanced was especially challenging for maintenance groups to sustain. Other concerns were unique to repair groups, including implementation of new systems, specific technology upgrades, and managing technical staff. Information presented below for each work area included general and specific responsibilities, staff characteristics, involvement in special projects, training, employee evaluation techniques, performance measures, and other relevant concerns. Later in this report, general systems maintenance practices, common concerns, and other overriding issues that drove this project are summarized and compared and contrasted to peer agencies.

Radio

The radio repair group completed bench work and field work in an effort to maintain, install, and repair various radio systems, destination boards, public address equipment, mimic boards, voice recorders, logic & control units, and other radio infrastructure components throughout the agency. Radio staff also serviced handheld radios that were assigned to many MDT personnel. Overall, the group was responsible for a large number of components because in some cases, vehicles contained multiple serviceable units. For example, each bus contained 3 destination boards. With well over 900 buses in the fleet, the radio shop serviced close to 3,000 of these items alone.

The radio shop operated 3 shifts per day, 7 days per week. One shift supervisor was assigned per shift, and each reported directly to the manager/SM. The technical workforce within the group was specialized, and the nature of responsibilities varied by shift. The main radio shop was located at the central maintenance facilities, but some technicians were placed at satellite locations (especially bus maintenance facilities) throughout the agency. The radio repair group faced issues that were common to many areas of systems maintenance, while others were specific to the radio group.

Although systems maintenance repair groups cared for many different items, the repair process often followed a common cycle, which included tasks completed in the field and in the shop. Specifically, technicians removed components in the field, returned them to the shop for repair, and then returned working items to the field for reinstallation. *Bench work,* the general term for component repair and rehabilitation completed within the shop, was mostly completed by the radio repair group first shift. The afternoon and night radio repair shifts primarily engaged in *field work*. Most field work focused on *strip-outs*, a term that referred to the process of removal, replacement, and installation of systems components.

As with all areas of systems maintenance, tasks completed by the radio repair shop required a significant degree of specialization and expertise. Specialization among transit electronic technicians (TET) within the radio repair group was recognized by the official agency position title of TET/radio. Further specialization also existed among individual technicians. Specifically, radio repair bench work was organized and completed according to expertise areas of the 7 day shift technicians. Each technician was responsible for unique component/systems repairs, including: hand-held radios, voice enunciators, vehicle logic units (VLUs), transit control heads (TCHs), system & mobile radios, field work & destination boards, and ancillary equipment, which was not as technical in nature.

Additional equipment maintained by TETs/radio included the radio infrastructure (consoles, bay stations, mobile radios, etc.) at the bus maintenance facilities. The radio group was also responsible for the implementation process of new items, which often involved preliminary checks of the equipment, programming, installation, and user orientation. New implementations were frequently designated as special projects. Special projects occurred regularly and involved such tasks as coordinating campaigns for reprogramming destination signs after new routes were assigned (which may be as often as 4 times per year).

The radio repair group also conducted preventive maintenance inspections (PMIs) of bus radio systems. Technicians routinely performed 60-70 inspections per month. Each PMI required about an hour to complete and involved equipment checks, connection cleaning, and battery tests. TETs/radio used a checklist to ensure all points were covered. Radio PMIs were completed while buses were parked in the bus yard. Vehicles did not have to be moved into a maintenance facility bay because TETs/radio worked out of service vans, which were equipped as "rolling benches" that included all necessary tools and equipment.

While radio PMIs were important, the group mainly focused on maintenance and repair because staff numbers precluded full attention to both areas.

Managers reported a preference for dedicated PMI personnel, but staff were not available for permanent assignment.

Specific issues that impacted the radio repair group included available space, obsolescence, and training. Proper storage space for sensitive components was especially limited. In fact, some materials were stored outside. Deficiencies within the group also existed among general storage space, office space, and bench working space. Supervisors found that because radio technologies were constantly being upgraded, existing equipment became obsolete quickly. This was especially problematic when the group attempted to acquire replacement components for out-of-production radio items. Contractual agreements and budgetary restrictions limited the ability to purchase new units, so old units had to be repaired regardless of the availability of spare or replacement parts. Managers had neither the budget nor the available staff coverage to send technicians for training. As such, technicians usually learned new component repair on the job through trial-and-error and review of schematic drawings. This limitation was found to be highly inefficient and led to frustration among staff and managers.

Electronic Lab

At the electronic lab, technicians refurbished and repaired component parts, especially among farebox equipment and electronic railcar components. The lab was housed at the William Lehman Metrorail maintenance facility on the second floor. One technical supervisor managed the facility, which included 12 full time, hourly TET/lab positions (1 vacancy existed at the time of this research effort.) The lab operated Mondays through Fridays during the day shift. Among the current staff, about half worked on a 4-day, 10 hours-per-day schedule, which the supervisor considered to be a more productive arrangement than the traditional 5-day work week. Mechanical and analytical skills among TETs/lab were highly specialized. As such, work assignments usually reflected staff areas of expertise, which included rail equipment, soldering, electronic board battery replacement, programming, digital equipment, and microprocessors. Lab technicians were also commonly involved in support activities for special projects.

The overriding purpose of the electronic repair facility was to maintain a minimum spare parts ratio: to maintain an appropriate number of spare parts available in stock rooms. The lab and technicians were highly specialized, and they serviced a number of electronic bus and railcar components. Lab personnel repaired and refurbished components; then parts were redistributed to maintenance facility stock rooms for use in regular repairs. Specific rail and bus electronic items serviced by the lab included: propulsion components, train destination signs, bus fare collection equipment, and auxiliary systems such as speakers, PA components, high speed over-voltage protectors, and the F-2 brake unit (an anti-skid device for railcars).

Parts concerns extended beyond regular repair issues in the lab. Railcar parts were up to 20 years old, and many items were based on old or obsolete technology. Frequently, the original replacement parts were no longer in production, or in some cases, the original manufacturer no longer existed. As a result, the lab supervisor was forced to utilize resourceful methods to acquire suitable replacement components. For example, relationships with other transit agencies that operated similar rail vehicles (such as MTA/Baltimore) were fostered in order to acquire functional salvage items. The lab supervisor also obtained spare parts through special orders, Internet searches, and special arrangements with vendors.

Due to the scarcity of specialized electronic replacement parts, MDT actively engaged in a policy of repairing and refurbishing such parts in-house whenever possible. The details of this process, and the role of the supervisor in it, were worth noting. After removing a malfunctioning part, the attending maintenance technician tagged it as "defective" and returned it to the stock area or stock room. A detailed description of the failure cause was commonly included on the tag. Following this, the stock room clerk sorted defective parts according to TET/lab specialty area. Parts to be serviced at the electronic repair facility were placed in a designated area and retrieved by the supervisor. At this point, the process sometimes lagged because the supervisor didn't always have enough time to collect the defective parts on a daily basis. (Ideally, these parts would be delivered to the lab every day.) Once brought into the lab, defective parts were sorted for repair according to which technician(s) were most adept at the specific tasks required to restore them to working order.

Additional noteworthy items about the electronic technician supervisor and the electronic repair facility involved productivity and performance. Technicians generally performed different tasks each day, so one of the only ways for the supervisor to gauge production was to physically observe each employee. The backlog of items to be repaired also indicated general productivity, however no specific repair time standards existed for the components handled in the lab. Overall, the equipment was highly complex, and a considerable time investment was usually necessary to pinpoint the cause(s) of failure. As such, a trouble-shooting technique known as "fault isolation" was utilized. Developed in the airline industry, this method called for the creation of wiring diagram flow charts to identify the exact sources of component failures. Through this step-by-step process, technicians found the problem quickly, or found that several steps of testing were necessary. Once repaired, components were tested using a voltage load-simulating device.

Video/TELCOM
During the initial phase of this research effort, the operations of the video and telecommunications shops were organizationally combined. Managers reported that this action was necessary in order to deflate conflicts related to technicians crossing over from one shop to the other. Specifically, under the terms of the union agreement, technical staff were prohibited from working in a shop they were not officially assigned to. As such, FESM/SM officially combined the groups so each area could utilize technicians as necessary. In addition, both groups maintained similar, sometimes overlapping responsibilities, so combining the groups was seen as a natural progression. For example, both groups faced common challenges associated with new technologies, such as the recent conversion to fiber optic data transmissions.

The new group was referred to as Telecom, Data, & Video and included 4 supervisors and 26 technician positions (TET/systems). The group had 2 TET/systems vacancies. Further details of the combined group as it existed in plan #2 are discussed later in this report. The remainder of this section discussed specific video shop and telecommunications shop responsibilities.

Video shop responsibilities included coordinating, monitoring, and directing all maintenance and installation of video systems for MDT assets. Specific activities included extraction of video captured by on-board vehicle cameras and preparation of video in response to incidents, customer complaints, and/or criminal activities. Common practices involved review of video, recording video to a compact disc or other re-playable media, and making the video available at the request of bus operations, transit safety & security, and/or transit and local police.

The telecommunications shop (TELCOM) installed and maintained all communications equipment related to several MDT areas including: train control, traction power, facilities maintenance, central control, Metromover, Metrobus operations, and Metrobus maintenance. Equipment maintained included uninterruptible power supplies (UPS), public address systems (PA), fire and intrusion systems in MDT buildings, and closed circuit television systems for Metrorail and Metromover.

Overall, the group focused on video, UPS, fiber, fire & intrusion, PA, and telephones. Specifically, 4-5 types of phones were maintained, including "hot phones," passenger assistance phones, regular phones, and elevator phones. Serviced equipment was located throughout the agency, including in all Metrorail and Metromover stations, and bus maintenance facilities. The group was responsible for maintenance and PM inspections of fire & intrusion equipment in all MDT buildings. In fact, the fire systems were in the process of a major upgrade at the time of this research effort.

Video equipment on buses was maintained on a 24-hour, 7-days-per-week schedule. Each bus was equipped with between 6 to 9 cameras. The system was designed to store video for up to 14 days, and then it would loop back to the beginning and overwrite the oldest video. MDT was in the process of implementing a video transmission system, which would transmit video data to a central location for storage and retrieval. In the event of an incident on a bus, a video technician would manually review the recording, retrieve the data in question, and burn it to a compact disc. Most often, this task was completed in response to customer complaints, although criminal or crash activities were also retrieved. Supervisors reported that the video retrieval process was time intensive.

The video/TELCOM group reported that equipment age presented an ongoing maintenance challenge. For example, the fire panels in Metromover stations were considered obsolete. Replacement parts were unavailable, and in the event of a failure, county codes required that a guard be physically posted to watch for trouble. Although relatively new, the PA system was also described as obsolete. The fiber/communications system was critical because it controlled train movements. As such, this system could not be allowed to become obsolete; replacement parts had to be available at all times. Further, continual upgrades led the video/TELCOM group to usually be involved in special projects.

Supervisors received a monthly schedule for required preventive maintenance inspections and distributed the work equally among technicians. A separate list was generated for each system maintained by the group. For example, video PMIs were completed only during the night shift and included the following tasks: set correct time, ensure all system components (cameras, microphones, silent alarms) worked properly, clean and adjust as necessary, complete repair form, and return to supervisor. In general, the group followed OEM recommendations for PMIs. Supervisors relied on experience to judge time standards for inspections. Excessive time spent on an inspection was addressed, but strict time measurements were difficult to uphold. Overall, the process had to remain subjective due to the variable nature of electronic component malfunctions.

Fare Collection and Farebox

The FESM/SM fare collection shop addressed fare and revenue equipment operated for the Metrorail system. The farebox shop focused on Metrobus revenue equipment. Although specific equipment and repair techniques varied, the fare-related systems maintenance groups shared similar responsibilities and methods. As such, they are described concurrently in this section.

At the time of this research effort, the FESM/SM farebox shop retained 16 technicians (3 vacancies) and 2 technician supervisors. The shop maintained and installed bus-mounted fare equipment including coin modules, bill modules, controller boards, cashboxes, and complete farebox units. Revenue island equipment, including receivers, probes, and mobile safes, were also maintained. Much of the farebox equipment was at least 20 years old; an effort to modernize fare systems was ongoing. As described earlier, the electronic lab refurbished and repaired many of the farebox component parts.

Fare collection shop staff included 9 TET/systems (2 vacancies) and 1 supervisor. The shop operated 2 shifts and maintained revenue equipment associated with the Metrorail system, including items located at stations and parking facilities. At stations, the group maintained bill changer machines, parking meters, entry/exit gates, coin and bill counters, and transfer dispensers. The group also maintained MDT finance department equipment located at the downtown Government Center offices, including the high speed ticket encoder. Three technicians worked in the field daily; they responded to calls for service using a service van as a mobile shop.

Both shops utilized specialized equipment and required highly specialized skills among technical staff. Technicians learned mostly on the job, as no specialized training on the equipment was available. Most TETs had many years experience; however, as technologies progressed, technical skills lagged. In addition, employees with high seniority but little or no technical experience sometimes picked into the group.

One of the main concerns of the fare collection group was maintenance and repair of the 2 high speed ticket encoder machines. The machines produced magnetic media for MDT, including monthly and weekly passes that are distributed to ticket offices for sale to customers. Passes, which are preprinted with the month and year, are fed into the encoder machine where data are encoded onto the card's magnetic strip. An expiration date is then printed on the card, and it is ejected from the machine. Thousands of cards are produced monthly, with machines running daily. Many problems are associated with this form of media. Data encoded onto the magnetic media were highly sensitive to being destroyed. In some cases, incorrect data are encoded, which results in incorrect tickets distributed to sales locations. The encoder machines have many mechanical parts, such as printer heads, rollers, feeders, belts, and motors. These moving parts are sensitive, and because of heavy use, they must be aligned frequently for the encoder to function properly. As such, maintainers perform daily preventive maintenance. The procedure is generally limited to visual inspection and attending to only items in need of adjustment. (Electronic components of the machines were reportedly much more durable). When one encoder is down for maintenance, the output for the other machine is increased. Compounding the issue of constant maintenance was the fact that only a few technicians demonstrated skills advanced enough to be allowed to work on the encoder machines. In fact, only one technician was considered an expert in the area.

Fare collection technicians were challenged to maintain items that accepted a variety of payments, including tokens, bills, magnetic media, and coins. As such, preventive maintenance was critical. Supervisors reported 100% compliance with the PMI schedule, which was divided into weekly assignments and distributed equally among technicians for completion on a daily basis. Fare equipment also experienced obsolescence issues. In some cases, replacement parts were unavailable for older equipment. Further, critical issues varied by machine. For example, while the electronic components in the encoders were reliable, similar items in different machines may be consistently in need of attention. Some electronics are no longer repairable; they are self-diagnosing and entirely replaced when they become faulty.

Fare collection maintainers used a work order system that tracked parts by unit. Designed by the supervisor, the system associated work orders with parts replacements and recorded serial numbers for parts removed and parts installed. Supervisors reported that special projects were infrequent. For example, equipment installations were generally not the responsibility of technicians, but they were completed on occasion (sometimes using overtime to do so).

FESM Modification Plan

The remaining portion of this chapter reviewed the overall FESM modification plan, introduced the proposed modifications specific to the systems maintenance section (plan #2), and summarized the conditions, concerns, and recommended actions presented in the plan.

Overview

In February 2005, the FESM division chief submitted a detailed proposal to modify the structure of the FESM division and to augment the divisional complement of professional, technical, and administrative support personnel. Throughout preceding years, demand for FESM services grew at a pace that demonstrated its resources were becoming stretched too thinly to meet agency needs. Further, as responsibilities expanded, FESM decision-makers recognized the potential for a decline in service effectiveness. As such, a divisional improvement effort became increasingly necessary.

The overall intent of the FESM improvement plan was two-fold: it presented a responsive solution to existing personnel deficiencies, and it represented a proactive approach to meet future staffing and management challenges likely to accompany ongoing and forthcoming MDT transit improvement projects. The division modification proposal included specific plans for each FESM area: field test engineering, systems maintenance, and structural inspections & analysis. CUTR organized the overall research effort in similar fashion. As such, this document focused on the systems maintenance section modification plan (also referred to as "plan #2" in the original FESM proposal and throughout this document).

Plan #2 – FESM/Systems Maintenance Modification Plan

The systems maintenance section administered the installation, repair, and preventive maintenance of vital electronics equipment at MDT. This responsibility extended to all such equipment found in revenue and non-revenue vehicles, stationary facilities, and portable devices. Planned transit enhancements, including the acquisition of new vehicles and the extension of rail service, will expand necessary duties in all areas of systems maintenance. As such, the second stage of the FESM modification proposal addressed the growing personnel and managerial needs of FESM/SM. Specifically, plan #2 focused on the following areas:

- Supervisory support (including reorganization and reclassifications);
- Technical support; and

- Administrative support.

The plan included specific personnel numbers, costs, justifications, and services to be enhanced through implementation of the plan. Because systems maintenance functions were complex and highly specialized, the FESM plan recommended reorganization into more manageable groups. The plan intended to realize greater effectiveness in both personnel supervision and maintenance management.

The following sections provide a brief overview of each area of the FESM systems maintenance section modification plan.

Supervisory support

The FESM/SM modification plan proposed to acquire 9 supervisory positions. Specifically, plan #2 requested the hiring of 3 chief supervisors and 6 technical supervisors (see Table 2.2). In addition, the plan also provided for the manager/systems maintenance to be reclassified as chief/systems maintenance. With the official re-designation of the systems maintenance section as a division, the reclassification was necessary because the official position of divisional oversight at MDT was referred to as "chief."

Table 2.2 Proposed Staff Acquisitions: FESM Plan #2/Systems Maintenance – Supervisory Support

Action	Position (quantity)	Details
Reclassify	Division Chief, Systems Maintenance (1)	· Existing Manager/Systems Maintenance re-designated as Chief of new Systems Maintenance Division · Position to oversee all electronic systems repair & maintenance programs
Acquire	Chief Supervisors (3)	· One Chief Supervisor to oversee each of the newly established systems maintenance categories: *communications, revenue*, and *power & electronic lab*
Acquire	Technical Supervisors (6)	· 6 additional Technical Supervisors to fully complement direct oversight of technicians within all systems maintenance subgroup work areas

By installing 3 chief supervisors, FESM/SM intended to add a layer of management that currently did not exist. Chief supervisors would direct and coordinate technical shift supervisors and manage systems maintenance work groups. Technical supervisors would directly supervise technicians and allow for a greater degree of specialization within work groups. With the inception of a chief supervisor, no technical supervisors would have to perform group-wide administrative duties. Position-holders would focus on close interactions with technicians and further refine expertise within the work group.

Technical support

The most considerable portion of the FESM/SM modification plan addressed electronic technician personnel needs. Specifically, the plan called for the addition of 37 experienced electronic technicians (see Table 2.3). New staff would be distributed among the systems maintenance work groups so as to afford each group an adequate personnel complement. Technicians would perform installation, repair, and preventive maintenance for video, TELCOM, radio, fiber, fare collection, farebox, and other areas of systems maintenance in need of additional staff.

Table 2.3 Proposed Staff Acquisitions: FESM Plan #2/Systems Maintenance – Technical Support

Action	Position (quantity)	Details
Acquire	Electronic Technicians (37)	• Add 37 Transit Electronics Technicians to attain full complement of necessary technical staff throughout the newly organized FESM/SM division

Administrative support

In order for an existing MDT section to attain division status, appropriate administrative support positions must be in place. Further, new maintenance areas would expand divisional administrative responsibilities. As such, the FESM/SM modification plan included the acquisition of 1 administrative officer (II) and 1 secretary (see Table 2.4). The administrative officer would support the division chief with tasks related to maintenance scheduling,

Table 2.4 Proposed Staff Acquisitions: FESM Plan #2/Systems Maintenance – Administrative Support

Action	Position (quantity)	Details
Acquire	Administrative Officer II (1)	• Administrative Officer II will support the Division Chief in the areas of maintenance scheduling, preventive maintenance compliance, and performance goals • Position will also assist in research, data gathering, trend analysis, report preparations, etc.
Acquire	Secretary (1)	• Secretary will serve at the discretion of the Division Chief • Responsibilities will include personnel matters, correspondence, budgeting, and other administrative duties

preventive maintenance inspection interval compliance, and performance goals. The administrative officer would also research and document historical trends, prepare reports, and complete additional tasks as needed. The secretary would provide support in all administrative matters, especially related to the areas of personnel, correspondence, standard record-keeping, and budget support.

Costs

As submitted, the proposed FESM/SM modification plan to support current and future transit growth at MDT altered the organizational structure and staffing of systems maintenance at MDT. Personnel numbers increased substantially, with several new positions created and a number of others reclassified. The estimated costs for full implementation of plan #2 (including 48 additional staff, 1 position reclassification, and all necessary equipment) totaled close to $2.9 million (see Table 2.5).

Table 2.5. Projected Costs: FESM Plan #2/Systems Maintenance

Position	Quantity	Unit Cost	Total Cost	Notes
Chief/Systems Maintenance	1	$ 4,427	$ 4,427	• Represents increase in current salary of manager/systems maintenance associated with reclassification to chief/systems maintenance
Chief Supervisor	3	$ 76,189	$ 228,567	
Technical Supervisor	6	$ 59,302	$ 355,812	
Electronic Technicians	37	$ 50,429	$ 1,865,873	
Administrative Officer II	1	$ 47,522	$ 47,522	
Secretary	1	$ 33,439	$ 33,439	
Equipment/other	-	-	$ 330,000	• Estimated costs to equip new staff positions • Necessary items such as office space, computers, vehicles, radios, office equipment, furniture, etc.
TOTALS	**49**	**-**	**$2,865,640**	

Upon completion of the peer agency review in Chapter III, plan #2 will be further analyzed in Chapter IV of this report. Specifically, peer agency responsibilities, and the management practices and organizational structures implemented to meet those responsibilities, will be compared and contrasted to form the basis of the evaluation. Further, the analysis section in Chapter IV will describe specific responsibilities and challenges of systems maintenance at MDT, and will assess the suggested personnel complement and costs put forth to meet those needs.

III. PEER AGENCY REVIEW

Introduction

Public transportation research efforts commonly included a peer agency review component. This method proved to be effective for gathering relevant information and making comparisons among public transit agencies. Further, data transfer between transit agencies was often cited as a best practice, especially with information related to maintenance functions. The peer review process usually involved several steps, including preliminary data gathering, identification of additional data for further comparison, development of peer selection criteria, selection of peers for review, site visits, and final comparisons.

A considerable benefit associated with the peer review process was that review criteria were highly adaptable to the specific needs of the study. For example, one research project might require general comparison between agencies, while the demands of another could warrant a highly specialized comparison. Further, a group of agencies selected as peers for one research effort might be completely irrelevant as peers for a different project.

In many ways, a peer agency review resembled a case study. Researchers usually arranged to visit a peer transit agency over the course of one or several days, conducted several interviews of relevant agency personnel, and observed common, relevant operating practices in order to compile an explicit profile of the peer. This technique allowed for considerable interaction with peer agency officials, and the structured, yet informal, interview setting provided the opportunity for flexibility and a more relaxed and open interviewee. Furthermore, this method afforded researchers the opportunity to establish a relationship that could potentially benefit subsequent phases of the current project or future research endeavors. Such was the case for this project. Specifically, contacts made during the first phase of the project helped to open doors for peer review efforts conducted for the second and third phases of the project.

Purpose

The peer review component of this research effort sought to document systems maintenance methods practiced by other transit agencies. Overall, the areas of concern that guided site visits included: the organizational structure of the agency and the systems maintenance area(s); management philosophy; techniques used for prioritizing and assigning systems maintenance work; systems maintenance group responsibilities, and personnel concerns. CUTR also paid attention to issues related to training, employee productivity measures, and the use of outside contractors. Researchers inquired about specific concerns of FESM/SM managers, including qualified personnel, responses to customer service issues, video recording review, available, space, and the availability of replacement parts. Additional relevant peer agency observations were noted as applicable.

Methodology

For previous research efforts, CUTR realized success by engaging in the site visit approach described above. During the initial planning phase of this project, CUTR and FESM managers identified 3 peer transit agencies for review. Primary factors that influenced the selection of peer agencies included growth trends and challenges similar to those faced by MDT. Peer selection was also based on prior knowledge and relationships with the peer agency, the existence of multimodal transit service among the peers, and comparable revenue vehicle fleet size.

In the interests of continuity, CUTR employed the same peer agencies for each phase of this project. During phase 1, CUTR established contact with field test engineering counterparts at peer agencies. For phase 2, researchers asked prior contacts to provide the most appropriate point(s) of contact related to systems maintenance activities at the agency. After determining peer officials likely to provide the most relevant information, CUTR gathered data through telephone interviews, published materials, previously-completed projects, and site visits to the agencies.

Although 3 peer agencies were selected for the initial case study in phase 1, preliminary investigations revealed one peer agency to be very similar in practice to another. In addition, limited availability among agency officials precluded researchers from scheduling site visits within a reasonable time frame. As such, researchers decided to forego the third peer in order to focus on the other 2 agencies.

Critical data compiled during site visits included: system extent and age, service characteristics, special environmental and climatic conditions, rehab investments (to date and planned), management philosophy, in-house vs. contracted activities, personnel details (including number of staff, qualifications, promotions, and training), supervisory duties, and employee productivity. The following sections presented specific systems maintenance program information by agency.

Peer Agency Systems Maintenance Practices

The transit agencies selected for peer review for this project were the Washington Metropolitan Area Transit Authority (WMATA), which served the Washington, D.C. region, and the Metropolitan Atlanta Rapid Transit Authority (MARTA), which served the greater Atlanta area in Georgia. The following sections presented peer agency review findings in detail. Further details related to individual peer selection criteria and peer research methodologies were included within each specific peer section.

WMATA

Overview

WMATA operated the second largest rail transit system and the fifth largest metro bus system in the US. The service area, with a population of 3.5 million within a 1,500 square-mile area, covered the District of Columbia, the suburban Maryland counties of Montgomery and Prince George's, the Northern Virginia counties of Arlington, Fairfax, and Loudoun, and the cities of Alexandria, Fairfax, and Falls Church. WMATA operated 2 transit modes: Metrobus (see table 3.1) and Metrorail (see table 3.2). Ridership in fiscal

Table 3.1. Peer Agency Operating Characteristics: WMATA - Bus Fleet

Bus Type by OEM	Fuel	Quantity	% of Total Bus Fleet
Flxible	diesel	351	24%
Orion	diesel	595	40%
Orion	CNG	250	17%
New Flyer	CNG	164	11%
New Flyer	hybrid	50	3%
Other	diesel	67	5%
TOTAL BUSES		**1477**	**100%**

year 2004 was 336 million total trips, including 190 million rail trips and 146 million bus trips. WMATA is used by approximately 42% of people working in the central urban area. WMATA Metrorail operated 904 railcars on 5 rail lines over 106 miles of track through 86 stations. The Metrobus operating fleet consisted of 1,477 buses that operated on 352 routes for a weekday average of over 135,000 revenue miles. The bus fleet was comprised of various manufacturers, including Orion, Flxible, New Flyer (CNG), and Ikarus and Neoplan, which were articulated.

Table 3.2. Peer Agency Operating Characteristics: WMATA - Rail Fleet

Rail Car Type by OEM	Quantity	Seats	Total Capacity	% of Total Rail Car Fleet
CAF/AAI	186	68	175	21%
Breda	428	68	175	47%
Rohr	290	81	175	32%
TOTAL RAIL CARS	**904**	**-**	**-**	**100%**

WMATA was involved in a variety of capital improvement projects. For example, the Transit Service Expansion Plan sought to double WMATA ridership by 2025. The agency was involved in a major capital improvement plan, which included system expansion projects and infrastructure renewal efforts.

Peer selection criteria & research methods - WMATA

CUTR initially considered WMATA as a peer agency for comparison mostly at the suggestion of FESM management personnel. Generally, research efforts employed more stringent peer selection criteria; however, this study was driven less by close adherence to operating characteristics and more by discovery of imitable management and staffing techniques. Overall, operating characteristics and performance measures were found to be different between MDT and WMATA. However, WMATA was engaged in a variety of capital improvement projects. FESM management initiated contact with their counterparts at WMATA to gain knowledge and insight about related special projects management.

After MDT engaged CUTR in this research effort, researchers pursued follow-up contact to determine relevant WMATA personnel. Initial examination revealed that unique conditions existed among counterpart divisions at WMATA. For example, the agency had recently undergone an ambitious reorganization effort, only to have second thoughts about the adjustments. In fact, WMATA staff tried to dissuade CUTR's initial interest prior to the phase one data collection effort, citing organizational uncertainty and the possibility that information gathered during site visits would end up invalid within weeks or months. However, it quickly became evident that WMATA management philosophy was innovative and worthy of inclusion in this study. As such, CUTR proceeded with the inclusion of WMATA as a peer for this study. (*It should be noted that during phases 2 & 3, CUTR learned that some of the organizational changes documented for the phase 1 report were indeed modified. Fortunately, these adjustments neither impacted the phase 2 or phase 3 efforts, nor affected the phase 1 results*).

For the phase 2 peer analysis, CUTR contacted WMATA engineering personnel interviewed during phase 1 and asked for suggested points of contact that were most relevant to the second phase of the study and most comparable to the responsibilities of the systems maintenance group at MDT. As before, availability, willingness to participate, and accessibility were also determining factors in the selection of specific interviewees.

The WMATA counterpart to FESM/SM was found to exist within the Office of Track and Structures/Systems Maintenance (TSSM). TSSM was a large, overarching group that provided maintenance and inspection services for rail track structures, traction power, automatic train control, automatic fare collection, communications, vehicle electronics systems, and special projects. The group also maintained the shops & material support office and included production and track engineering personnel.

TSSM management staff were very open to participating in this research effort. In fact, the general superintendent of TSSM invited CUTR to attend the weekly group production meeting and arranged for managers to meet with researchers in a panel-type setting. After introductions and a general discussion session with the entire staff of systems maintenance assistant general superintendents and work group superintendents, CUTR determined which personnel were most relevant for one-on-one interviews and arranged an interview schedule.

To gain a broad perspective of systems maintenance practices at WMATA, CUTR sought to interview high level TSSM managers as well as supervisors with direct oversight of technical personnel. Specifically, researchers interviewed the following WMATA management personnel:

- General Superintendent – TSSM
- Assistant General Superintendent - TSSM
- Superintendent – Shops & Material Support (SAMS)
- Shop Supervisor - SAMS

Additionally, interviews conducted for the phase 3 portion of this effort also yielded insights related to the systems maintenance project phase.

CUTR documented knowledge gained at WMATA in the following section. Specifically, the text below described the organization and responsibilities of TSSM, the TSSM systems maintenance group (TSSM/SMNT), and the TSSM/SMNT shops and material support group (SAMS). Other work groups were also described as relevant. Official positions, group work flow, challenges, and other pertinent issues were also presented.

Organization & procedures – WMATA

Until 2005, WMATA organized systems maintenance operations under one general superintendent. A different general superintendent oversaw rail track & structures maintenance and inspections operations. However, under this arrangement, communications between groups suffered and rivalries surfaced. Such interdivisional conflicts led WMATA to reorganize the groups under the oversight of 1 general superintendent. While lower level supervisors and staff initially resisted modifications, upper level WMATA management supported the changes intensely. The resultant group, collectively referred to as the Office of Track & Structures/Systems Maintenance (TSSM), realized communications improvements and eased tensions.

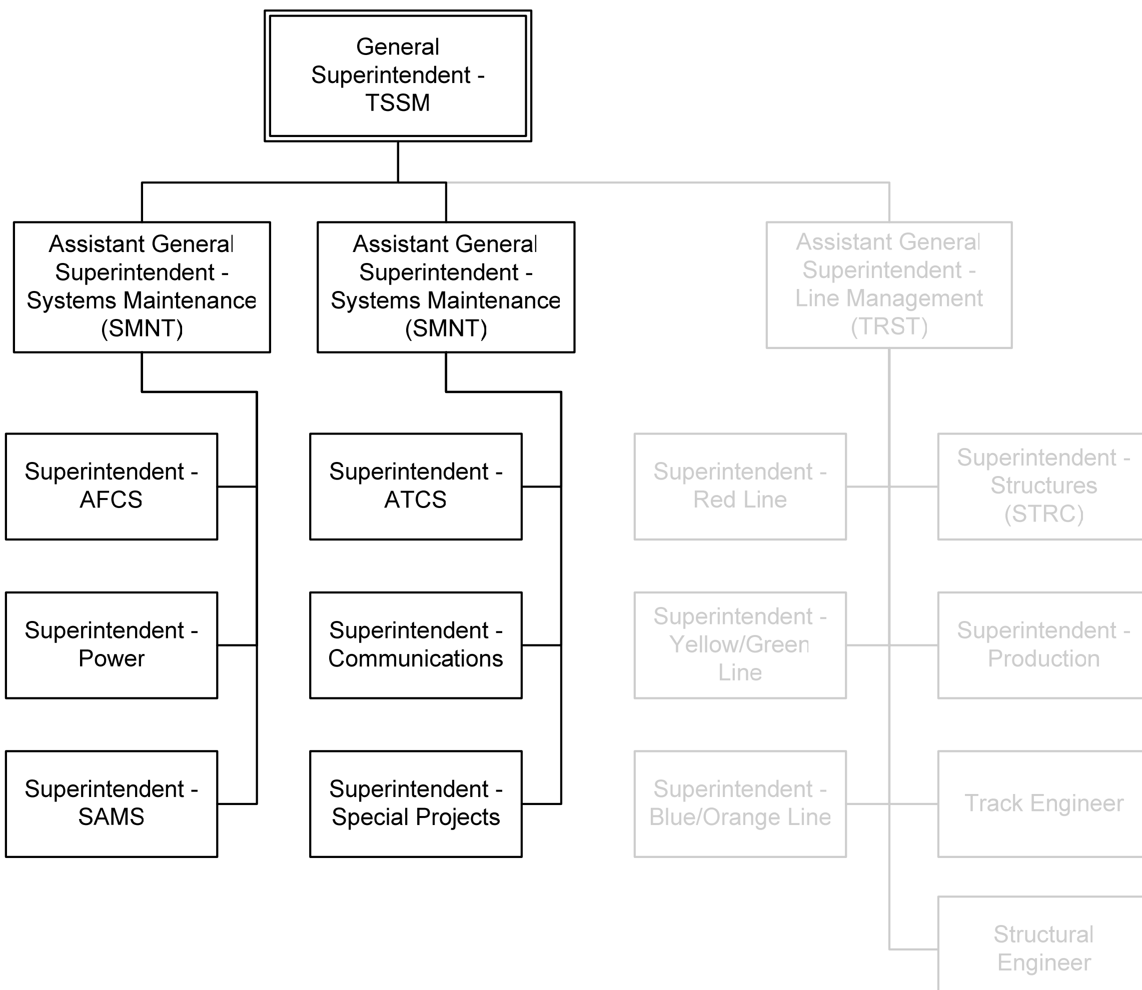
As of this writing, the general superintendent/TSSM directly supervised 3 assistant general superintendents (AGM), as well as several administrative staff (see Figure 3.1). Two of the 3 AGMs managed systems maintenance areas, while the third provided (rail) line management, including oversight of rail track & structures. The general superintendent directly reported to both the WMATA chief of staff and the general manager/chief executive officer.

> *The mission of the Office of Systems Maintenance is to enhance safety and reliability of WMATA operations through comprehensive maintenance programs for automatic fare*

> *collection, automatic train control, communications, parking equipment, lighting, low voltage systems, and rail traction power. Activities are supported by a repair shop and material control branch.* – Official mission statement, TSSM/SMNT.

Within TSSM, the systems maintenance group (SMNT) was divided into 2 overall areas. An AGM managed each systems maintenance area; both areas included 3 work groups (see Figure 3.1). One AGM/systems maintenance managed work groups responsible for power systems, automatic fare collection systems (AFCS), and SAMS. The other AGM/systems maintenance was responsible for communications systems, automatic train control systems (ATCS), and special projects.

Figure 3.1. Organizational Chart, WMATA: Track and Structures / Systems Maintenance (TSSM)



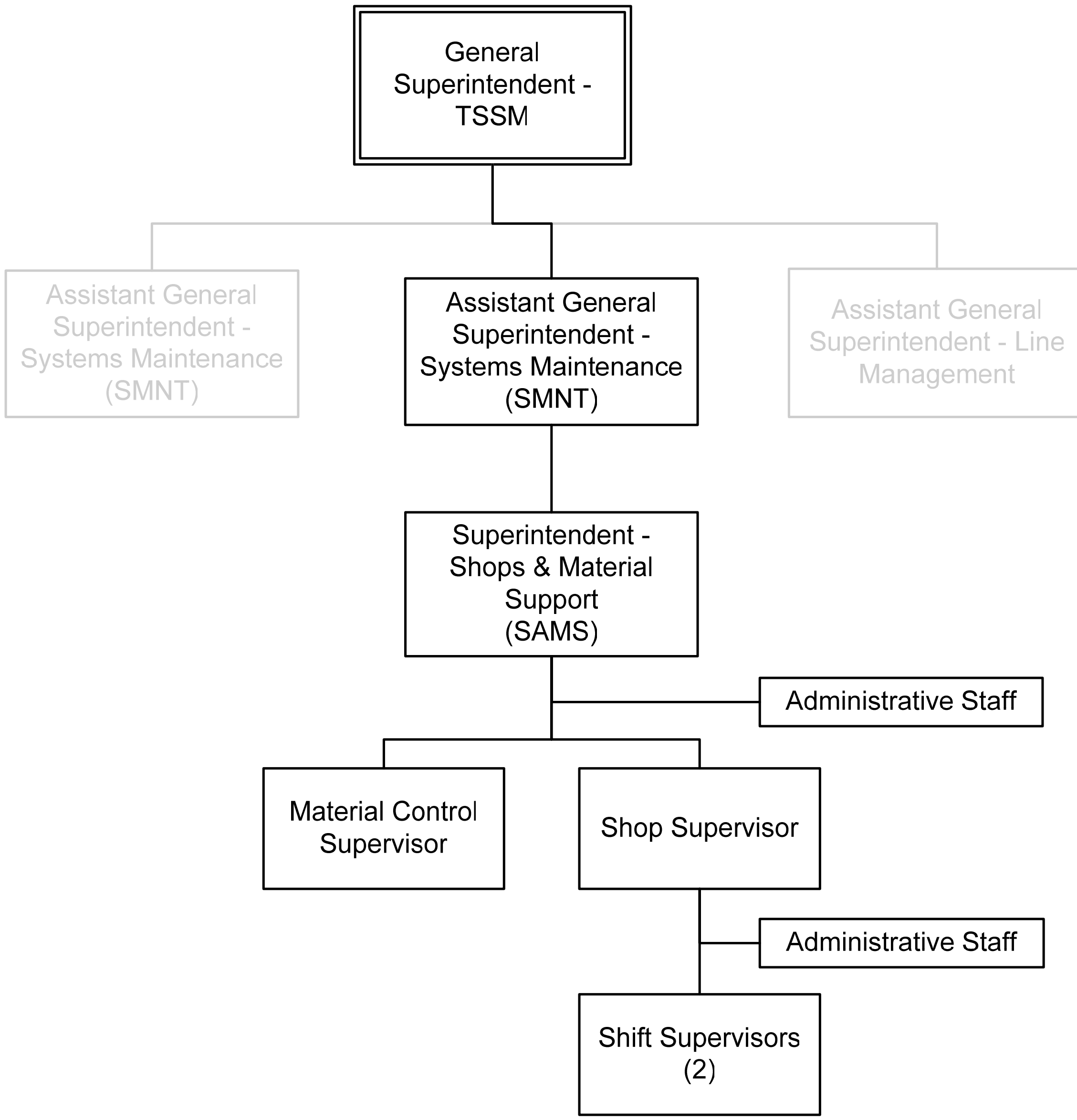
Overall, TSSM/SM employed 68 management staff, 17 administrative support staff, and 308 technical field personnel. The total operating budget for TSSM/SM in fiscal year 2006 was $33.5 million, with personnel costs accounting for $27.9 million of the overall total. The total capital budget was approximately $15 million. TSSM/SMNT identified 14 major operating projects and 16 major infrastructure renewal and/or capital improvement projects that were ongoing at the time of this writing.

Within TSSM, 6 tiers of management ranged from the general superintendent down to the shop floor. The management structure within each of the six SMNT groups was generally similar. Each group was managed by a superintendent that reported to the AGM. Serving under each superintendent were varying numbers of area managers/supervisors and assistants. Lastly, shift supervisors reported to area managers/supervisors. In the interests of brevity, and in order to avoid repetition, CUTR selected SAMS to exemplify the structural organization and management progression among work groups within SMNT (see Figure 3.2). Typically, 1 supervisor was assigned per shift. In the case of SAMS and AFCS, only 2 shifts operated: 6 AM – 2 PM and 2 PM – 11 PM. The power, communications, and ATCS groups operated 3 shifts over 24 hours.

The superintendent/SAMS served as the accounting property officer for SMNT and was responsible for purchase requisition approval and purchase card approvals. SAMS provided material and equipment support across the agency. It served as an intermediary between procurement and various divisions, especially TSSM. The group also provided technical support such as acceptance testing, component repair, calibration, and locksmith services. As overall manager of the repair shop, the superintendent/SAMS was responsible for oversight of disciplinary actions, budgetary review, attending and coordinating training, working closely with the shop supervisor, and assigning tasks as necessary. Similar responsibilities extended to each SMNT superintendent.

A considerable portion of managers' and supervisors' daily effort was spent responding to unscheduled issues. Area managers and other mid-level supervisors actively handled complaints, requests, and other issues that arose on short notice. High level administrators and board members frequently identified specific problems and requested that mid-level managers respond as soon as possible. Scheduling of regular tasks was sometimes confounded by the volume of short-notice issues.

Figure 3.2. Organizational Chart, WMATA: TSSM/SMNT – Shops & Material Support Group (SAMS)



SMNT management personnel also monitored work progress and project status, attended to field work concerns, and handled customer service issues. Several administrative tasks, including the approval of purchase requests and purchase orders, were also completed.

SMNT technicians were organized around 4 levels: "AA" (highest), "A", "B", and "C" (lowest). In the event that a technician transferred to different job, s/he had to meet 3 requirements: at least 2 years experience, return to the

"C" level at the new job, and return to the classification of "helper." As a result of these criteria, the rate of employee movement was generally low. In addition, the policy discouraged inexperienced, unqualified employees from picking into technical positions. In most instances, only technicians with more than 15 years experience requested transfers because they were better able to meet the requirements and were more likely to land in the shop they desired.

SMNT maintained all WMATA communications and alarm system equipment except for cellular telephones, which were maintained under contract. In general, vehicle maintenance technicians removed faulty systems equipment and returned it to the storeroom. From there, SMNT staff gathered faulty items, returned them to the appropriate shop, and repaired items as necessary. With repairs completed, reconditioned items were returned to storerooms. For example, SAMS maintained a variety of component shops to repair components and put them back into inventory.

The automated fare collection group (AFC) maintained all stationary fare-related equipment. WMATA utilized a number of different fare media, including "smart cards," various passes, and magnetic media. Magnetic media were encoded and produced by machines at the time of purchase. TSSM maintained over 675 ticket vending machines. Managers described fare vending machines as the weakest component among all maintained assets. AFC provided maintenance for the equipment, but the group was not responsible for removing revenue from the machines. In addition, AFC implemented fare increases and other fare-related modifications as necessary. The group also maintained revenue equipment at park-and-ride garages. When necessary, SMNT shops performed modifications. In some cases, SMNT groups established specific personnel teams to complete modifications.

SAMS did not maintain bus components. SMNT maintained cameras and radios on buses, but bus maintenance technicians were responsible for all other bus systems, including fareboxes. Managers reported that most fareboxes in the fleet were new so, maintenance issues were generally minimal at present. However, bus maintenance technicians referred to TSSM/SMNT personnel for systems-related technical advice as needed.

The WMATA transit police maintained responsibility for digital video recorder (DVR) technology in service at the agency. SMNT management staff referred to the transit police as the "owners" of all DVR equipment. In fact, official policy dictated that only the transit police were allowed to review recorded video, and station-based DVR equipment was networked to police offices. The transit police also dealt with incidents and customer complaints that required video review. Bus-mounted DVR equipment used time stamps in order to allow quick access to specific points on the video. Technicians were sometimes asked to pull machines and investigate operating problems. However, managers reported that overall, DVR issues had minimal impact systems maintenance.

SAMS did not complete preventive maintenance inspections, but all other systems maintenance groups performed a set number of PM inspections per month. Managers assigned PMIs by shift using work orders. Once completed, work orders were entered into the computer maintenance management system. The system allowed managers to ensure 100% compliance with the inspection schedule. It also generated a monthly list of inspections due. For example, the communications group performed PMIs every 45,000 miles.

To measure productivity among work groups, SMNT managers monitored items such as PM completion rate, daily incident reports, train trip reports, and work orders. For train trip reports, goals were measured in miles per trip. Assistant general superintendents received weekly reports that included such performance measures as work orders issued vs. work orders closed and project management reports. The AFC group submitted daily reports to the AGM. AGMs also tracked time used to support projects and the percentages of capital project time and maintenance time spent on rail tracks. Mangers tried to balance access as only 33 hours of non-revenue service time on Metrorail tracks were available per week.

To some degree, SMNT performance was tied to fleet delays. Specifically, a delay of 4 minutes or more attributed to a faulty SMNT-maintained system was considered a "chargeable delay." In this case, "chargeable" indicated that the group was either responsible for or contributed to the delay. Annual goals allowed for a set number of allowed delays per year. The cause(s) of delays generally dictated accountability and helped set goals for following time interval. Delays affected personal performance evaluations, especially regarding bonuses, incentives, and/or compensation. Negative impacts ultimately filtered down to all employees within the group. Managers reported that negative consequences only impacted personnel at a rate of about 5% - 10%.

SMNT did not complete employee annual reviews. Technicians were only subject to an annual review-type critique when they applied for promotion.

Approximately 5 years ago, SAMS managers began compiling an internal database related to time standards. The goals of this effort were to establish expected repair times for specific components and to help keep technicians accountable. Managers intended to identify ineffective employees and to move them to a different task, if possible. However, managers found it difficult to hold employees to specific standards because of the union contract. Specifically, the standards were not identified in the official collective bargaining agreement. Managers agreed to turn the effort into solely a motivational tool. They felt that poor performance was usually unintentional, rather it was the result of poor work habits. In fact, managers found that well-meaning employees often completed extra tasks that while beneficial, were not imperative to the repair at hand. As a result, overall repair times tended to be excessive.

Managers judged technician productivity by reviewing the best and worst times necessary to complete repairs and setting expectations based on an average repair time report. The report showed total equipment and total failure service repairs, and then the average repair time was calculated in hours. Total equipment repairs were approximately 57,000. Managers reviewed the report on a monthly basis and confronted individuals who were below the average. They also looked at the dollar value of repairs. When managers attempted to discuss findings and observations with employees, the consultations were not received well. Ultimately, managers agreed that relatively few employees were engaged in such work practices, and they decided to abandon the effort. However, a disconnection remained between managers' review of technician performance and technician accountability. Supervisors were only able to appeal to technicians to improve. No formal method was in place for managers to force technicians to change their work habits or to enforce time standard requirements.

A significant concern among WMATA systems maintenance managers involved escorting contractors. Specifically, WMATA required systems maintenance personnel to accompany contractors during onsite project work. With up to 50 contracted projects ongoing at any given time, this requirement proved onerous. Further, in some cases project work was spread out to such a degree that 2 escorts were necessary for a single project. Escorts were charged with securing the work zone and monitoring activities to ensure safety. Escorts were precluded from actively working on the project. In cases where contractor schedules overlapped, managers tried to coordinate projects to make the use of escorts more effective. However, managers reported that such efforts were usually difficult to arrange.

Exacerbating the concern over escorting, WMATA staff occasionally had to train contractors. As necessary, managers also reviewed and approved contractor work plans to ensure that revenue was not negatively impacted and that unsafe conditions were not created as a result of the project terms. SMNT managers reported that WMATA staff commonly ended up putting in as much support, effort, and time into contracted projects as the contractor does. Supervisors tried to rotate escorting assignments among technicians and expressly desired that all technicians be certified as escorts.

SMNT managers were concerned about available funding to implement new systems, while lifecycle maintenance costs for these systems were not considered in the original plan. Further, minimal support and/or training was accounted for in contracts with OEMs. Mid-level managers were also concerned about the disconnection between procurement and maintenance. In addition to purchases, contracted repair and maintenance efforts often overlooked shipping costs and time constraints. In some cases, critical items sent to vendors for repair were gone for a considerable length of time.

SMNT was challenged to find replacement components and other necessary parts. Generally, technicians and supervisors determined whether components should be repaired or replaced, and they sought the more cost efficient solution. In some cases, replacement parts were unavailable, so technical staff were left with no alternative but to repair component parts until the entire system was replaced. As a result, WMATA had widely adopted a policy of infrastructural renewal. In relation to SMNT, systems were generally being replaced rather than being maintained or serviced by technicians. For example, communications systems were reported to be totally unserviceable.

Overall, 43 renewal projects were in progress, but no additional manpower to support projects was retained. In fact, a large portion of infrastructure renewal work was completed on weekends. Contractors were also used to maintain some systems. The general superintendent and AGMs determined which renewal projects were contracted and were repaired in house. An example of contracted infrastructure was the chemical detection system. The system, in place at 21 Metrorail stations, was considered to be more of a research & development operation.

TSSM/SMNT was also in the process of adopting a "condition assessment" approach to systems maintenance. Specifically, managers determined the approximate time frame for necessary repairs, such as "immediate," "within 5 years," "within 10 years," etc. An inclusive list of infrastructure areas in need of renewal was generated annually. In the past, SMNT had no input during this process. Once renewal needs were submitted, the infrastructure renewal program was the sole decider of which projects to implement. Unfortunately, some problems grew out of this arrangement. For example, the inclusion of training and/or spare parts in contracts was often overlooked. In addition, maintenance needs were generally not considered a priority when contracts were under development. In some cases, inexperienced project managers omitted critical systems maintenance components from contracts. For example, the bus video recording system contract included neither spare parts, nor training, nor technical manuals, and the TSSM request for additional support and technicians was denied. Service support agreements were also found to be inadequate in the areas of technical support and software updates.

According to SMNT managers, the group received only limited support from the WMATA engineering group (PDEC). SMNT reported a lack of classical maintenance engineering within the systems group. SMNT managers considered adding engineers to the group in order to have more immediate engineering support for group priorities, but at the time of this writing, this action had not been taken.

Available space was a minimal concern among SMNT managers. In fact, some groups had recently gained additional space because of moves and other rearrangements. Most systems maintenance groups retained adequate shop space, which included separate offices for supervisors, lunch rooms, and employee locker room facilities. In most cases, technicians maintained their own work bench and were not required to share with others. Ample storage space was available, and several shops maintained areas reserved for specific tasks.

According to SMNT managers, finding and retaining qualified technicians was a significant problem. In fact, WMATA human resources asked TSSM to drop its 2-year electrical experience rule, but so far, the group has refused to do so. Human resources wanted to hire people right out of high school. Other industries also reported difficulty in attracting qualified electrical technician applicants. SMNT felt that one barrier to recruitment was the 24-hour, 7 days-per-week operation of most repair shops in the group. Specifically, potential employees were resistant to working on the third (or "midnight") shift, and commonly, new employees started on this shift. As such, this was considered a main source of attrition among new technicians. In addition, managers reported that WMATA was not able to compete with compensation rates of private industry.

Another barrier to attracting desirable applicants was thought to be the requirement that employees pass an exam to advance. In general, there were 2 ways for technicians to advance. In some cases, technicians were promoted because of a vacancy in the higher position. In this instance, the technician took the exam and moved up upon passing the test. This method had been in place for approximately 5 years. The second way technicians advanced was by semi-annual promotion. Under this method, the technician had to be on the job for a minimum of 5 years before promotion was accepted.

In 2005, TSSM implemented a specific technical skills program in place to recruit and train technicians. Trainees spent 2 weeks in the field working in each area of systems maintenance. A mentor was assigned to work with each trainee. Mentors were paid 5% over their regular pay rate for participating in the program. At the end of the 2 week period, trainees were required to take a set of exams and achieve a minimum score in order to pass.

SMNT managers described their concern about the lack of procedural documentation. Over time, specializations had developed mostly by default. However, few specific descriptions of repair techniques were available in written format. As a result, a considerable body of knowledge existed in practice only. Managers were concerned about the potential for reduced productivity in the event that knowledgeable employees retired or otherwise left the agency. Related to this issue, supervisors felt that a mentoring-type of arrangement would also be beneficial among technicians preparing to depart the agency. Rather than simply allowing experienced staff to resign, managers sought to pair the departing technician with less experienced staff. As a result, eventual replacement staff would be more fully prepared to assume specific responsibilities.

Technicians were sometimes sent for outside training. However, such training tended to be costly so, it was used only occasionally. In some cases, supervisors arranged for instructors to conduct onsite sessions. Previous examples included a 1-week class for surface-mount soldering and 2-day radio theory sessions. In addition, shop managers attempted to establish training programs through local universities or colleges. Ideally, trainers would instruct staff at the agency because sending personnel offsite tended to be difficult. No decisions on this effort were affected at the time of this writing.

Managers generally disagreed with the policy that prohibited SMNT technicians from working on warranty systems. OEM support generally lasted for 7 years, but the agency usually expected to retain assets for up to 25 years. If given the opportunity to directly observe OEM maintenance practices, SMNT supervisors believed technical staff would develop considerable proficiency in maintaining the item(s) throughout its anticipated service life. Managers suggested that this type of hands-on training arrangement be specified in procurement contracts.

MARTA

Overview

The Metropolitan Atlanta Rapid Transit Authority (MARTA) was recognized as the 9th largest transit system in the US. The service area, with a population of over 1.5 million, covers the city of Atlanta and the counties of Fulton and DeKalb. On any given weekday, an average of over 460,000 people ride MARTA, with over 61% using the system to travel to and from work. MARTA operates 3 modes of transit: bus, rail, and paratransit. At the time of this writing, the MARTA revenue fleet was comprised of 556 buses (441-CNG, 145-Clean Diesel) (see Table 3.3), 338 rail cars (see Table 3.4), and 110 paratransit lift vans. MARTA rail cars operated almost 23 million annual miles over 48 miles of track through 38 rail stations. The average age of rail cars was 16.5 years. Meanwhile, MARTA buses traveled over 25 million miles per year on 120 routes. The agency also maintained 9 major facilities

Table 3.3. Peer Agency Operating Characteristics: MARTA – Road Vehicle Fleet

Vehicle Type / OEM	Fuel	Quantity	% of Total Road Vehicle Fleet
Buses (35-40 ft., low-floor)			
Orion 7	diesel	145	15%
New Flyer	CNG	411	42%
Total Buses		**556**	**57%**
Paratransit vehicles	various	125	13%
Non-revenue vehicles	various	300	30%
TOTAL VEHICLES		**981**	**100%**

and employed 4,355 people. For fiscal year 2005, MARTA's capital budget was $445.8 million, its operating budget was over $306 million, and the total assets were valued at $4.7 billion.

MARTA was actively involved in a variety of special programs. Among these were the Clean Fuel Bus Program, the Small Bus Program, and planning studies, including the study of Bus Rapid Transit. In addition, MARTA was in the process of a major rail rehabilitation effort. Specifically, over 200 rail cars are scheduled to be completely rebuilt and all 48 miles of rail track were being refurbished. Special projects specifically involving systems maintenance included the "Breeze Card" automated fare collection implementation, AVL installations, CCTV replacements, and various telecommunications applications.

Table 3.4. Peer Agency Operating Characteristics: MARTA – Rail Car Fleet

Rail Car Type	Quantity	# in Rehab	% of Total Rail Car Fleet
CQ310	118	18	35%
CQ311	120	28	35%
CQ312	100	0	30%
TOTAL RAIL CARS	**338**	**46**	**100%**

Peer selection criteria & research methods - MARTA

CUTR originally engaged MARTA for peer agency comparison based largely on two related criteria. First, MARTA was in the process of a major rail car overhaul project. Specifically, the ongoing project involved the complete rehabilitation of 238 vehicles, which comprised over 70% of its rail car fleet. With a similarly ambitious rail car modernization effort scheduled, MDT FESM managers contacted their counterparts at MARTA and forged a relationship to gain knowledge and insight, especially in the areas of personnel needs and project management. An initial review of practices at MARTA revealed that a closer review was warranted.

After contracting with CUTR for review of the personnel modification plan, FESM staff suggested that researchers utilize the established relationship with MARTA and provided CUTR with preliminary findings and contact information. From there, CUTR initiated contact with MARTA personnel in positions deemed most relevant to the study and most comparable to the responsibilities of the FESM division. Availability and accessibility were also determining factors in the selection of specific interviewees.

For the phase 2 peer analysis, CUTR contacted MARTA engineering personnel interviewed during the phase 1 investigation and asked for suggested points of contact that were most relevant to the second portion of the study and most comparable to the responsibilities of systems maintenance at MDT. As before, availability, willingness to participate, and accessibility were also determining factors in the selection of specific interviewees.

MARTA had no dedicated systems maintenance division counterpart to FESM/SM. Rather, systems maintenance functions at the agency were organized within the Department of Technology/Office of IT Infrastructure & Systems Management (ISM). The office also included technical engineers, enterprise network engineers, technical support services, systems programmers, and computer operators.

To gain a broad perspective of systems maintenance practices at MARTA, CUTR sought to interview higher level managers as well as hands-on supervisory personnel. Specifically, researchers interviewed the following MARTA management personnel:

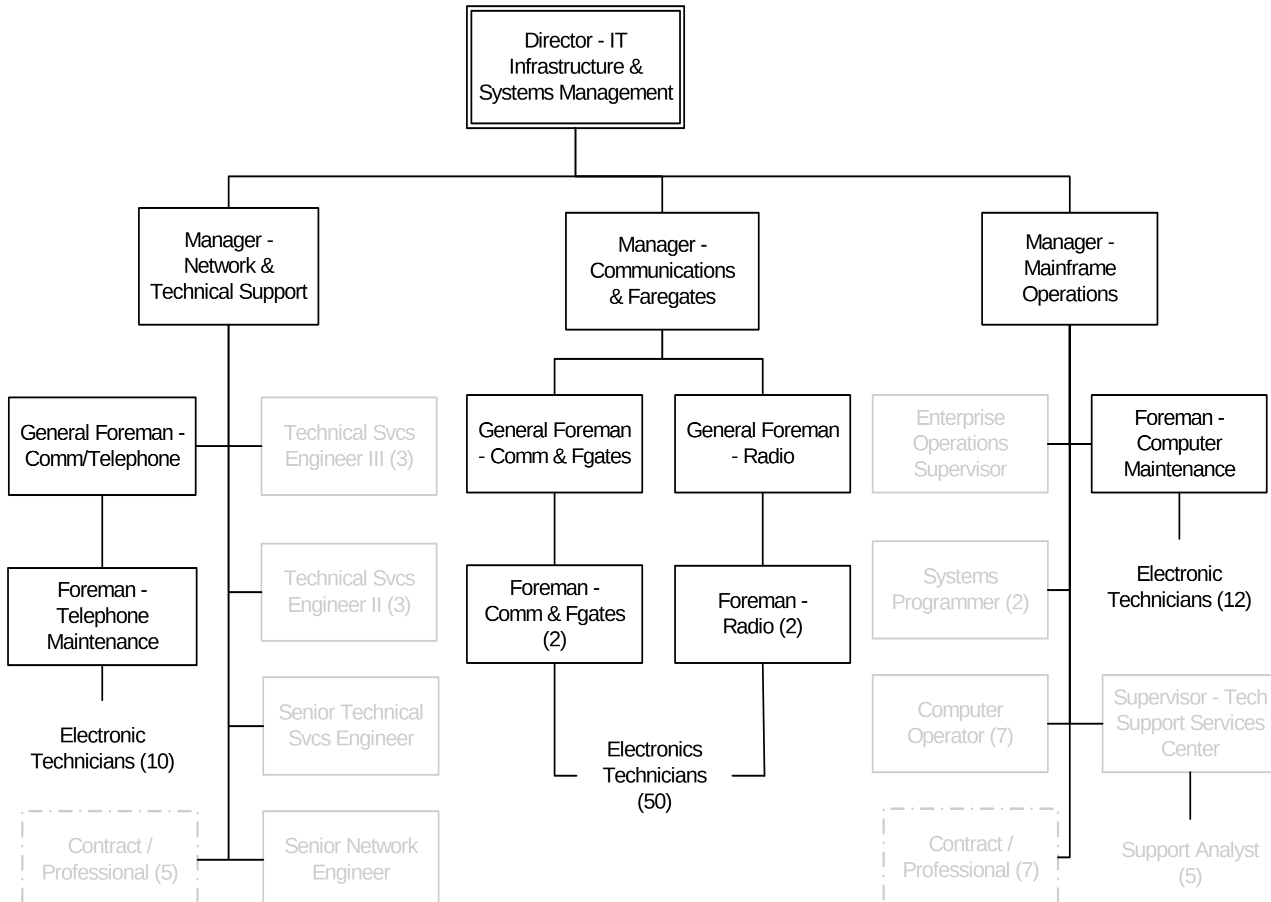
- Manager – Network & Technical Services
- General Foreman – Communications & Faregates
- General Foreman - Radio

In the following sections, CUTR documented the knowledge gained at MARTA. Specifically, the text below described the organization and responsibilities of the systems-maintenance-type groups. Official positions, work flow, challenges, and other relevant issues were also presented.

Organization & procedures – MARTA

MARTA proved to be a good choice for systems maintenance peer review. While no separate group was in place, most systems were maintained by various groups within the Department of Technology, Office of IT Infrastructure & System Management (see Figure 3.3). Overall, the department retained 38 management and administrative staff and 74 union technician and supervisor positions. The organization reflected recent modifications, which were implemented in early 2006. Systems had been maintained under a different group, but the former chief information officer recognized the rapid pace at which systems technology was becoming more

Figure 3.3. Organizational Chart, MARTA: Department of Technology, Office of Infrastructure & Systems Management (ISM)



complex. As such, MARTA took a proactive approach and grouped systems maintenance responsibilities with information technology.

ISM consisted of 3 groups: communications & faregates, network & technical support, and mainframe operations. Each group contained traditionalsystems maintenance areas, which MARTA referred to as "crafts." Specific crafts were radio, telephone, faregate (rail), and computer. Under the previous management structure, all crafts were the responsibility of one manager. The current grouping placed radio and fargates under one manager, telephone under a different manager, and computer under the third manager.

ISM utilized a 3-tiered management structure. Group managers, located at the central administration offices, were the first level and reported to the director/IT, ISM. Each of the 4 crafts was managed by a general foreman, the second tier manager, which reported to group managers. Lastly, foremen were retained within each craft to directly supervise technicians. The offices of general foremen and foremen were located at the shop level. General foremen worked Monday through Friday on the day shift. The shops operated 24 hours, 7days per week, including the faregate shop, which had recently expanded to a 24-hour operation. Ideally, foremen would cover every shift, but a shortage led to only limited coverage of night shifts.

For the most part, general foreman responsibilities involved administrative duties based on the needs of the shop. In fact, direct interaction with technicians was limited, but general foremen managed contractors when necessary. On the other hand, foremen were described as "working supervisors" because they worked in the field directly with technicians and were hourly employees. There are no "lead technicians" among the crafts; foremen functioned as the "lead" in many respects. However, in the event that foremen exceeded 40 hours during the week, they received their regular pay rate for the additional hours, not overtime pay.

MARTA systems maintenance technical staff were officially classified as "journeymen/electronic technicians." Only one level of technician existed among systems maintenance crafts. Managers reported that a shortage existed among technical staff, which impacted their ability to meet responsibilities and inspection requirements during regular hours. Technicians were represented by the Amalgamated Transit Union (ATU). Technician overtime was based on seniority first, but managers also tried to offer overtime based on the number of hours of overtime each technician had already earned. Specifically, overtime was first offered to technicians with the lowest running total of overtime hours for the year.

Technicians used a general work order to initiate repair activity. For example, in the event that a technician uncovered a problem on a vehicle in the yard, s/he opened a work order specific to that vehicle. For preventive maintenance inspections, the systems group reported that much of the equipment they maintained did not have PMIs. Many of the systems and components, such as radios, were "run-until-failure" items. These components were discarded and replaced with new components when necessary. In fact, foremen described their role as more of predictive maintenance, rather than preventive maintenance. In cases where PMIs were necessary, the planner generated weekly and monthly schedules.

While the overall goal for systems maintenance was to complete scheduled tasks 80% of the time, and spend only 20% of time on reactive tasks, the reality was closer to 60% scheduled and 40% unscheduled. A confounding factor for systems maintainers was that the MARTA rail system included 3 types of rail cars. As such, differences among the availability of component parts for different car types were common. Technicians repaired and refurbished older component parts with the intention of returning them to maintenance store rooms. However, demand was high enough that usually repaired parts went directly to the shop floor. As newer rail cars came into service, component repair would become less of an issue because many items were unserviceable.

The telephone craft maintained all non-radio items and areas specifically designed for or utilizing voice communications equipment. The group retained 10 staff to service telephones, call center equipment, customer service center equipment, and customer information center equipment. In addition, the group was responsible for 11 carrier-grade switches throughout the authority and all data and voice cabling in all buildings. The telephone group also maintained data transport systems such as SONET and T1 lines.

MARTA was in the process of implementing a "smartcard" automated fare collection system. As such, the agency was phasing out the use of tokens. All maintenance for fareboxes and existing token machines was contracted. Ticket vending machines (TVM) are being installed, but managers were unsure whether TVM maintenance would be contracted or handled in-house. Currently, TVM devices were under warranty, so a decision was not imminent.

The computer craft maintained computer equipment and peripheral devices. Specifically, technical staff worked with the technology service center to maintain visual passenger signs and wayside remote transport units (RTU). Each station was equipped with approximately 6-7 visual passenger signs. RTUs were a controller unit for switches, traction control, etc. Managers described the devices as "old technology" that relied on hand-wired internal components. Other devices maintained by the group included automatic train destination systems, train control, and the logical data transport system.

The radio craft group maintained a wide range of equipment, including closed-circuit televisions (CCTV) and fire & intrusion systems for all non-administration facilities, as well as a variety of radios and onboard communications devices. Specifically, the group maintained the system-wide 800 MZ radio system, which included handheld radios, bus radios, train radios, and station radios. MARTA had not installed cameras on buses as of this writing, but the radio group would likely be responsible for camera maintenance if and when onboard video is implemented. The radio group maintained railcar communications systems including the PA and display boards, and bus communications systems including voice enunciators and display systems.

The radio group staffed bus maintenance facilities with technicians during at least 1 shift on 4 days per week. Specifically, the group maintained 20 hours of coverage at 2 bus facilities and 10 hours of coverage at 4 other shops. Radio duties for the bus fleet included inspections, reporting, replacements, and repair. Technicians completed vehicle inspections on the lot (referred to as "radio checks") and filed reports. Bus discrepancies were reported through a printout from the bus. The technician found the bus and began checking it. If the bus was not found or was otherwise unavailable, the technician started PMs on buses that were onsite. This same procedure was generally followed for rail cars in the rail yard.

Radio shop managers observed the philosophy that technicians be skilled in each of the main areas of the craft (radio, CCTV, fire). In the fire & intrusion area, technicians were not required to be certified, mainly because it was difficult to find certified applicants. In the past, MARTA had a program that required technicians to be certified in 1 of 3 areas within 6 months of their hiring. However, this requirement proved to be problematic because the group lost people directly because of it. As a result, the agency developed a different approach: applicants are required to be experienced electronic technicians with abilities such as schematics and technical manual comprehension, working on circuit boards, and troubleshooting.

ISM, as well as MARTA in general, worked to enact technology upgrades whenever possible. Management recognized the need to maintain technician skill levels in relation to this policy, and they made a clear effort to prevent skill sets from lagging. For example, new fare gates were completely different from former technology. In response, MARTA utilized a "training council," which involved training staff being assigned to craft groups. The agency also utilized a "train-the-trainers" approach as new technology was implemented. The trainers were then responsible to train and/or instruct technicians.

MARTA created an apprenticeship program, which involved 2½ years of effort in order to become an electronic technician. Seniority was only used to rank people after they had passed an initial entrance exam. Once accepted, technicians were required to pass through the 2½ year program. In addition, all applicants were required to drop down to apprenticeship level pay while training. MARTA used to send people to the community college to get trained and/or certified. Now, the agency offers tuition reimbursement, so people can go to CC on their own to become qualified to apply.

Overall, the agency hired most electronic technicians from the outside. The union agreement stipulated that people were to be hired from within the agency, if available. As such, jobs were posted internally first; however, pre-certified people were rarely available in-house. If no qualified staff applied, the search turned outward. Another issue related to acquiring new staff was salary structure. Although compensation at MARTA was comparable with the transit industry, managers felt it did not compete well with private industry offers. However, MARTA had reduced the difference to about 12% below private industry. (At one point, the gap was much wider).

Overall, agency policies discouraged technicians from picking into and out of different areas ("cross-crafting"). The ATU agreement with MARTA included specific provisions to help prevent technical staff from picking into systems maintenance areas that they were unqualified to hold. Specifically, before picking, the applicant had to be a designated electronic technician. In addition, when a technician bid on another craft, s/he was required to go through an interview process and pass basic testing. Once moved into the new craft, the technician was required to revert to the apprentice level for 18 months (regardless of specialty). Only then could the individual return to journeyman status.

In general, productivity measures for systems crafts varied. For the telephone group, time and attendance were associated with work order. Specifically, 92.5% of technician's time had to be associated with work orders. Employee performance rating was generally subjective. Managers did not have training records, so they were unable to hold technicians accountable. Specifically, managers had no way to examine a training record and claim that an employee should have known the specifics of a situation. In addition, the general foreman had limited time to track individual productivity on a regular basis.

MARTA recently implemented a new system that required technicians to clock in based on the work order. The system tracked time spent on specific tasks. Creation of the work order drove specific tracking areas. The group received a report including the number of work orders, with the intention of tracking time for repairs. This information was used to track employees. At present, craft groups performed no individual performance reviews for union personnel. The new system was intended to help gauge time and productivity of staff. At present, managers had no way to track employee productivity beyond the number of work orders closed during the week.

Overall reporting included work-order performance and time and attendance. Individual groups reported in more specifics. Systems maintenance productivity was generally based on simple percentages. For example, the number of items reported to be broken was compared to the number that were fixed. MARTA also tracked the number of rail cars or buses held out of service directly because of systems maintenance-related issues. For example, if a PA system malfunctioned, the vehicle could not go into service. As such, vehicle availability, rather than fleet performance measures, indicated systems maintenance effectiveness.

Systems maintenance managers reported that they were actively involved in procurement and development activities. Technicians were also asked for input in some cases. Specifically, MARTA policy encouraged the eventual maintaining groups to contribute to the initial stages of project development. Managers suggested that before crafts became fully responsible for new systems, they should be assured of complete functionality. In addition, maintenance groups should test new items within the appropriate maintenance shop before accepting items or prior to the end of the warranty period.

It was interesting to note that although MARTA utilized a considerable number of contractors, the agency did not require that they be escorted when onsite. However, general foremen felt that an escorting practice was warranted, based on past issues involving contractors responsible for negative impacts on maintained systems.

The following chapter includes a comparison analysis of the peer agencies and MDT. Specifically, similarities and differences that exist among the systems maintenance groups are described. Common challenges, innovative solutions, and other relevant lessons learned are presented in detail.

IV. MODIFICATION PLAN REVIEW & COMPARISON ANALYSIS

Introduction

Previous chapters of this research report presented current conditions within FESM/SM and ongoing practices at 2 peer agencies. Specifically, CUTR reviewed and documented systems maintenance responsibilities at MDT, including detailed information obtained through staff interviews and culled from the section modification plan. Researchers also examined the current organization of FESM/SM and the personnel needs associated with recent and future system expansions. In Chapter III, the peer agency review included details about systems maintenance practices at WMATA and MARTA. Peer information included management philosophies, organization, staffing arrangements, maintenance procedures, general concerns, performance evaluation, and additional relevant information at each agency.

Having compiled data from MDT and peer agencies, CUTR proceeded to address the chief concern of this research effort: to determine the reasonableness of the proposed modifications to FESM/SM. To accomplish this task, researchers reviewed the modification plan, compared and contrasted the peer agencies with MDT, and discussed the degree to which the enhancements would meet current and expected MDT systems maintenance needs.

After a brief description of the methodology, the remainder of this chapter focused on 2 overall areas of interest. First, researchers presented a critical review of the FESM/SM modification plan. The section described the vision and justifications underlying the plan, as well as the distinctive terms of the proposal, including anticipated salary costs and equipment needs. In the later part of this chapter, CUTR documented the processes and results of the comparison analysis. Specifically, researchers developed the knowledge gained during the peer and MDT reviews into a discussion of systems maintenance needs and the degree to which the proposed modifications adequately met those needs.

Methodology

Similar to the relatively unconventional methods described for selecting peer analysis candidates, a critical review of labor needs for a transit systems maintenance group posed more challenges than researchers anticipated. Different practices, terminologies, and organizational structures rendered precise comparisons impractical. For a variety of reasons, data were often incomplete, unavailable, anecdotal, or otherwise unusable within strict analysis techniques. For example, peer agency managers described various attempts to track employee performance. Although the effort intended to help employees rather than to punish them, unions generally resisted such efforts, especially because such terms were not specified in collective bargaining agreements. Employee morale usually suffered as a result of these efforts. Managers were unwilling to release specific data to researchers.

Researchers found no generally-accepted systems maintenance supervisory ratios. Ratios varied not only by agency, but also within systems maintenance groups from one work area to another. Most often, supervisors determined ratios using their experience and knowledge of staff work habits and capabilities. Regardless of actual staffing needs, personnel numbers were mostly driven by available funding and systems maintenance groups' ability to find and retain qualified applicants. Additionally, the nature of systems maintenance shops sometimes hindered direct supervision. For example, some shifts were directly supervised by officially designated managers, while other shifts shared supervisors or were overseen by experienced staff with no official managerial authority. Supervisors also spent a considerable amount of effort on administrative tasks, which limited their availability on the shop floor.

Overall, experienced managers were best-suited to devise the most beneficial organizational structure and management practices to meet their agency's needs. Further, systems maintenance employee productivity was difficult to quantify and to compare within and between agencies. The time necessary to complete electronic component repairs varied widely, depending on several key variables such as knowledge, skill, parts availability, etc. As a result, employee performance reviews were highly subjective. Fleet performance data were more suitable to gauge the overall performance of systems maintenance divisions rather than to judge individual productivity. In addition, failures or service disruptions directly attributable to systems maintenance failures were very difficult to determine. Supervisors were mostly concerned that tasks were completed properly and on schedule.

Based on the conditions described above, CUTR developed a specialized methodology to determine the appropriateness of the FESM/SM modification plan. Overall, the terms of plan #2 were substantial. As such, researchers felt that an interagency comparative analysis should consider common concerns, innovative remedial actions, and successful outcomes (if known). Specifically, CUTR compared current systems maintenance responsibilities, practices, and organizational structures among MDT and the 2 peer agencies. Afterwards, CUTR looked for emulative practices among the peer agencies and made suggestions about the terms and reasonableness of the MDT modification plan. Where applicable, the methodology developed for this review was described in greater detail throughout the following sections.

Review of Plan #2 – FESM/SM Modifications

The following section examined the second portion of the FESM divisional modification plan, which addressed systems maintenance personnel requirements for current service levels and transit growth projects. In general, plan #2 focused on supervisory, technical, and administrative systems maintenance staffing needs to meet current and anticipated workloads. The plan also included organizational modifications intended to improve management functions and work flow, and to develop greater specialization among transit electronic technicians.

While Chapter II of this report presented a brief summary of plan #2 and introduced its original components, additional details are found below. Specifically, overriding goals driving the most important systems maintenance responsibilities are presented. In addition, CUTR described current conditions pinpointed by management personnel as justification for the proposed modifications. Lastly, specific elements regarding salary costs and equipment costs were presented.

Vision and justification

The advent of a number of major capital efforts, including the acquisition of several hundred new buses, the rehabilitation of the railcar fleet, and the extension of the Metrorail system, initially prompted managers to outline an extensive, 3-part reorganization and modification plan for the FESM division.

In fact, the expansion of the bus fleet alone presented a substantial increase in FESM/SM workloads.

While phase 1 included significant modifications for field test engineering, plan #2 presented significant adjustments to the systems maintenance group in order to successfully meet current responsibilities and future challenges. Overall, the plan intended to acquire and maintain sufficient technical, supervisory, and administrative personnel; to organize personnel within a more efficient structure; to increase specialization among the workforce, and to remake the section into a fully recognized division.

An effective preventive maintenance program was a key element of every "service excellence" maintenance organization. The Miami-Dade People's Transportation Plan (PTP) mandated that MDT demonstrate service excellence through fleet modifications and proper support for all agency assets, including a well-developed maintenance program. The benefits of an effective preventive maintenance program were many, including improved reliability, reduced repair costs, and increased equipment life spans. FESM management staff believed that the existing systems maintenance program would be overwhelmed by new demands and would be unable to attain the service excellence goal. Further, managers agreed that without significant staffing and organizational improvements, service and reliability would suffer under the weight of increased responsibilities. Such ideas would not have developed without strong evidence that suggested the potential for future problems.

Based on the recommendations of both original equipment manufacturers and MDT field test engineers, almost 73,000 technician-hours per year were required to meet preventive maintenance needs of all equipment maintained by FESM/SM. With 1,410 annual work hours available per technician, preventive maintenance requirements alone mandated 52 fulltime technicians. However, FESM/SM retained only 57 technicians. As a result, only 5 technicians would be available to complete all other systems maintenance needs among 5 groups.

Systems maintenance managers also found that preventive maintenance completion rates had markedly declined since the implementation of the PTP. For example, systems maintenance personnel completed 64% of closed circuit television preventive maintenance inspections in 2002. Within 2 years, the rate had declined to 51%. A second example clearly indicated the correlation between failures and PM completion percentage. In 2001, the

TELECOM group completed 82% of scheduled PMs along with 6,200 repair actions. By 2004, the PM completion rate had fallen to 51%, while the number of repair actions rose to more than 12,000. Clearly, the situation was cause for concern among FESM/SM leadership.

Systems maintenance managers envisioned a fully-staffed systems maintenance division to handle all preventive maintenance needs and to complete all other support functions associated with the equipment. Sufficient staffing levels would allow for specialization among maintenance groups. Under this vision, technicians would specialize on tasks, becoming highly efficient in selected repairs. Anticipated outcomes included faster repair times, better overall maintenance, and fewer failures or service disruptions. A full complement of technical personnel would also ensure closer adherence to PM schedules, which would result in lower repair costs, less repair downtime, and better service. In addition, staff increases would allow managers to immediately respond to all requests for assistance without compromising preventive maintenance schedules.

Proposed FESM/SM Division Staffing Acquisitions

The overall objective of the FESM modification plan was to acquire experienced supervisory, technical, and administrative personnel, along with necessary equipment, to successfully maintain, install, and repair electronic systems equipment in use throughout MDT. A full complement of systems maintenance personnel would allow the newly-established division to provide complete support for all existing systems and to meet future challenges.

Specific staff and equipment acquisition details (including costs) were described in the following sections.

Supervisory support

Reclassify the existing Manager/SM to Chief/SM. Proper MDT protocol called for a division to be managed by a "chief." By reorganizing systems maintenance into a division, the need to reclassify the main position of oversight followed. As such, the existing manager/systems maintenance would be re-designated as chief/systems maintenance. Overall, the responsibilities of the chief position would remain largely similar to those currently assigned to the manager/SM position. In addition, the chief/SM would continue to report to the chief/FESM. The annual cost associated with the reclassification would be $4,426.50, which would be in addition to the current manager annual compensation of $88,530.

Acquire 3 chief supervisor positions. Under the existing system, no overall group supervisors were in place for systems maintenance work groups. This condition often resulted in disconnect among shift supervisors. In addition, although no official oversight authority for the work group was in place, the day shift supervisor commonly functioned as the de facto work group liaison to the manager/systems maintenance. However, this individual had no official oversight authority and could not technically distribute assignments or other directives to other shift supervisors. By recognizing one individual as manager of the group, the chief supervisor would retain official oversight authority to direct technical (shift) supervisors, thus eliminating rivalries and improving communications. Further, the chief supervisor would no longer function as a shift supervisor, which would free the position-holder to focus on administrative duties and interactions with higher level managers. The estimated annual compensation for each chief supervisor position was $76,189, and the total annual cost for 3 chief supervisors was $228,567.

Acquire 6 technical supervisor positions. The acquisition of 6 technical supervisors would supply all shifts among systems maintenance work groups with first line supervisor coverage. In addition, technical supervisors would be specialized to their specific work group. With the proposed acquisitions, supervisors would only rarely be required to supervise personnel outside of their own area of expertise. Technical supervisors would maintain the ability to provide precise technical oversight, instruction, and guidance to technicians, as necessary. Technical supervisors would also be qualified to critically evaluate specific technical skills and performance among employees. The estimated annual compensation for each technical supervisor position was $59,302, and the total annual cost for 6 technical supervisors was $355,812.

Technical support

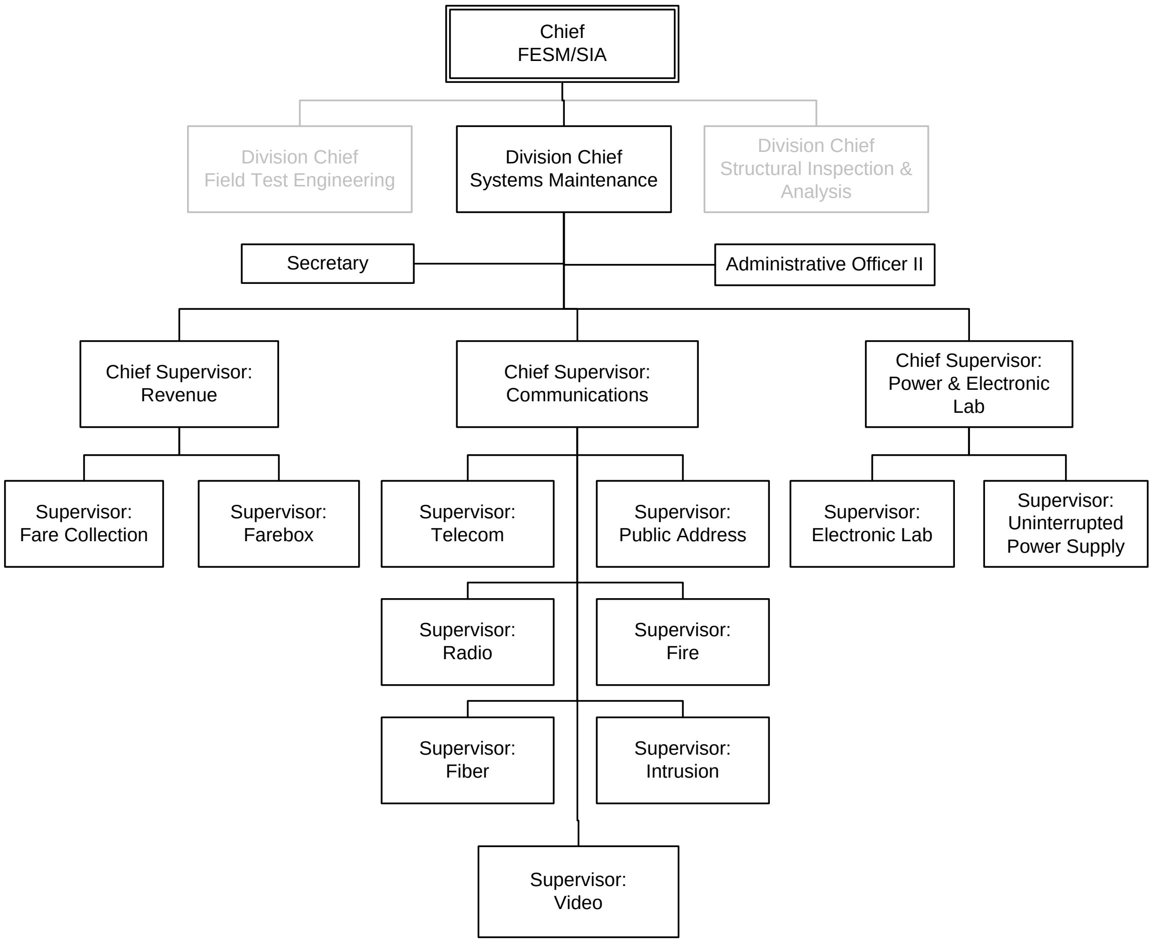
Acquire 37 electronic technician positions. FESM management personnel were convinced that current systems maintenance staffing levels were insufficient to meet current and expected needs of recent and future MDT expansion efforts. Plan #2 specified that 37 additional electronic technician positions be created, acquired, and distributed among systems maintenance work groups as needed. Specifically, FESM/SM decision-makers intended that technicians develop specializations and proficiency in specific areas of systems maintenance. As a result, preventive maintenance schedules would be strictly adhered to, all equipment would be maintained at optimal performance levels, and repair costs and service impairments would be reduced. Adequate staffing levels would also allow systems maintenance to provide immediate response to calls for assistance and special requests. The estimated annual compensation for each electronic technician position was $50,429, and the total annual cost to acquire 37 electronic technicians was $1,865,873.

Administrative support
Acquire 1 administrative officer II position and 1 secretary position. Administrative support needs existed within the FESM/SM section, and reorganization to division status would add to administrative responsibilities. The administrative officer II position would provide direct support to the chief/SM in the areas of maintenance scheduling, PM compliance, and performance goals. This position would also assist in meeting demands of a specialized technical staff such as researching historical data, monitoring trends, preparing reports, and completing other supportive tasks as necessary. A secretary dedicated to the FESM/SM division was also warranted to support required administrative functions including personnel matters, correspondence, filing, and budgeting. The annual compensation for the administrative officer II position was $47,522, and the annual compensation for the secretary position was $33,439.

Proposed FESM/SM Division Organization

Along with the proposal to significantly increase staffing numbers, plan #2 identified a substantial modification to the organizational structure of FESM/SM, including elevating the official status of the group from section to division (see Figure 4.1). As described in Chapter 2 of this report, the video and TELCOM systems maintenance groups were merged after the start of this research effort. The terms proposed by plan #2 went much further in the reorganization proposal. Specifically, work groups would be organized into 1 of 3 categories: revenue, communications, and power & electronic lab. Each category would be managed by a chief supervisor. Within each category, technical supervisors would supervise specific work groups. The revenue group would include fare collection and farebox groups. Proposed specialty groups within the communications area were TELCOM, public address, fire, intrusion, radio, fiber, and video. The proposed power area would include UPS and the electronic lab.

Figure 4.1. Organizational Chart, MDT: Proposed FESM/SM Division



The next section of this report discussed the findings of the current state of FESM/SM and the proposed section modifications in terms of comparisons with the findings of the peer agency review.

Manpower Needs / Comparison Analysis

In order to determine the reasonableness of plan #2, CUTR completed a comparison analysis based on the peer review and the review of the current state of FESM/SM at MDT. The following sections described the need for a comparative analysis and the methods devised to complete it. Afterwards, the current states of FESM/SM and the peer agencies were compared and contrasted. Lastly, CUTR presented a series of findings based on the analysis.

Methodology

In the past, CUTR completed manpower analyses for MDT and other transit agencies. For example, a bus mechanic manpower analysis was completed for MDT in 2003. In that study, researchers noted the lack of industry-wide work standards in transit but, several types of data were maintained by MDT and made available to CUTR for the investigation. Researchers used the available vehicle performance data, mechanic work hours, and projected vehicle mileage data to devise a methodology for predicting maintenance staffing levels. For example, a typical calculation from the previous research effort involved the number of mechanic work hours per mile determined from total work hours and total miles. Further, a figure for the required number of full time mechanics was determined through a function of total vehicle miles and the number of miles per mechanic. Unfortunately, similar data were either not available or not relevant to the present study.

As a result of the unique characteristics related to transit systems maintenance responsibilities, CUTR devised a somewhat unconventional methodology to address the specific personnel needs identified by the FESM/SM modification plan. Proper execution of this research effort required CUTR to establish a substantial foundation of information. Specifically, prior to assessing the reasonableness of the FESM/SM modification plan, researchers compiled, reviewed, and documented the following information:

- Current responsibilities of MDT FESM/SM personnel;
- Current organizational structure of the MDT FESM/SM section;
- Details of ongoing and future MDT projects that demanded support from FESM/SM (if any);
- Anticipated future responsibilities of the FESM/SM, especially areas likely to require dedicated support;
- Details of the FESM division modification plan, which included a plan to modify the FESM/SM section;
- Suggested FESM/SM modifications and personnel acquisitions;
- Anticipated labor and equipment costs associated with implementation of the FESM/SM modification plan;
- Relevant systems maintenance practices, responsibilities, and management philosophies currently utilized by 2 peer transit agencies.

Once compiled, CUTR utilized the preliminary data as the basis for analysis of the FESM/SM section modification plan. Specifically, researchers compared the current state of FESM/SM to conditions among the peer agencies. The analysis focused on similarities among the peers, and determined emulative practices, if any. Further areas of interest included management philosophies, organizational structures, methods utilized to measure employee productivity, and other techniques related to personnel.

Discussion

The ultimate goal of this analysis was to determine the reasonableness of proposed modifications to FESM/SM without using conventional manpower needs analysis methods or standard transit performance data. In this absence, CUTR looked closely at current conditions and systems maintenance practices among the peer transit agencies. Researchers also focused on the concerns of FESM/SM managers and described peer agency actions or conditions related to these concerns. Overall, CUTR documented several notable similarities and differences throughout the following section.

Several similarities were found to exist among systems maintenance groups at MDT, WMATA, and MARTA. Each agency was actively engaged in a number of capital improvement projects that would likely impact systems maintenance efforts, if they hadn't already. All 3 agencies offered multiple modes of transit, including diverse metrobus fleets and heavy rail systems, and faced challenges associated with rapidly advancing transit technologies. While MDT was the only agency that maintained an automated guideway mover system, it was also the only agency without subterranean rail lines.

None of the systems maintenance groups adhered to strict ratios of managers to technicians, but management representatives at each agency were conscious of the benefits of maintaining a low number. Managers at each agency also recognized the potential for negative outcomes associated with overworked, understaffed, or incomplete groups of systems maintenance technicians. In fact, each agency desired additional technical staff because managers felt that numbers were insufficient to meet their needs, especially those related to PMI schedules. Further, each systems maintenance management official stressed the importance of maintaining strong communications between management and staff, as well as between higher level agency management and the systems maintenance group.

Researchers also observed a variety of differences among systems maintenance operations. For example, wide variation existed among the organizational structures of systems maintenance groups. The number of official layers of management between executive staff and technical personnel varied from 6 (WMATA) to 3 (MDT). Other differences were related to management philosophies, work methods, reporting practices, determining personnel needs, and overall goals and priorities.

Systems maintenance groups observed similar goals and objectives. Common goals focused on completing preventive maintenance inspections, responding to short-term requests, and refurbishing older parts that were otherwise unavailable. Each group served in a preventive capacity, guarding against catastrophic failures. Systems maintenance personnel were not judged in terms of common fleet performance measures. Rather, overall group performance was indicated in terms of completed PMIs and lack of failures attributable to systems maintenance. To varying degrees, each agency expressed interest in utilizing a dedicated crew of technicians to focus on PMIs. However, because each group demonstrated personnel shortages, none had engaged the idea at the time of this writing.

The peer properties and MDT each located the majority of their systems maintenance operations within larger, overarching departments. For example, MARTA tended to look favorably on technological advancements. As such, systems maintenance areas were grouped within technology infrastructure. WMATA valued strong communications and common goals among its infrastructural maintainers, so a significant portion of its systems maintenance operations were combined with structural maintainers and rail line maintainers. Obviously, systems maintenance at MDT was also part of a larger, multi-disciplinary group. Each agency included some form of engineering functions under the same executive officer as systems maintainers; however, WMATA engineering support within TSSM was limited to structural and track maintenance. As such, WMATA systems maintenance managers expressed desire for engineering personnel within their group.

Both peer agencies organized their systems maintenance operations under multiple layers of oversight. Specifically, 1–2 levels of executive management (such as general and assistant general superintendent, or group manager) directed 2 or more specialized systems maintenance areas or crafts. Specialized areas also included at least 2 layers of management, such as general foreman and foreman; or superintendent (possibly assistant superintendent), area manager, and shift supervisor. The lower levels of supervision tended to work closer to technicians, with offices generally in the same location as repair shops. Peer agencies believed that this type of organization provided for better communications and quicker response to repair needs. They also believed that a common mission between maintenance and inspection personnel resulted in an overall increase in productivity. The FESM/SM modification plan sought to emulate a multi-tiered systems maintenance management structure. Supervisor ratios among the peers and FESM/SM varied and no standard was evident. Managers tended to set staffing levels based on perceived need, the availability of qualified personnel, and budgetary concerns.

Overall, MDT, WMATA, and MARTA maintained similar systems maintenance practices in some areas and exhibited clear differences in others. Work flow among structures groups generally followed a common pattern, which began with technicians removing faulty systems or component parts and returning the items in question to the repair shop. From there, staff decided to repair or replace the item. Then, the item was repaired or a new item was acquired, and the working part was returned to parts inventory. In some cases, parts demand was so great that reconditioned parts were returned directly to the repair shop for installation.

In general, systems maintenance groups among the agencies engaged whatever means were necessary to ensure that replacement parts were available to repair technicians. In fact, locating adequate replacement parts was among systems maintenance managers' greatest concerns, and each group resorted to innovative means in order to acquire them. Further, each agency followed a policy of in-house repair and refurbishment for all parts whenever possible. However, managers (especially at MARTA) recognized that as parts grew more complex, they were increasingly becoming disposable "run-until-failure" items that had to be replaced rather than repaired when they failed.

Only MARTA made notable use of contractors for traditional systems maintenance tasks. Specifically, the agency contracted out for maintenance and repair of fareboxes and token machines. However, MARTA was in the process of implementing new fare media systems and eliminating the use of tokens. WMATA reported only using contractors to maintain cellular telephones. A more significant issue for WMATA involved the agency policy of contractor escorting. Managers reported that manpower levels were negatively impacted because every contracted project on agency property required an escort. Systems maintenance personnel were not allowed to work on projects; they only served to secure the area and monitor project activity. In some cases, WMATA systems personnel were required to train contractors in specific areas before they could begin work. WMATA managers were frustrated that in some cases, agency staff expended considerable effort to support contracted projects. Neither MARTA nor MDT utilized contractor escorts, although managers at both agencies felt it would be reasonable and justified to provide them.

FESM/SM managers were particularly concerned about unqualified personnel picking into technical positions based solely on their seniority. Both peer agencies had well-developed policies in place to discourage this practice. Potential technicians were required to pass an initial exam just to be eligible for consideration by systems maintenance. After meeting initial qualifications, technicians reverted to entry-level or apprentice status for a set period at the new position, despite their years of seniority. These methods were reportedly very effective. As such, peer group managers found "cross-crafting" to be a minimal issue.

Management personnel within each systems maintenance group reported many of the same concerns. Each group considered their allotment of technicians to be less than needed, and managers reported difficulty in finding qualified electronic technician applicants. Supplemental training for existing personnel also posed challenges including sufficient funding, availability of training, and ability to utilize working hours on non-maintenance activities. However, systems maintenance groups recognized the importance of maintaining technical skills among staff and devised innovative means to provide additional training. Most supervisors pointed out the importance for adequate maintenance training to be included in procurement contracts. They reported that when it was included, training was often minimal and far less than the amount necessary to allow technicians time to develop adequate skills. MARTA systems maintainers identified their concerns over a variety of vehicle types, especially rail cars, because technicians had to be proficient with many different components, rather than dealing with just one type.

Overall, managers were frustrated in their attempts to measure systems maintenance employee productivity. Specialized techniques were developed in some cases, but they were generally met with considerable resistance from employees. Systems maintenance managers also experienced difficulty in holding employees accountable for skills because documentation of training did not exist or was not readily available to managers. Miami was the only agency to specify technical skill in the official titles of maintenance personnel. WMATA classified technicians according to skill grade, while MARTA referred to all technicians by the same moniker, regardless of skill level. Further, the agencies varied in their expectations of overall employee skill: WMATA and MDT sought mostly specialized technicians, while MARTA saw value in training technicians in all areas of their work group. MARTA also demonstrated innovation in tracking productivity among technicians.

Specific practices and issues are worthy of mention in this comparison discussion. For example, only MDT systems maintainers reported a significant lack of space for repair facilities, storage, and managers' offices. In addition, concerns regarding on-board videos were limited to MDT. Specifically, while WMATA also had cameras on buses, the video recordings were the domain of their transit police. WMATA systems maintenance serviced the cameras and related equipment, but only the police were allowed access to the images. At the time of this writing, MARTA had not installed video recording equipment into their fleet.

FESM/SM related considerable concern regarding the inability to maintain all systems. In fact, the issue of "unmaintained systems" drove the creation of the modification plan. Neither of the peer agencies reported such a concern nor did they describe conditions where systems went unmaintained. However, as mentioned earlier in this section, the groups increasingly were agreeable to "run-until-failure" components.

Findings

The overall purpose of the comparative review was to establish a baseline of information from which to determine the "reasonableness" of the FESM/SM modification plan. However, this task proved to be more challenging than originally anticipated. In the absence of relevant employee performance data, a peer comparison was the most effective means for researchers to demonstrate the merits and/or drawbacks of the divisional plan terms. As such, researchers examined the peers for important similarities, influential practices, and other experiences. Through a combination of these best practices and specific data related to MDT FESM/SM, researchers could state with general certainty the "reasonableness" of the terms of plan #2.

Researchers found that the current FESM/SM organizational structure warranted modification. Specifically, both peer agencies maintained a distinct structure that included a multi-tiered hierarchy of management. Such an arrangement afforded many luxuries to systems maintenance managers that MDT supervisors did not currently enjoy. As an example, executive managers at the peers focused on specific upper-level management responsibilities; direct supervision and responsibility for shop-level employees was left to the discretion of middle- and lower-level managers. On the other hand, the manager/SM at MDT was officially responsible for every technician within the group and handled a multitude of personnel responsibilities. Furthermore, lower level supervisors at MDT had no official oversight authority to manage technical staff. Although personnel problems were reportedly rare within FESM/SM, the potential existed for miscommunication, frustration, and other undesirable outcomes. In addition, the addition of managers in specific technical areas would encourage a degree of specialization among managers and technicians that would most likely benefit employee morale, technical efficiency, and overall productivity and effectiveness. Peer agency practices demonstrated that these concepts yielded similar positive results. As such, CUTR considered the provisions in plan #2 to add 2 layers of specialized official management to be reasonable.

CUTR could not determine with precise certainty that the plan to acquire 37 transit electronic technicians was adequate. However, researchers felt that given the best practices observed among the peer agencies and the existing FESM/SM workload examples, a plan to add some quantity of technical staff was reasonable. Specifically, video/TELCOM technicians were responsible to maintain at least 6,000 pieces of camera equipment and over 3,500 destination boards on buses. In addition, MDT radio staff were required to complete approximately 70 preventive maintenance inspections and necessary repairs per week. Overall, 52 technicians would have to work fulltime on preventive maintenance inspections just to meet the currently required schedule. Each peer agency also identified a need for additional technical support. However, neither peer had undergone recent expansions to the degree that MDT added vehicles to its bus fleet. As such, this made comparison among agencies difficult. Because CUTR had previously established that technical managers were best suited to determine precise staffing needs, researchers believed that the number of requested technician positions was likely to be a reasonable estimate of need.

As mentioned earlier, to reach division status, a working group at MDT had to retain sufficient clerical and administrative support. At present, the 2 sections and 1 division within FESM shared limited support staff. As a result, many supervisors completed clerical tasks, which they had neither the time nor the training to successfully complete. As such, CUTR believed that the provisions to add 2 administrative support staff outlined in plan #2 were reasonable.

Although Plan #2 provided for the acquisition of office equipment and supplies for new staff, the plan did not include an itemized list of necessary equipment. Based on the results and itemized lists found in plan #1 and plan #3, researchers believed that the amount budgeted for equipment seemed reasonable. However, CUTR could not state explicitly that the provision was sound due to the lack of details.

CUTR did not include a total compensation analysis in this phase of the project. Specifically, total compensation comparisons between agencies were not valid, especially among technical, represented personnel. Furthermore, management responsibilities and organization varied to a degree that would likely impact a strict comparison of compensation. Lastly, categories in the ERI database (described in phase 1) were too general to apply specifically to the positions requested by plan #2. The large number of positions in the database with slight relevance to the requested positions left too much potential for error. As such, researchers felt that estimates would be too broad to be applicable in this instance.

V. CONCLUSIONS & RECOMMENDATIONS

This research effort was designed to address a number of key questions regarding the modification and improvement of the FESM division at MDT. For phase 2 of the project, CUTR conducted a multi-step investigation to determine the reasonableness of the FESM/SM modification plan. The plan addressed systems maintenance personnel deficiencies and other challenges associated with ongoing and planned agency growth. For this study, researchers examined the current state and organizational structure of FESM/SM; reviewed practices at peer transit agencies; assessed the modification proposal; devised a research process; and conducted comparative and total compensation analyses.

CUTR organized the following chapter into 2 general areas. First, researchers presented a series of conclusions based on each step of the investigation. Later, the chapter included a series of recommended actions based on the overall findings and results of this study effort.

Conclusions

CUTR observed several conclusions as a result of this research effort. It was not surprising to learn that transit systems maintenance groups faced common challenges, maintained similar responsibilities, and observed many of the same work standards. However, these groups commonly engaged in a variety of methods to achieve similar goals.

FESM/SM was challenged to fully meet existing or anticipated demands for services. Specifically, the allotment of technical and supervisory personnel was considered insufficient to meet FESM/SM needs. Further, the division retained no dedicated administrative staff.

A detailed list of observational conclusions resulting from this research effort is cataloged below.

1. Background

1.1. At the inception of this project, Systems Maintenance was one of 2 sections within the Field Engineering & Systems Maintenance division, which also included the Structural Inspection & Analysis division.

1.2. FESM/SM was originally conceived, staffed, and organized to accommodate a 500-vehicle Metrobus fleet. Under the terms of the People's Transportation Plan passed in 2002, the Metrobus fleet will expand to include over 1,200 vehicles.

1.3. The Metrorail system began service in 1984-85. In 2003, the Metrorail system was expanded to reach the Palmetto Station. The current Metrorail system included 136 vehicles and 22 stations. Three future expansions of the Metrorail system were under development, including the North Corridor, the East-West Corridor, and the Miami Inter-modal Center. When implemented, the total length of these extensions would nearly double the current mileage of the system.

1.4. In 1986, MDT implemented the Downtown Loop of the Metromover automated people mover system. 2 extensions (Omni, Brickell) began operations in 1994. Overall, the Metromover system operated 29 vehicles through 21 stations over 4.4 miles of guideway.

2. Organization of Systems Maintenance Section

2.1. The position of section oversight for FESM/SM was the manager/SM. This position reported to the chief/FESM.

2.2. FESM/SM was organized into 5 work areas: farebox, fare collection, radio, electronic repair lab, and video/TELCOM. The video and TELCOM groups merged after this project was initiated. 11 supervisors were distributed among the work areas in varying numbers.

2.3. FESM/SM technical staff consisted of 75 unionized transit electronic technician (TET) positions in 3 areas of specialty: /lab, /radio, and /systems. Under the current management structure, all 75 technicians officially reported to the manager/SM; however, technicians generally received daily assignments from supervisors.

2.4. No administrative support was specifically dedicated to FESM/SM. The section shared administrative support personnel with the other areas of the FESM/SIA division.

3. Systems Maintenance Staff & Responsibilities

3.1. FESM/SM was responsible for the installation, repair, and preventive maintenance of vital electronic equipment. FESM/SM provided support to all MDT transit modes and stations, as well as the departments of transit revenue, facilities maintenance, safety & security, and information technology. An itemized list of MDT assets maintained by FESM/SM is found in Table 2.1 on pages 6-7 of this report.

3.2. Overall challenges faced by FESM/SM included acquiring qualified and capable technical staff, compliance with preventive maintenance inspection schedules, maintaining obsolete equipment, acquiring replacement components for out-of-production items, refurbishing existing component parts, implementing and maintaining new technologies, and responding to specific action and/or repair requests.

3.3. The radio repair shop retained 17 technicians and 3 supervisors, and operated 3 shifts per day, 7 days per week. The group maintained portable, vehicle-mounted, and stationary radio and communications equipment.

3.4. The electronic repair lab, located at the William Lehman Metrorail maintenance facility, retained 11 TET/lab positions to complete maintenance, repair, and refurbishment of farebox and electronic railcar components. Many parts maintained by this group were unavailable as new because of their age.

3.5. The video/TELCOM repair group retained 26 TET/systems staff and 4 supervisors to maintain, repair, and install video systems on MDT revenue vehicles. Buses were equipped with between 6 to 9 cameras. The group responded to requests for video review in cases of incidents or complaints.

3.6. Telecommunications equipment maintained by the video/TELCOM repair group included PA systems, fire & intrusion systems, closed circuit television systems, elevator and passenger assistance telephones, and fiber communications networks.

3.7. The farebox repair group retained 16 technicians and 2 supervisors to maintain bus-related fare equipment including fareboxes, controllers, cashboxes, revenue island equipment, and mobile safes. Because much of the equipment was over 20 years old, the group used many parts that were refurbished in the electronic repair lab.

3.8. The fare collection repair group retained 9 TET/systems and 1 supervisor to maintain Metrorail-related fare equipment, including bill changer machines, parking meters, transfer dispensers, and high speed ticket encoder machines. As was the case with the farebox group, much of the fare collection equipment was older or obsolete. The ticket encoder machines were especially challenging to maintain because of their heavy use by the revenue department.

3.9. A large portion of time spent by all FESM/SM repair groups was related to completing preventive maintenance inspections and completing repairs as a result of inspection findings. To fully comply with manufacturers' and MDT field test engineering recommendations, FESM/SM calculated that 52 TETs dedicated to the completion of PM activities were needed.

3.10. In 2002, MDT began acquiring new buses to increase fleet size. As a result, the number of scheduled PMs almost doubled between 2002 and 2004. Corresponding to this increase, FESM/SM experienced a significant decease in the percent of completed PMs.

4. FESM/Systems Maintenance Modification Plan (Plan #2)

4.1. In February 2005, FESM management proposed a 3-part plan to significantly modify the divisional structure and complement of technical, supervisory, and administrative personnel. The second component of the plan specified modifications for the systems maintenance section.

4.2. Overall, plan #2 provided for the following positions to be retained by FESM/SM: 3 chief supervisors, 6 technical supervisors, 37 TETs, and 2 administrative support staff. In addition, the manager/SM would be reclassified as chief/SM to oversee the reorganized systems maintenance division.

4.3. Section modifications included in plan #2 involved elevating the official status of the section to "division," adding 2 layers of official supervision, and organizing FESM/SM into 3 overriding groups: revenue, communications, and power & electronic lab.

4.4. The proposed revenue group would consist of the existing farebox and fare collection maintenance areas. Plan #2 provided for the revenue group to be managed by the new position of chief supervisor. Each maintenance area would be managed by a supervisor.

4.5. The proposed communications group would consist of the 7 specialized maintenance groups: the existing radio, TELCOM, and video maintenance areas, and the newly formed fiber, public address, fire, and intrusion maintenance areas. The communications group would be managed by a new position of chief supervisor, and each maintenance area would be managed by a supervisor.

4.6. The proposed power & electronic lab group would include the existing electronic repair lab and create a specialized group for uninterrupted power supply repair and maintenance. The power & electronic lab group would be managed by the third chief supervisor position, and each maintenance area would be directly managed by a supervisor.

4.7. To provide dedicated administrative support for the new FESM/SM division, plan #2 included the acquisition of 1 administrative officer II and 1 secretary. The plan intended for these positions to report to the newly-designated chief/SM.

4.8. According to plan #2, the total annual compensation required for each new chief supervisor position was $76,189.

4.9. According to plan #2, the total annual compensation required for each new technical supervisor position was $59,302.

4.10. According to plan #2, the total annual compensation required for each new electronic technician position was $50,429.

4.11. Plan #2 provided for the manager/SM annual compensation to be raised by $4,427 to coincide with reclassified as chief/SM.

4.12. Total annual compensation costs for administrative support identified in plan #2 included: $47,522 for the administrative officer II and $33,439 for the secretary.

4.13. Plan #2 accounted for necessary equipment to establish the proposed personnel acquisitions. In addition, the plan allotted for necessary office equipment for use by division staff. Total equipment costs were estimated to be $330,000.

4.14. Overall, plan #2 proposed to acquire 48 staff and reclassify 1 staff. The total of all costs associated with the project was approximately $2.9 million.

5. Peer Agency Review

5.1. The two peer agencies reviewed in research effort were WMATA (Washington, D.C.) and MARTA (Atlanta, Georgia).

5.2. The WMATA Metrorail system operated 904 rail cars over 5 lines on 106 miles of track through 86 stations.

5.3. The WMATA Metrobus fleet included almost 1,500 buses, including almost 500 alternative fuel vehicles (CNG and hybrids).

5.4. At least 3 existing WMATA Metrorail lines were in the process of expansion at the time of this writing. In addition, 2 completely new rail lines were under development.

5.5. WMATA organized systems maintenance and track structures responsibilities under 1 large group (TSSM) that was managed by a general superintendent. TSSM was divided into 3 groups: 2 focused on systems maintenance concerns (SMNT), 1 focused on rail line management. Each sub group was managed by an assistant general manager (AGM).

5.6. At WMATA, one AGM/SMNT managed work groups responsible for power systems, automatic fare collection systems (AFCS), and shops & materials support (SAMS). The second AGM/SMNT managed work groups responsible for communications systems, automatic train control systems (ATCS), and special projects.

5.7. Each of the 6 SMNT work groups was managed by a superintendent. Supervisors were assigned to each shift and reported to the superintendent.

5.8. SMNT technicians were classified according to 4 levels, from the highest level "AA" through the lowest "C." SMNT actively practiced a policy that discouraged technicians from switching between work groups.

5.9. SMNT maintained systems that were similar to those maintained by FESM/SM. Notable differences were as follows:

5.9.1. WMATA used "smart cards." In addition, magnetic media were printed by vending machines at the time of purchase.

5.9.2. SMNT did not maintain digital video recording devices and did not have access to video recordings. Requests for review of videos were handled by the WMATA transit police. (SMNT did maintain cameras, microphones, and peripheral components in the video system).

5.10. SMNT did not complete annual reviews for employees. Technicians were only subjected to a review process when they applied for promotion. Managers tried to implement several ideas for monitoring employee performance and providing feedback, but each of these efforts was not received well by employees.

5.11. SMNT expended considerable effort to comply with WMATA policy of escorting contractors when they were working onsite. Escorts monitored activities and made sure work areas were secured and safe, but they were precluded from active involvement in project activities.

5.12. SMNT managers expressed concern that lifecycle maintenance costs and technician training costs were often not included in procurement specifications. SMNT was generally not involved in the procurement process.

5.13. SMNT were challenged to maintain older equipment and find replacement components for old or obsolete systems.

5.14. SMNT participated in 43 ongoing renewal projects but reported that no additional staff were allotted to assist in the effort.

5.15. TSSM and SMNT observed the practice of "condition assessment," which involved reviewing systems and indicating anticipated length until critical repairs were necessary for the system in question. Condition grades included "immediate repair necessary," "repair expected within 5 years," "repair expected within 10 years," etc.

5.16. In general, SMNT groups had few space concerns. SMNT generally had sufficient shop and storage space among each work group.

5.17. SMNT managers where challenged to attract and retain qualified technicians. The group altered some introductory requirements, but did not alter others. Specifically, training requirements and lower pay than private industry were seen as barriers to finding staff.

5.18. SMNT managers described their concern over a lack of procedural documentation. Although a mentoring program existed, sharing of knowledge among experienced maintenance personnel was limited. Managers continued to push for policies that allowed newer staff to work with experienced technicians and/or OEM maintainers in order to become more knowledgeable in complex repair techniques.

5.19. The MARTA rail system operated 338 railcars on 2 lines over 48 miles of track through 39 stations. The MARTA metro bus fleet was comprised of 556 buses, including 441 CNG and 145 clean diesel vehicles.

5.20. MARTA had no active expansion projects, but expansions to each rail line were under consideration.

5.21. MARTA took an innovative, progressive approach to systems maintenance by organizing several areas within its Office of IT Infrastructure & Systems Management. The group included technical engineers, enterprise network engineers, technical support services, systems programmers, and computer operators. Overall, ISM retained 38 managers and administrative staff and 74 unionized technician and supervisor positions.

5.22. ISM consisted of 3 groups: communications & faregates, network & technical support, and mainframe operations. Each group contained traditional systems maintenance areas, which MARTA referred to as "crafts."

5.23. Specific crafts were radio, telephone, faregate (rail), and computer.

5.24. ISM utilized a 3-tiered management structure: group managers managed general foremen, and general foremen managed foremen.

5.25. Foremen and general foremen worked among the maintenance shops. Group managers maintained offices within the central administration building.

5.26. ISM technical staff were officially classified as "journeymen/electronic technicians." Only one level of technician existed among systems maintenance crafts.

5.27. MARTA embraced technology advancements whenever possible. ISM maintained training policies to keep technician skill sets current.

5.28. MARTA was in the process of implementing a "smartcard" automated fare collection system and was phasing out the use of tokens.

5.29. MARTA contracted out for maintenance of fareboxes and existing token machines. Ticket vending machines for the new system were currently maintained under warranty. At the time of this report, no decision had been made concerning maintenance for TVMs.

5.30. As of this writing, MARTA had not placed cameras in its metro bus fleet. According to managers, no decision to do so was pending.

5.31. ISM radio craft operated a maintenance shop and also placed technicians at various bus maintenance facilities.

5.32. ISM desired that technicians be skilled in all maintenance areas. However, the agency maintained policies that discouraged technicians from switching between jobs ("cross-crafting").

5.33. ISM also reported difficulty in attracting qualified electronics technician applicants. Less competitive pay and experience requirements were identified as barriers.

5.34. ISM was in the process of developing technology to track employee productivity. For example, technicians clocked in and out using work order numbers; this method indicated to managers the length of time employees spent on specific tasks. Tracking or grading performance was more difficult.

5.35. ISM personnel, even technicians, were involved in the procurement and acquisitions process. MARTA considered maintenance needs and lifecycle costs during initial stages of specification design.

6. Comparison Analysis

6.1. Typical data used for a manpower-type analysis were generally not available for systems maintenance positions, and work-time standards did not exist. In addition, fleet performance data were not directly relevant to the field. As a result, researchers used a comparative analysis to determine the "reasonableness" of plan #1

6.2. Based on the recommendations of both original equipment manufacturers and MDT field test engineers, almost 73,000 technician-hours per year were required to meet preventive maintenance needs of all equipment maintained by FESM/SM. With 1,410 annual work hours available per technician, preventive maintenance requirements alone mandated 52 fulltime technicians.

6.3. FESM/SM retained only 57 technicians, so only 5 technicians would be available to complete all other systems maintenance needs.

6.4. An example that illustrated FESM/SM personnel needs was that technicians completed 64% of closed circuit television preventive maintenance inspections in 2002. Within 2 years, the rate had declined to 51%.

6.5. Systems maintenance groups at each transit agency reviewed in this study (including FESM/SM) recognized that system growth would impact their ability to meet responsibilities as intended.

6.6. While each systems maintenance group maintained largely similar responsibilities, many differences existed among their methods for meeting their tasks.

6.7. Each systems maintenance group was organized under a larger, overarching group. However, specific details regarding the organization and composition of each group varied to some degree.

6.8. Plan #2 called for FESM/SM to be reorganized into 3 groups, including power & electronic lab, communications, and revenue. The first and last groups would each include 2 work groups, while the second would include 7 work groups.

6.9. Overall, managers, especially those at the shop level, were most capable of determining staffing needs. This was especially true because employee productivity within systems maintenance was difficult to monitor and highly variable.

6.10. Among the agencies reviewed for this research effort, only MDT had experienced such a significant increase in the number of buses in its fleet. As such, no comparable increases in systems maintenance demands were found among the peer agencies. The only related comparison was the issue of escorting contractors at WMATA. This was the responsibility of systems maintenance and with up to 50 contracted efforts ongoing at any given time, this requirement presented a significant impact on available technical staff.

6.11. Critical examples of FESM/SM staffing issues concerned the increased number of maintained components due to the acquisition of several hundred new buses. For example, the radio shop maintained 3 destination signs per bus. In a 500-vehicle fleet, this represented 1,500 units, but a rise to 1,200 vehicles increased the number of signs to 3,600. Many similar examples existed.

6.12. Among the 3 systems maintenance groups reviewed in this study, only FESM/SM maintained and reviewed digital video recordings. MARTA did not have cameras installed on vehicles, and WMATA transit police were the sole reviewers of digital video.

6.13. Each systems maintenance group expressed concerns about technician training. Specifically, each group desired supplemental training or certification training for technicians, but the availability of training was often limited. Funding for training was also limited at best. And, systems maintenance groups found it difficult to send technicians for training during regular work time.

6.14. FESM/SM experienced a significant space and storage problem. This was not the case among peer groups. In general, peer agency systems maintenance groups had ample space available for work areas, storage, managers' offices, and employee facilities.

6.15. Each systems maintenance group was challenged to find and maintain component parts for obsolete items. In many cases, there was no choice but to maintain the item because replacements were no longer manufactured. Technology conversions were gradually headed toward "run-until-failure" components.

6.16. Systems maintenance groups reported difficulty in attracting qualified applicants. Potential reasons for this included lower pay than private industry, experience and examination requirements, and unfavorable starting work schedules.

6.17. FESM/SM managers reportedly spent a lot of time responding to customer complaints and completing unscheduled tasks. Similar conditions existed among peer agencies.

6.18. Systems maintenance groups practiced similar overall work methods. Differences existed in organizational structures, management levels, employee classifications, and specific concerns.

6.19. Only MARTA made extensive use of contractors for maintenance functions on selected systems.

6.20. The peer agencies established specific measures to discourage employees from picking into different jobs. Their efforts were successful to the point that neither peer identified this as a serious problem.

6.21. Each group was significantly challenged in their attempts to track technician productivity.

6.22. Overall, CUTR found that the development of a plan to reorganize FESM/SM, including the addition of 2 tiers of supervisory levels, several technical staff, and administrative staff was reasonable and justified, especially considering the current and future challenges faced by the group.

6.23. Specifically, the plan to divide existing FESM/SM groups into several specialized areas emulated peer practices. Peer agencies reported that such arrangements worked well there, so it was reasonable to assume that similar changes at MDT would also realize positive outcomes.

6.24. CUTR was fairly certain that the specific numbers of supervisory personnel requested by plan #2 were reasonable and sound. Again, this provision emulated peer practices by assigning managers to each level and work group within the field.

6.25. CUTR could not precisely determine that the number of transit electronic technicians requested in plan #2 was feasible or adequate. Researchers felt that given the best practices observed among peer agencies and FESM/SM workload examples, a plan to add some quantity of technical staff was reasonable and justified.

6.26. FESM/SM had to retain dedicated administrative personnel in order to be recognized as a division. At the time of this writing, the group shared administrative personnel with other areas of FESM. As such, researchers determine that the terms of plan #2 that allowed for the acquisition of 2 administrative personnel were reasonable.

Recommendations

The MDT FESM/SM modification plan presented a detailed, proactive approach to the challenges associated with ongoing and imminent agency growth, modernization efforts, and implementations of advanced technologies. Specifically, the plan addressed personnel deficiencies, supervisory needs, and equipment costs. FESM/SM managers engaged CUTR to review the modification plan and to determine the reasonableness of the provisions within it.

The recommendations that resulted from this research effort were categorized into 2 areas. First, recommendations specifically related to the reasonableness of plan #2 are listed. After that, CUTR suggested actions and recommended next steps for FESM/SM based on the body of knowledge gained over the course of this project.

1. The FESM/SM modification plan represented a clear attempt by managers to head off potential problems likely to result from insufficient staffing levels. At a minimum, current staffing inadequacies would remain an annoyance and continue to delay preventive

maintenance schedule compliance. At worst, critical repairs could be delayed to such a point that passenger safety and service reliability became compromised. As a result of this research effort, the terms of plan #2 were generally considered to be reasonable.

2. The findings of this investigation led CUTR to recommend that at a minimum, the organization of FESM/SM should be restructured according to the terms outlined in plan #2. Clearly, additional levels of management were warranted for systems maintenance work areas. The reorganization plan reflected peer agency organizations, which were heavily praised by supervisory and technical personnel working within them.

3. After officially reorganizing FESM/SM, the agency should strongly consider acquiring supervisory personnel to fill each manager position. Peer agencies achieved a high degree of oversight, control, and specialization through the use of a multi-tiered management structure. Based on plan #2, this was a goal of FESM/SM, and it could be approached through a fully-staffed supervisory group.

4. Technical managers are most familiar with their staffing needs, strengths and weaknesses among current staff, and the intricacies of their facilities. No research effort or case study could hope to approach this level of intimate knowledge. As such, the acquisition of technical staff as defined in plan #2 should be seriously considered by MDT.

5. The current and future workloads of managers, supervisors, and technical staff were found to be heavy enough to preclude the assignment of additional responsibilities, such as administrative tasks. In addition, as the responsibilities of the group continue to increase, such workloads will likely also increase significantly. Further, one of the desired outcomes of plan # 2 was to officially designate FESM/SM as a division. Based on all factors mentioned here, CUTR recommends that administrative personnel identified in plan # 2 be acquired.

6. FESM/SM managers should revisit plan #2 and explicitly define the required equipment to be purchased. While all new positions require common start-up items, it is important that these items are described in detail before they can be acquired.

7. Peer agency systems maintenance groups maintained specific goals and objectives, and each defined a clear mission statement. FESM/SM should consider developing a written mission statement and stating specific goals and objectives in written format to serve as a point of reference and guidance for the group. Hard copies of these items should be presented to all staff, especially technicians, and they should be posted in high traffic areas.

8. CUTR recommended that MDT engage significant modernization efforts for FESM/SM office and shop facilities. Current facilities generally seemed to lack sufficient space for staff and materials, and they commonly lacked adequate privacy for managers to deal with personnel issues and other sensitive matters.

9. FESM/SM managers expressed concern about the time involved with handling special requests, especially regarding customer service issues. Among the most time-consuming tasks was reviewing digital video recordings and burning compact discs of the recordings. CUTR found that systems maintenance groups at the peer agencies did not deal with digital video recordings. As such, CUTR recommends that FESM/SM relinquish the review and burn responsibilities associated with digital video equipment. However, FESM/SM would continue installation and other maintenance responsibilities for the equipment as necessary. Potential areas within MDT that might assume video review and storage responsibilities include customer service, transit police, light-duty staff, etc.

10. Systems maintenance technical positions usually involve safety-critical responsibilities. Furthermore, it is dangerous, as well as frustrating to managers and co-workers, for inexperienced personnel to pick into these positions. As such, researchers encourage the agency to review peer practices and devise a plan to implement policies that discourage unqualified personnel from switching into the group.

11. Systems maintenance managers expressed considerable dismay at the prospect of losing experienced personnel and having no standardized method in place to document such procedural experience. Further, managers were frustrated that technical staff were precluded from gaining hands-on experience from OEM technicians on components and systems currently under warranty. As a result of the findings of this research effort, MDT should consider adopting modifications to existing policies in these areas. Innovative approaches are needed in order to

document procedures and gain experience for less-experienced staff. Such action has the potential to yield considerable benefits to staff, management, and maintenance effectiveness.

12. Systems maintenance personnel generally agreed that fare collection equipment (including change machines, vending machines, and other magnetic media machines) was among the most troublesome to maintain. MARTA contracted out the service and maintenance of these machines. Although new fare collection technologies are under development, FESM/SM may want to explore the possibility of emulating MARTA's practice in this area. The anticipated outcome would be more technicians available to work in other areas.

13. Although this research demonstrated that specialization among technicians is desirable, FESM/SM may consider adopting the MARTA policy of training technicians to be proficient in all maintenance areas within their group. For example, if the proposed organization is adopted, revenue group technicians would be trained in farebox and fare collection areas.

MIAMI-DADE TRANSIT

FIELD ENGINEERING, SYSTEMS MAINTENANCE, and STRUCTURAL INSPECTION & ANALYSIS DIVISION (FESM)

Divisional Modification Plan Review & Recommendations:

PHASE THREE REPORT – STRUCTURAL INSPECTION & ANALYSIS

MARCH 2007

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I. INTRODUCTION

This research project intended to assist Miami-Dade Transit (MDT) in documenting current internal processes, planned growth, personnel needs, and available resources within the Field Engineering, Systems Maintenance, and Structural Inspection & Analysis division (FESM) and to develop recommendations for the plan to address them. This assessment, completed by the Center for Urban Transportation Research (CUTR) at the University of South Florida (USF), includes a review of the current practices within the division, a comparison with similar divisions at peer transit agencies, and recommendations for a division improvement plan. This project was performed under the existing inter-local agreement between Miami-Dade County and USF.

The overall research effort completed by CUTR was organized around 3 phases that correspond with each area of the FESM division. This report represents the completion of the STRUCTURAL INSPECTION & ANALYSIS (SIA) phase of the project, which was the third and final phase of the project.

Background

MDT remained committed to providing safe and reliable transportation systems to the people of south Florida. Nonetheless, demands on the present systems continued to grow. With the passage of the People's Transportation Plan (PTP) in 2002, MDT became legally obligated to improve and expand its service. For example, planned growth among the Metrobus fleet will more than double the number of buses serving the citizens of Miami-Dade.

While such improvements were certainly welcomed by all, the rapid pace of expansion and the large number of newly acquired vehicles presented major challenges to most divisions within MDT. Specifically, divisions that were originally conceived, staffed, and managed to accommodate a 500-vehicle metro bus fleet were compelled to meet the greater demands associated with a significantly larger fleet. Because of the high volume of additional responsibilities within the FESM division, staff were increasingly pressed to the limits of their specific areas of expertise.

At the time of this writing, FESM consisted of one division and two sections. To address challenges posed by MDT expansion plans and improvement projects, the FESM management team drafted an organizational modification proposal. Among the proposed changes were elevating the two divisions to division status. This proposed modification allowed for greater authority and oversight within the specific fields of engineering, systems maintenance, and structural inspection and analysis. Further modifications suggested by FESM management personnel addressed personnel shortages and established a more detailed hierarchy of management.

Phase Three Overview

During the third phase of this project, CUTR reviewed the proposed acquisitions of personnel and equipment and increases in overtime by the FESM/SIA division. CUTR also documented the scope of SIA division responsibilities, current staff positions and organization, and ongoing major projects. Researchers gathered information from staff interviews, observations, agency documentation, data analyses (if available), and interviews with peer transit agency officials. CUTR examined structural inspection & analysis management techniques, supervisory ratios, and common structural inspection & analysis practices. Specifically, transit-related structural inspection & analysis management styles and organizational goals and objectives were compared and contrasted. In addition, CUTR performed a regional compensation analysis for structural inspection & analysis positions in south Florida. Lastly, this research presented recommended actions for the SIA division.

Report Organization

This research project involved 4 areas of effort, which are detailed throughout the 4 remaining chapters of this report. Chapter II described the current state of the structural inspection & analysis division, including major responsibilities, a review of staff positions, and presentation of the in-house divisional modification plan. Chapter III presented information compiled from peer transit agencies and provided a comparative analysis of peer agency practices and MDT. Chapter IV included an analysis of the divisional modification plan, a salary comparison analysis for structural inspection & analysis positions, and a discussion of structural inspection & analysis staff productivity. The fifth and final chapter presented conclusions and recommendations to improve the structural inspection & analysis division.

II. CURRENT STATE:

STRUCTURAL INSPECTION & ANALYSIS DIVISION (SIA)

Introduction

This chapter described the current state of the Structural Inspection & Analysis division (SIA), which is one component of the Field Engineering, Systems Maintenance, and Structural Inspection & Analysis division (FESM) at Miami-Dade Transit. Specifically, the chapter presented areas of divisional responsibility and discussed the organizational structure. Further documentation focused on the functions and responsibilities of specific positions within SIA. Later portions of the chapter summarized the divisional modification proposal.

This review demonstrated the scope of SIA responsibilities. Further, the review showed the degree to which the division was able to meet its responsibilities with current staffing levels. A critical factor proved to be recent and anticipated growth in demand for structural inspection & analysis services, while technical staff numbers remained constant. This documentation served as the basis for an analysis of the feasibility and appropriateness of the SIA modification plan.

To complete this section, CUTR documented the divisional history, organizational structures, current internal processes, workload, and resource allocation within SIA. Information sources included available reports, staff and management interviews, and field visits. Researchers also noted the effects of recent and future system expansions on the division.

SIA Division Organization and Responsibilities

Overview

Upon inception, FESM concentrated on tasks necessary to maintain existing equipment and systems. Over time, the scope of services expanded and division responsibilities increased. With the introduction of Metrorail service, a structural inspection and analysis program became necessary to monitor conditions of the elevated railway infrastructure. As the system grew and new services were implemented, the expansion of inspection program responsibilities followed.

The main objective of the inspection and analysis program was to prevent catastrophic structural failures. As such, program activities focused on early detection of structural flaws and other potentially hazardous conditions. Ideally, a thorough inspection and analysis effort sought to minimize the extent of structural deterioration, resulting in lower repair costs. Overall, SIA was responsible for the review and documentation of current conditions along the Metrorail and Metromover system superstructures. Specifically, the division provided inspection and analysis support for the following MDT assets:

- elevated segments of the Metrorail system (*excluding* the topside of the guideway);
- Metrorail stations;
- elevated segments of the Metromover system (*including* the topside of the guideway;
- Metromover stations; and
- technical drawings of the Metromover and Metrorail system structures

Inspections were completed according to 2-year cycles. Using field inspection books, which graphically represented historical conditions and technical specifications of each 100-foot section, inspectors worked in pairs to completely review each structural component of the elevated railways and guideways. Key variables documented included system, segment, direction, cycle, pier ID, and inspector. Inspection findings were documented as updates to field inspection books. When conditions warranted, inspection results also generated repair orders. Among the specific structural elements and conditions described within action reports were anchor bolts, cracks, debris, exposed steel, honeycombing, failed patches, rust stains, cracks, drilled holes, pier clearance, guideway pads, exposed plates, and the presence of rust and/or corrosion.

At the time of this writing, SIA retained 1 division chief, 1 inspector supervisor, 4 inspectors, and 2 drafters. The group maintained vital infrastructure documents and utilized an in-house database to catalog the Metrorail and Metromover structural systems. The division cataloged inspection findings for each structural segment and identified areas in need of repair. This process generated repair requests when conditions warranted. The structural inspection & analysis group coordinated with the

MDT track & guideway division to ensure completion of necessary system repairs. Structural inspection personnel verified repair actions and logged findings into the field inspection book database.

The following sections described SIA history, personnel classifications, and specific position responsibilities in greater detail. Relevant personnel issues, such as those related to recruitment, training, retention, advancement, and evaluation, were also noted where relevant.

Background of SIA program

When Metrorail went into operation in Miami during 1984-85, a structural inspection program was implemented to support the system. The majority of the original Metrorail system consisted of an elevated, "double-T" concrete infrastructure, which included 5 bridges of varying lengths. The Metrorail line is double-tracked, and depending on location along the system, one track is referred to as "inbound" and the other as "outbound." At the time of the Metrorail implementation, 2 field inspectors were assigned to monitor and review structural conditions along each 100-foot segment throughout the entire elevated portion of the system. Upon returning from the field, inspectors turned over findings to engineering drafters, who documented results, compiled reports, generated repair orders when necessary, and noted follow-up information as it became available.

As the Metrorail system grew and the Metromover system was implemented, expansion of the inspection program followed. Specifically, additional Metromover-related structural inspection responsibilities included the Downtown Loop, the Omni extension, and the Brickell extension. Metromover system expansions prompted MDT to double the SIA divisional inspection staff and to add an inspector supervisor position. SIA also replaced the facilities maintenance division as the responsible group for Metrorail station inspections.

The most recent expansion, in 2003, involved the Metrorail Palmetto extension, which differed in design from the original system. Specifically, the new portion was constructed using steel box girders rather than concrete double-T girders. Future Metrorail expansion efforts included the Miami Intermodal Center, the East-West Corridor, and the North Corridor. These anticipated expansions, which would likely double the mileage of the existing system, will directly impact SIA workloads. However, at the time of this writing, the SIA division had not retained additional inspectors. Further, the division retained only 2 drafters to catalog all documentation and inspection result data received from the 4 inspectors. In addition, the SIA division had no dedicated administrative support. As such, most secretarial tasks were completed by the senior drafter.

FESM/SIA managers recognized the existing dilemma and the potential for negative consequences as a result of overwhelmed support staff. As such, SIA management requested the acquisition of additional drafting and administrative support personnel through the 2005 divisional modification plan. The plan also requested overtime approval to improve safety and security of inspectors.

The following sections provide additional details related to organizational structure, specific responsibilities, functions, and necessary expertise associated with SIA division structural inspection and drafting services.

Organization of SIA division

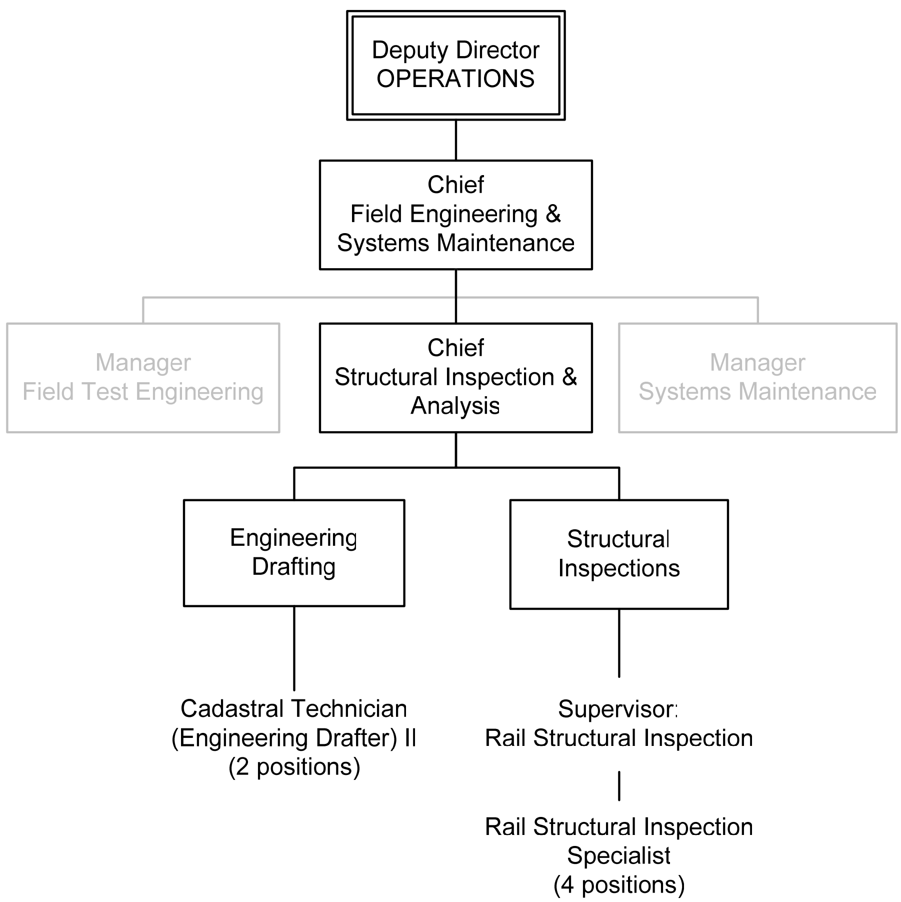
The FESM division is one of 4 divisions under MDT Operations. The position of chief/FESM reported directly to the deputy director of operations and monitored 2 sections and 1 division (SIA). Because SIA was classified as a division, the oversight position was also classified as a chief (see Figure 2.1). The chief/SIA reported directly to the chief/FESM. Staff reporting directly to the chief/SIA included 2 engineering drafter positions (officially referred to as *cadastral technicians* by the Miami-Dade County employee relations department) and the inspector supervisor (or *supervisor: rail structural inspection*). A staff of 4 inspectors (or *rail structural inspection specialists*) reported to the inspector supervisor.

The following sections described the structural inspection & analysis work areas. In general, SIA can be viewed as a 3-part, cyclical operation. First, inspectors worked in the field to observe structural conditions. Then, drafters received, recorded, and reported on inspection findings. Lastly, the chief supervised and reviewed the efforts of both groups. The chief also coordinated with maintenance divisions, especially track & guideway, to ensure that unacceptable conditions were repaired. Information presented for each area included general and specific responsibilities, staff characteristics, involvement in special projects, training, employee evaluation techniques, performance measures, and other critical issues and concerns.

Structural inspection services

The structural inspection program existed to ensure the fundamental safety of the Metrorail and Metromover systems at MDT. Specialized and technical in nature, the program monitored precise structural details closely and identified flaws at early stages. Field inspection books graphically represented current and past conditions for every portion of the Metromover and Metrorail structural systems, including stations. The books also contained several views of each segment including *bottom view, outside view, inside section, ahead & back elevations,* and *reflected view.* Inspectors referenced field inspection books, which existed in bound and electronic formats, for historical details on each structural segment. As mentioned earlier, the ongoing maintenance and updating of these inspection records were among the main priorities of the SIA division. The role of structural services in this process was to accurately observe and record conditions in the field.

Figure 2.1 Current Organizational Chart, MDT: FESM/SIA Division



State and federal statutes required the agency to maintain technical structure documentation found in the field inspection books in perpetuity. Upon request, the documents were made available for audit purposes, and in many instances, they were the sole source of construction specifications. At

MDT, technical documents were reproduced in electronic format, which facilitated their use both in the field and during the recording process. Conditions observed during inspections were precisely noted in the field and documented within the permanent records. Thorough notation of past observations allowed inspectors to gauge current conditions and to determine the rate of structural deterioration.

Once entered into the data management system, inspection results automatically generated priority rankings for each condition. The priority scale included "1" – *immediate repair necessary*, "2" – *repair necessary within 3 months*, and "3" – *repair must be made within 9 months*. For example, the condition of exposed steel on a structure would warrant a "1" ranking. In some cases, such as in the event of hairline cracks, conditions were noted but did not receive a priority ranking. SIA personnel reported that level 1 priorities were infrequent occurrences, an indication that most flaws were discovered well in advance of a critical situation.

With priorities assigned, repair reports were generated, reviewed, and distributed to the appropriate MDT repair group. After repairs were addressed, repair reports were returned to SIA for final review and data entry.

Overall, SIA inspection staff consisted of 1 division chief, 1 inspector supervisor, and 4 inspectors. The following sections presented specific details related to each technical SIA position.

Chief – Structural Inspection & Analysis

The position of chief/SIA maintained oversight of the division. The current chief was a licensed professional engineer. At present, 3 SIA staff reported directly to the chief: 1 inspector supervisor and 2 drafters. General responsibilities of the chief included directing staff, reviewing remedial action reports, coordinating with other MDT divisions, planning inspection schedules, contractor oversight, and other administrative tasks.

At the beginning of a typical working day, the chief met with the inspector supervisor to review tasks, assignments, and priorities. Special requests or projects were also discussed as necessary. In addition, drafters advised the chief of their daily work plan and any other current issues. Other regular tasks included a variety of interdepartmental coordination and communication efforts. For example, engineering projects sometimes required SIA input, and SIA funneled remedial action requests to the track & guideway maintenance division.

For much of the day, the chief focused on review, administrative, and planning tasks. Specifically, the chief reviewed various stages of remedial action reports (RARs). According to the general work flow, drafters input inspectors' findings. Conditions automatically received a priority rating through the data management system. Corresponding RARs were generated, and drafters submitted RARs to the chief for review. The chief approved each RAR to this point, and then turned reports over to the track & guideway maintenance group for scheduling and completion of repairs. After repair actions were completed, RARs were returned to the chief for final review. Lastly, the chief returned RARs to the drafters to be noted in the electronic database and on the electronic CAD drawing.

Florida state statute (335.074) mandated that a structural condition report, which rated conditions of the elevated system structure, be completed every 3 years. As such, SIA scheduled and completed inspections on a cyclical basis. The chief staggered inspection schedules to fit within specific cycles, then worked to maintain and complete the mandated report and to submit it as necessary. Specifically, SIA personnel inspected every portion of the Metrorail and Metromover guideway infrastructures every 2 years. The inspection cycles followed a specific order: Metrorail, Metromover/downtown, Metromover/Brickell & Metromover/Omni, and Palmetto Extension.

The chief also maintained additional responsibilities. For example, the chief reviewed community construction proposals with potential to impact Metrorail or Metromover structures. Urban construction projects in close proximity to MDT rail structures were surveyed, monitored, and approved. Although not engaged frequently, the chief collaborated with and managed contractors and consultants when necessary. The chief also provided input and support on an as-needed basis to the MDT transit engineering division, especially regarding the planned North Corridor and MIC Metrorail expansions. Occasionally, the chief provided field supervision, mainly in a quality control capacity. The chief was also responsible for obtaining necessary permits for SIA work planned in proximity to Miami-Dade Expressway Authority properties. In addition, the chief worked with other state and local agencies to accommodate the inspections and to divert traffic when necessary.

Inspectors & Inspector Supervisor

The positions of "inspector" and "inspector supervisor" were frequently referred to in this report. However, the official Miami-Dade County titles for these positions were "rail structural inspection specialist" and "supervisor: rail structural inspection," respectively. While cumbersome, the official titles reflected the true nature and responsibilities of the positions.

According to county specifications, rail structural inspection personnel must possess "considerable knowledge of inspection methods and techniques pertaining to pre-stressed concrete girders, hammerhead caps, and other Metrorail and Metromover structures." Inspectors must be knowledgeable in many other areas, including: relevant safety rules, structural maintenance & repair processes, special tools and equipment, and reading and interpreting structural drawings and blueprints. Significant knowledge and skills in these areas were essential to the inspector's ability to meet the challenges of the position. Specific inspector duties included inspecting girders and piers, identifying structural defects, accurately recording findings, coordinating with other departments, and operating special equipment.

At present, SIA employed 4 inspectors and 1 inspector supervisor. The level of experience among inspectors ranged from 2 to 8 years of performing inspections. The inspector supervisor had been with MDT since the inception of the Metrorail system. Inspectors were members of the TWU union. The supervisor was not a member of TWU, so the position-holder was precluded from engaging in regular inspection duties. Rather, the supervisor provided oversight in the field and assisted with traffic control or other diversionary measures when necessary.

As noted previously, the Metrorail system consisted of 5 bridges of various lengths. Structural inspections of the Metrorail system were organized and completed over the course of 2-year cycles. Specifically, inspectors started a new cycle at bridge #1 and continued in order through bridge #5. All portions of the Metrorail bridge segments, except for the tops, were inspected. The nature of Metrorail structural placement and design often prompted inspections to be scheduled during weekend or nighttime hours in order to cause as little disruption to local vehicle traffic and the surrounding communities as possible. After completing Metrorail bridge inspections, inspectors examined Metrorail stations. Station inspections generally involved a 6-day process. Metromover system inspection cycles followed Metrorail station inspections. However, Metromover stations were inspected as part of the mover guideway inspection process.

For inspections, the supervisor generally advocated a policy of safety and accuracy over speed. In addition, the supervisor hosted a biweekly meeting to reinforce proper safety practices and to stress the importance of accurate data recording.

A typical working day within the structural inspector group began with a review of field inspection book data for the structural segments scheduled to be inspected that day. Inspectors noted segment histories, including past remedial actions, if any. After that, inspectors headed to the field to begin the physical inspection process. In most cases, inspectors picked up where they left off the previous day. Inspectors routinely skipped high traffic or otherwise congested or hazardous areas during peak traffic hours and returned to inspect those areas at safer, off-peak times. The specific bridge segment inspection process commonly started at the first abutment and proceeded along the 100-foot segment. Inspectors looked for cracks, deficiencies, and other flaws. Inspectors noted defects accordingly and returned inspection results to the cadastral technicians for electronic cataloging.

It is important to note that inspectors did not perform repairs. When safety-critical conditions were discovered during the inspection, standard protocol directed inspectors to immediately report to central control. Dispatchers then determined which maintenance group was responsible for the specific problem and notified them accordingly. In some cases, inspectors were required to wait at the site until maintenance personnel arrived (such as at stations).

As in many areas of transit, supplemental training, certifications, and other remedial instruction among SIA inspectors was a concern. For example, only 1 of the 4 inspectors was a certified bridge inspector. At the time of this writing, the 3 remaining inspectors were waiting to be certified. Further, although the supervisor was a certified welder and had been trained to inspect welds, the inspectors had not been trained in the discipline. This was especially problematic because the Metromover system contained welds. Specifically, the recent Metrorail extension, a steel box girder construction, contained a considerable number of welds. Although a welding school was located close to the structural inspection offices, SIA personnel were precluded from attending due to a lack of training funds. The supervisor stressed that although this was not currently a high priority concern because weld-containing structures were relatively new, the effects would be felt as the system aged.

Structural inspection personnel faced many challenges. As noted earlier, the original Metrorail superstructure consisted of 100-foot concrete, double-T segments. However, recent extensions (Palmetto) consisted of steel box girders for the 100-foot segments, which posed considerable obstacles and hazards to inspectors. Specifically, the original double-T girders were exposed and easy to view and inspect from the outside or even from ground level. On the other hand, steel box girders were enclosed metal boxes that had to be inspected from the inside. As such, proper inspection of steel box girders necessitated that the inspector crawl inside the structure. Among the many hazards associated with steel box girders were the threat from storms (especially lightning), poor ventilation, severe accumulations of pests and pest excrement, and hazardous, incendiary electrical equipment.

Another challenge posed to inspectors was the lack of space for SIA personnel and assets. Specifically, inspector desks were located in a large room within the electronic lab. The room walls did not extend to the ceiling, and the supervisor did not have a private office. Further, SIA lacked adequate storage space for the Metrorail and Metromover system field books. As a result, volumes were scattered across various locations; some were piled in the electronic lab, and others reportedly had been lost. This was an especially serious concern because costs involved in replacing a specific field book were exorbitant. Further, security could be compromised in the event that the books fell into the wrong hands.

Cadastral services

The main focus of SIA cadastral services involved creating, maintaining, and updating technical schematic drawings of the Metromover and Metrorail superstructure systems. As such, the majority of cadastral tasks involved accurate and timely documentation of inspection findings into the system drawings. Metromover and Metrorail system drawings existed in two formats: electronically, within an in-house database; and hard copy, within field inspection books. Specific cadastral responsibilities also included generation of repair and status reports, cataloging of inspection field books, and creation of electronic schematic drawings, when necessary.

The following section described specific tasks performed by cadastral technicians within the SIA division.

Cadastral Technician

Although SIA retained 2 cadastral technician positions, only 1 position was filled until recently. In fact, the addition was not officially classified as part of SIA; rather, the individual was "borrowed" from another area. Both technicians served under the direction of the chief/SIA. Cadastral responsibilities were generally constant, and when necessary, the chief established priorities for the group and assigned immediate actions. Daily communication between the drafters and the chief was mostly verbal, but drafters also submitted a weekly, written report of cadastral activities to the chief.

According to the official Miami-Dade County position description, cadastral technicians served as assistants to engineers and performed a variety of tasks, including official recording, computations, technical sketching and drawing, official document accuracy verification, etc. Cadastral technicians were required to demonstrate thorough knowledge of principles, techniques, and instruments of engineering drafting. Further, each position holder was expected to be adaptable to the specific technical needs of the job at hand. With highly specialized responsibilities, this was especially necessary of SIA cadastral technicians. For example, both were certified in the application of AutoCAD.

Cadastral technicians met similar qualifications, and structural inspection findings drove the efforts of both. However, individual SIA responsibilities varied between them. One technician maintained several years of service at SIA, and in addition to a full schedule of inspection recording tasks, the technician also performed divisional administrative duties, when necessary. This drafter reported that approximately 85% of work time was spent documenting structural inspection results. The second cadastral technician spent a majority of work time creating electronic drawings, especially for new Metrorail system segments. When time allowed, the newer cadastral staff member also assisted with inspection result documentation.

While structural inspectors handled SIA fieldwork responsibilities, cadastral technicians managed the observational data. Specifically, the general work flow entailed field inspection findings, which were noted in books containing graphical representations of each 100-foot Metrorail or Metromover bridge segment, which were turned over to drafters for input and analysis. Findings from structural inspections of stations were also documented in this manner. Drafters recorded current structural conditions into an electronic database using the in-house "Inspection 2000" data management system. For each bridge section, field inspection books included a range of 6 to 20 different viewpoints, which all included notations regarding structural conditions. As each system was double tracked, both inbound and outbound segments were illustrated. Specific documented conditions included: system, segment, element, record number, location, quantity, direction, inspection date(s), cycle, pier, and inspector(s). Once data was recorded, drafters generated RARs, which presented inspection findings in detail, as well as repair priorities for each observed condition. Drafters submitted RARs to the chief/SIA for review and repair action. If and when repairs were made, specific actions were noted, re-examined by the chief, and resubmitted to drafters for final data entry. At this point, the RAR was considered closed. This general operation was repeated for each structural segment. As noted earlier, just 2 drafters were available to process findings submitted by 4 inspectors. As such, the pace of inspection findings returned to drafters exceeded their ability to keep up with the demand for their drafting and documentation services.

Cadastral technicians acted as librarians for field inspection books. Part of this responsibility included creating drawings for new rail and mover sections or recreating drawings of existing segments that had become damaged, destroyed, or otherwise unavailable. Drafters used construction plans to do initial drawings, and they also referenced field observations when necessary and if available. It is also important to note that a large number of inspection books were necessary to represent both systems in their entirety. As such, storage space for field inspection books was found to be significantly deficient; books were kept in numerous locations rather than in one central location. As a result, the lack of space to house inspection books impaired drafters' abilities to maintain precise, secure organization.

Administrative support

At present, the SIA division had no dedicated administrative personnel. As such, the cadastral technician with long term SIA experience handled vital secretarial duties. However, fulltime drafting responsibilities limited this individual to devote no more than 15% of available work time to administrative tasks.

The acquisition of a fulltime secretary was a major component of the SIA modification plan. Ideally, administrative staff would also serve a librarian role for the field inspection books. This position would also support all administrative functions for the division, including personnel matters, record keeping, correspondence, filing, procurement of office equipment, and directly assisting the chief with budgetary tasks.

FESM Modification Plan

The remaining portion of this chapter reviewed the overall FESM modification plan, introduced the proposed modifications specific to the structural inspection & analysis division (plan #3), and summarized the conditions, concerns, and recommended actions presented in the plan.

Overview

In February 2005, the FESM division chief submitted a detailed proposal to modify the structure of the FESM division and to augment the divisional complement of professional, technical, and administrative support personnel. Throughout preceding years, demand for FESM services grew at a pace that demonstrated its resources were becoming stretched too thinly to adequately meet agency needs. Further, as responsibilities expanded, FESM decision-makers recognized the potential for a decline in service effectiveness. As such, a divisional improvement effort became increasingly necessary.

The overall intent of the FESM improvement plan was two-fold: it presented a responsive solution to existing personnel deficiencies, and it represented a proactive approach to meet future staffing and management challenges likely to accompany ongoing and forthcoming MDT transit improvement projects. The division modification proposal included specific plans for each FESM area: field test engineering, systems maintenance, and structural inspections & analysis. CUTR organized the overall research effort in similar fashion. As such, this document focused on the structural inspection & analysis divisional modification plan (also referred to as "plan #3" in the original MDT-FESM proposal and throughout this document). Previous phases of the CUTR project discussed other segments of the FESM proposal.

Plan #3 – SIA Modification Plan

As noted earlier in this chapter, MDT implemented a structural inspection & analysis program to guard against catastrophic structural failures along the Metrorail and Metromover systems. Left unchecked, minor flaws and inexpensive repairs could easily become costly public safety threats. Through a rigorous program of inspection, monitoring, and documentation, SIA worked to identify and correct potentially hazardous flaws before severe deterioration occurred.

Throughout the course of past and future system expansions, support personnel numbers did not keep up with SIA needs. Specifically, while additional inspection personnel were acquired to account for new system implementations (Metromover: Downtown Loop, Brickell Loop, Omni Loop; Metrorail: Palmetto Extension), no corresponding additions to the complement of drafting personnel were made. FESM management expected planned system growth to exacerbate this situation. As such, the SIA modification plan sought to increase support staff, acquire necessary equipment for new staff, and allot funds for necessary inspections that incur overtime labor costs. It is significant to note that the modification plan did not provide for the acquisition of additional technical personnel (inspectors).

The SIA divisional modification plan identified specific personnel additions, costs, justifications, and services to be enhanced through implementation of the plan. The plan also reflected modifications in terminology, which would more precisely describe the specific role of SIA. The following sections provided a brief overview of the FESM structural inspection & analysis divisional modification plan. Further analysis of the plan and comparisons to peer agency operations appeared later in this report.

Personnel acquisitions

The SIA modification plan proposed to acquire 2 staff positions. Specifically, plan #3 requested the hiring of 1 engineering drafter (cadastral technician) and 1 secretary (see Table 2.1). Ideally, each new hire would have prior experience in his/her respective fields.

The drafter position would be responsible for such tasks as drafting new schematic drawings, recording new inspection data, and generating inspection reports. The position was especially important in order for the division to meet legally-obligated reporting criteria (Florida Statute 335.074), which mandated full reporting of inspection results every 2 years. Current drafting staff had been challenged to meet this requirement.

Table 2.1 Proposed Staff Acquisitions: FESM Plan #3 – SIA Division

Action	(Quantity) Position	Details
Acquire	(1) Cadastral Technician	· Level 2 candidate with prior experience · Needed to ensure compliance with Florida statute regarding frequency of reporting inspection results · Duties include drafting, inspection data recording, & report generation
Acquire	(1) Secretary	· No current administrative support in SIA · Eliminate need for drafter to handle secretarial duties · Duties also include managing field inspection book library

The secretary would be required to support all divisional administrative functions, especially those that involved personnel matters, record-keeping, correspondence, filing, procuring office equipment and supplies, and budgeting support. Additional secretarial responsibilities would include assisting inspectors and cadastral technicians with the assembly and distribution of field inspection books, retrieving filed materials, and monitoring the status of outgoing and incoming field inspection books. The fulltime administrative support position would relieve drafting personnel from current secretarial responsibilities.

Equipment acquisitions

The SIA plan also provided for the acquisition of necessary equipment for each new staff position. Specifically, plan #3 allotted for sufficient office space, office furniture, and computer equipment for 1 engineering drafter (cadastral technician) and 1 secretary (see Table 2.2). The plan also included the acquisition of essential office equipment necessary for a fully operational division, including a fax machine, a photocopy machine, and a scanner.

Table 2.2 Proposed Equipment Acquisitions: FESM Plan #3 – SIA Division

Count	Item	Details
1	Scanner	· Item to support needs of division staff
1	Facsimile ("fax") machine	· Item to support needs of division staff
1	Photocopy machine	· Item to support needs of division staff
2	Desktop computer	· Items to support each proposed staff acquisition
2	Office furniture setup	· Items to support each proposed staff acquisition
128	Office space square feet	· Necessary space allowance for each proposed new staff

Overtime provisions

The final portion of the SIA modification plan addressed overtime needs related to inspections and to office work. Specifically, plan #3 described 4 areas of inspection fieldwork that were best completed during non-traditional business hours due to security and safety concerns. Technical difficulties, as well as personnel deficiencies, pushed cadastral technician office work off schedule, which risked non-compliance with reporting deadlines.

Due to the location of the Metrorail and Metromover systems and the nature of their construction and design, structural inspections often conflicted with weekday vehicle traffic patterns and transit vehicle service hours. Specifically, the Metrorail and Metromover systems included girders and supporting structures that spanned expressways, expressway entrance & exit ramps, high-volume state roads, and other busy local roadways (see Table 2.3). Inspectors also faced geographic challenges, including spans over the Miami River and close proximities to buildings. In some areas, single-tracking was necessary for inspectors to complete their scheduled tasks. To minimize traffic conflicts and transit service interruptions and to increase worker safety, SIA personnel coordinated with local law enforcement officials and transit operations to complete work during late-night or weekend hours. As such, plan #3 included an overtime budget to account for staff compensation during non-traditional working hours.

Table 2.3 Areas Requiring Overtime Inspections: FESM Plan #3 – SIA Division

Area	System	Details/Specific locations
Expressways	Metrorail	· Dolphin Expressway (SR-836) · Airport Expressway (SR-112)
Expressways	Metromover	· Interstate 95, including entry & exit ramps · Interstate 395
Top of guideway	Metromover	· All areas including, inner & outer downtown loops, Omni extension, Brickell extension · Inspection of concrete running surface & supports required SIA personnel to be in physical path of mover vehicles
Miami River crossing	Metrorail, Metromover	· Inspections require single tracking because of need for Bridge Master rail equipment
Other critical roadway crossings	Metrorail, Metromover	· Areas experience heavy weekday vehicle traffic: - North Side station along NW 79th Street - Hialeah: 21st St., from Palm Ave. to Red Road - Spans over US Highway 1 at Lejune Rd. and Bird Rd. - Biscayne Blvd. and School Board station - Spans over Okeechobee Rd. and the FEC Canal

Several technical difficulties with computer software and database managing systems resulted in recording delays for inspections completed during 2002-2004. In order to meet inspection reporting deadlines, overtime work by cadastral technicians was required. As such, plan #3 included funding provisions for overtime work to ensure compliance with state statutes.

Upon completion of the peer agency review in Chapter III, further analysis of plan #3 is presented in Chapter IV of this report. Specifically, peer agency responsibilities, and the management practices and organizational structures implemented to meet those responsibilities, will be compared and contrasted to form the basis of the evaluation. Further, the analysis section in Chapter IV will describe specific responsibilities and challenges of structural inspection & analysis at MDT, and will assess the suggested personnel complement and costs put forth to meet those needs.

III. PEER AGENCY REVIEW

Introduction

Public transportation research efforts commonly included a peer agency review component. This method proved to be an effective means for gathering relevant information and making comparisons among public transit agencies. Further, data transfer between transit agencies was often cited as a best practice, especially with information related to maintenance functions. The peer review process usually involved several steps, including preliminary data gathering, identification of additional data for further comparison, development of peer selection criteria, selection of peers for review, site visits, and final comparisons.

A considerable benefit associated with the peer review process was that review criteria were highly adaptable to the specific needs of the study. For example, one research project may require general comparison between agencies, while the demands of another may warrant a highly specialized comparison. Further, a group of agencies selected as peers for one research effort may be completely inappropriate as peers for a different project.

In many ways, a peer agency review resembled a case study. Specifically, researchers arranged to visit a peer transit agency over the course of one or several days, conducted several interviews of relevant agency personnel, and observed common, relevant operating practices in order to compile an explicit profile of the peer. This technique allowed for considerable interaction with peer agency officials, and the structured, yet informal, interview setting provided the opportunity for flexibility and a more relaxed and open interviewee. Furthermore, this method afforded researchers the opportunity to establish a relationship that could potentially benefit subsequent phases of the current project or future research endeavors. Such was the case for this project. Specifically, contacts made during the first phase of the project helped to open doors for peer review efforts conducted for the second and third phases of the project.

Purpose

The peer review component of this research effort sought to document structural inspection & analysis methods practiced by other transit agencies. The overall areas of concern that guided site visits included: the organizational structure of the agency and the structural inspection & analysis area(s); management philosophy; techniques used for prioritizing and assigning structural inspection & analysis work; structural inspection group responsibilities, and personnel concerns. CUTR paid particular attention to inspection and drafting processes in place at the peer agencies, including reporting, supervisory input, inspection report storage, available space, equipment requirements, and on-the-job hazards. Other details were noted when relevant.

Methodology

For previous research efforts, CUTR realized success by engaging in the site visit approach described above. During the initial planning phase of this project, CUTR and FESM managers identified 3 peer transit agencies for review. Primary factors that influenced peer selections included growth trends and challenges similar to those faced by MDT. Peer selection was also based on prior knowledge of and relationships with the peer agency, the existence of multimodal transit service among the peers, and comparable revenue vehicle fleet size.

Obviously, fleet size, vehicle mix, and other service vehicle-related variables had minimal relevance to the structural inspection & analysis phase (phase 3) of this project. However, in the interests of continuity, CUTR utilized the same peer agencies throughout each phase of this project. During phase 1, CUTR established contact with field test engineering counterparts at peer agencies. For phase 3, researchers asked prior contacts to provide the most appropriate point(s) of contact related to structural inspection & analysis activities at the agency. After determining peer officials likely to provide the most relevant information, CUTR gathered data through telephone interviews, published materials, previously-completed projects, and site visits to the agencies.

Although 3 peer agencies were selected for the initial case study in phase 1, preliminary investigations revealed one peer agency to be very similar in practice to another. In addition, limited availability among agency officials precluded researchers from scheduling site visits within a reasonable time frame. As such, researchers decided to forego the third peer in order to focus on the other 2 agencies.

Critical data compiled during site visits included: system extent and age, service characteristics, special environmental and climatic conditions, rehab investments (to date and planned), management philosophy, in-house vs. contracted activities, personnel details (including number of staff, qualifications, promotions, and training), supervisory duties, and employee productivity. The following sections presented specific structural inspection & analysis program information by agency.

Peer Agency Structural Inspection Practices

The transit agencies selected for peer review for this project were the Washington Metropolitan Area Transit Authority (WMATA), which served the Washington, D.C. region, and the Metropolitan Atlanta Rapid Transit Authority (MARTA), which served the greater Atlanta area in Georgia. The following sections presented peer agency review findings in detail. Further details related to individual peer selection criteria and peer research methodologies were included within each specific peer section.

WMATA

Overview

The Washington Metropolitan Area Transit Authority (WMATA) operated the second largest rail transit system and the fifth largest bus system in the US. The service area, with a population of approximately 3.5 million within a 1,500 square-mile area, covered the District of Columbia, the suburban Maryland counties of Montgomery and Prince George's, the Northern Virginia counties of Arlington, Fairfax, and Loudoun, and the cities of Alexandria, Fairfax, and Falls Church.

WMATA operated 2 transit modes: Metrobus and Metrorail. Ridership in fiscal year 2004 totaled 336 million trips, including 190 million rail trips and 146 million bus trips. Approximately 42% of people working in the central urban area use WMATA. At the time of this study, WMATA Metrorail operated 904 railcars on 5 rail lines over 106 miles of track through 86 stations. The Metrobus operating fleet consisted of 1,477 buses that operated on 352 routes for a weekday average of over 135,000 revenue miles.

WMATA managed a variety of ongoing capital improvement projects. For example, the Transit Service Expansion Plan sought to double WMATA ridership by 2025. The agency was also involved in a major capital improvement plan, which includes system expansion projects and infrastructure renewal efforts.

Peer selection criteria & research methods - WMATA

CUTR considered WMATA as a peer agency for comparison mostly at the suggestion of FESM management personnel. Generally, research efforts employed more robust peer selection criteria; however, this study was driven less by strict adherence to operating characteristics and more by discovery of imitable management techniques. Overall, operating characteristics and performance measures were found to be different between MDT and WMATA. Yet like MDT, WMATA was engaged in a variety of capital improvement projects. FESM management initiated contact with their counterparts at WMATA to gain knowledge and insight about related special projects management.

After MDT engaged CUTR in this research effort, researchers pursued follow-up contact with relevant WMATA personnel. Initial examination revealed that unique conditions existed among counterpart divisions at WMATA. For example, the agency recently underwent an ambitious reorganization effort, only to have second thoughts about the adjustments. In fact, WMATA staff tried to dissuade CUTR's interest prior to the initial phase one data collection effort, citing organizational uncertainty and the possibility that information gathered during site visits would end up invalid within weeks or months. However, it quickly became evident that WMATA management philosophy was innovative and worthy of inclusion in this study. As such, CUTR proceeded with the inclusion of WMATA as a peer for this study. (It should be noted that during phases 2 & 3, CUTR learned that some of the organizational changes documented for the phase one report were indeed modified. Fortunately, these adjustments neither impacted the phase 2 & 3 efforts, nor affected the phase 1 results.)

For the phase 3 peer analysis, CUTR contacted WMATA engineering personnel interviewed during phase 1 and asked for suggested points of contact that were most relevant to the third portion of the study and most comparable to the responsibilities of structural inspection & analysis at MDT. As before, availability, willingness to participate, and accessibility were also determining factors in the selection of specific interviewees.

The WMATA counterpart to MDT-FESM/SIA was the Office of Track and Structures/Systems Maintenance (TSSM). TSSM was a large, overarching group that provided maintenance and inspection services for rail track structures, traction power, automatic train control, automatic fare collection, communications, vehicle electronics systems, and special projects. The group also maintained the shops & material support office and included production and track engineering personnel.

CUTR found TSSM staff to be highly interested in contributing to this research effort. The general superintendent of TSSM invited CUTR to attend the weekly group production meeting and arranged for management staff to meet with researchers in a panel-type setting. After introductions and a general discussion session, CUTR determined which personnel were most relevant for one-on-one interviews and arranged an interview schedule. For further insight into rail structure inspection & analysis at WMATA, CUTR interviewed the *superintendent of structures – maintenance & inspections*, the general superintendent–TSSM, and the lead TSSM administrative assistant.

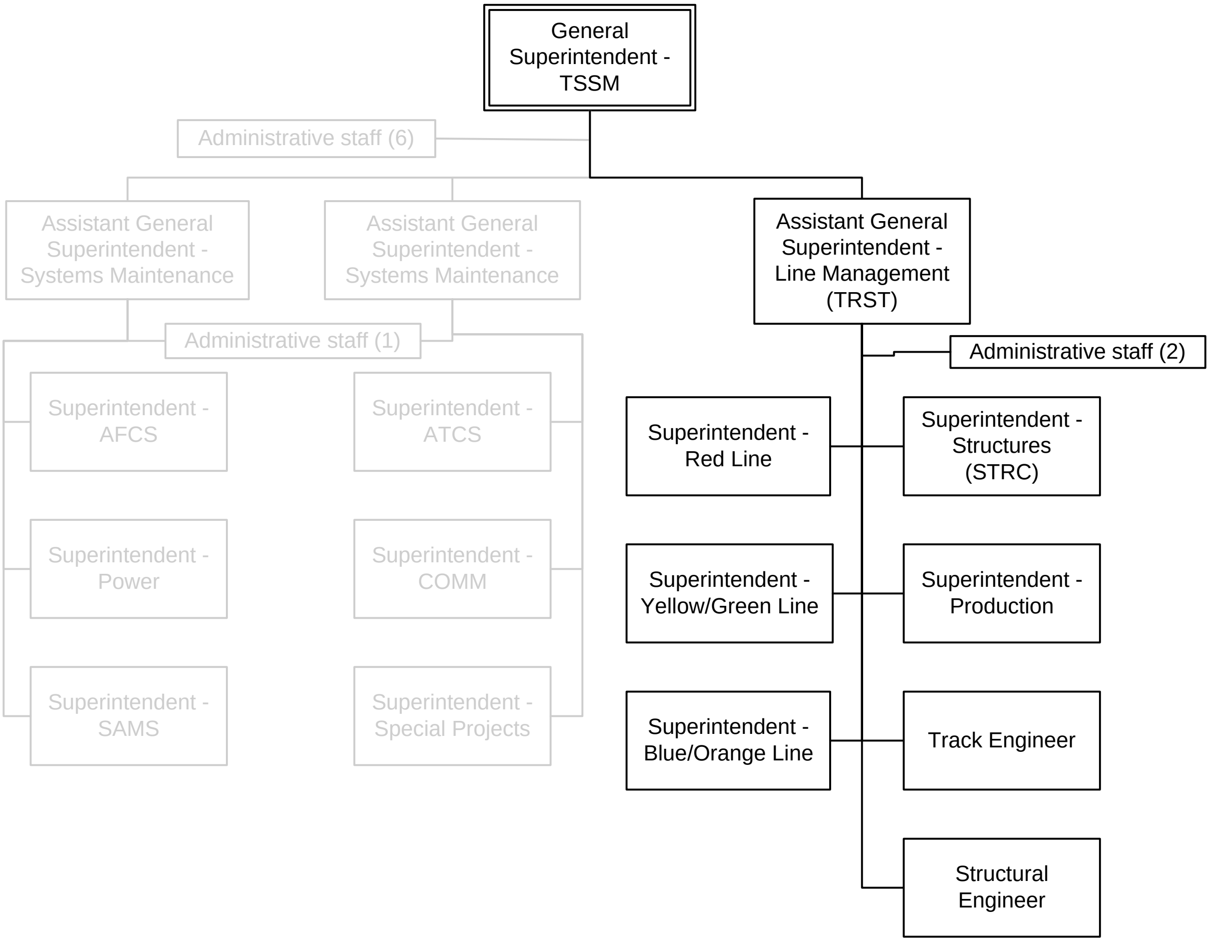
In the following sections, CUTR documented the knowledge gained at WMATA. Specifically, the text below described the organization and responsibilities of TSSM, the TSSM Line Management group (TSSM/TRST), and the TSSM/TRST structures inspection group (STRC). Official positions, group work flow, challenges, and other relevant issues were also presented.

Organization & procedures – WMATA

As of this writing, WMATA organized its structural inspection program within the TSSM. A general superintendent headed TSSM and directly managed 3 assistant general superintendents, as well as several administrative staff (see Figure 3.1). 2 of the 3 assistants managed systems maintenance areas, while the third provided line management, including oversight of rail track & structures. The general superintendent directly reported to both the WMATA chief of staff and the general manager/chief executive officer.

Overall, TSSM employed 68 management staff, 17 administrative support staff, and 308 field personnel. The total operating budget for TSSM in fiscal year 2006 was $33.5 million, with personnel costs accounting for $27.9 million of the overall total. The total capital budget was approximately $15 million.

Figure 3.1. Organizational Chart, WMATA: Track and Structures / Systems Maintenance (TSSM)

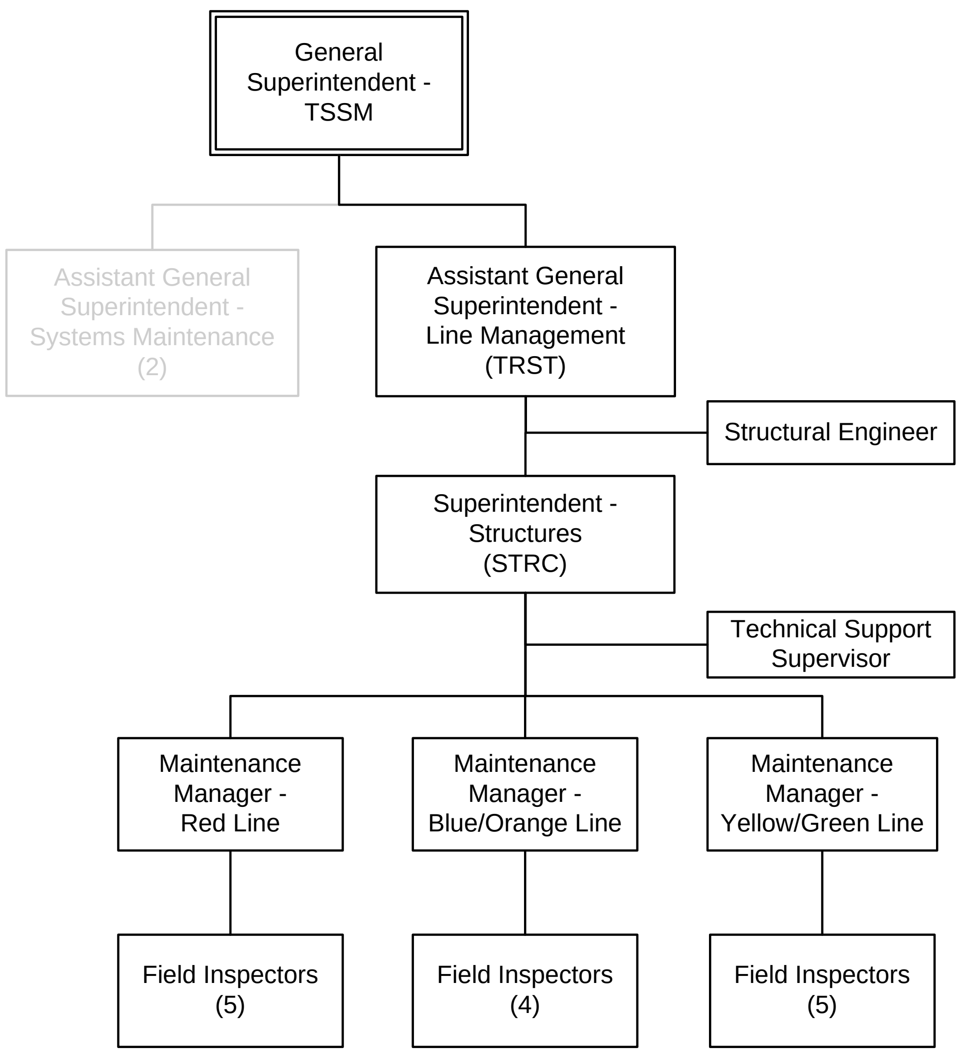


Within TSSM, the line management group (TRST) was responsible for track maintenance, structures maintenance, production, and related administrative support. The official stated mission of the Office of Rail Track & Structures (TSSM/TRST) was *to provide comprehensive inspection, maintenance, and rehabilitation of the rail system to ensure safe and reliable rail transportation in regard to track guideways and related structures.*

Organized under the direction of an assistant general superintendent, TRST retained 5 superintendents and 2 engineers (see Figure 3.1). 3 of the superintendents shared direct oversight of all day-to-day track maintenance throughout the Metrorail system, including the mainline and yards. Each track maintenance area included an assistant superintendent, maintenance managers, and various supervisors. Track maintenance functions were divided and completed according to 3 regions based on the 5 Metrorail lines. The regions were blue/orange, yellow/green, and red. This arrangement, which grew out of a reorganization effort in fall of 2005, allowed for track maintenance groups to be more closely aligned with rail operations.

Another of the TRST superintendents managed the Structures Inspection group (STRC), which focused on rail track structural inspections and rail track structures maintenance. To accomplish this, STRC retained 18 full time staff, including 1 review engineer, 3 maintenance managers, and 14 NICET-certified bridge inspectors (see Figure 3.2).

Figure 3.2. Organizational Chart, WMATA: TSSM/TRST – Structural Inspection Group (STRC)



(STRC) is dedicated to implementing and executing all phases of professional structural inspection to assure a safe and dependable infrastructure for the safe passage of patrons on the Metro Rail and Metro Bus systems and to protect the public investment in the infrastructure. – Official mission statement of STRC group

Like the overseeing groups of TSSM and TRST, the STRC group practiced a "total integrated management" approach. Specifically, the group maintained 2 areas of responsibility: line conditions assessment and personnel & equipment resource management. Line condition assessment staff performed field inspections and were organized by Metrorail line (red, yellow/green, and blue/orange). The personnel & equipment resource management group completed repairs as necessary. With maintenance and inspection functions located under 1 group, TSSM and STRC management personnel found that communications were more effective and staff were able to more fully recognize that each position was working toward the same goal: *to ensure safe and reliable service for riders.*

Another aspect of the WMATA management philosophy followed by TSSM, TRST, and STRC was reflected in management personnel backgrounds. Specifically, managers were intentionally selected for their oversight skills rather than their technical knowledge. For example, WMATA placed non-engineers in management positions with the belief that engineers should focus on technical matters and in-field responsibilities, thus leaving administrative and personnel matters to a skilled management professional. This philosophy also reflected the value placed on engineering capabilities.

Regular STRC duties focused on structural condition assessment, which included examination, preservation, and repair of all revenue tracks, yard tracks, and non-revenue tracks, as well as all aerials, bridges, retaining walls, and tunnels. Specifically, STRC was responsible for the structural inspections of the following WMATA and other common railroad corridor assets:

- 86 station, including 39 at surface level and 47 subterranean locations
- 15 aerial structures with 1,295 bridge units & 71,690 linear feet
- 55 WMATA bridges w/ 449 units
- 25 CSX and AMTRAK bridges w/ 224 units
- 13 pedestrian bridges w/ 125 units
- 6 yard-access bridges
- 577 escalator support structures
- 192 elevator shafts & support structures
- 510,998 linear feet of tunnels

- 603,398 linear feet of right-of-way security fencing & gates
- 52,280 linear feet of yard security fencing & gates
- 15 pedestrian tunnels
- 11 bus garages
- 175,551 linear feet of retaining structures
- 22 parking garages (w/ 107 total parking levels)
- 295 shaft structures, including fans, vents, emergency egress, & access

In addition to structural inspections, STRC also maintained cradle-to-grave inspection files for all structures. These records involved over 3,000 processed inspection reports per year. Further, STRC coordinated with various WMATA engineers to develop long-range capital improvement programs or to develop urgent support actions, as necessary. Additional responsibilities included arranging for lane closures and other permits, and responding to failure service reports and passenger complaints.

As of this writing, STRC retained 14 inspectors to review conditions and to report findings. Inspectors were hourly employees represented by the Amalgamated Transit Union (ATU). It is noteworthy that WMATA cannot officially use the word "inspector" to refer to line condition assessment staff. Rather, the positions were officially labeled "structural evaluation technician." Structural repair staff positions included "A" and "AA" level mechanics and "AA" lead personnel.

Overall, the condition assessment process began with field inspections. STRC completed inspections according to cycles. Specifically, program staff inspected every structure at least once every 2 years. However, because of fatigue cracking and other premature deterioration found to occur more frequently among steel box girders, all 'dynamically-loaded' structures were inspected once per year. Approximately 3,200 preventive maintenance inspections were completed annually. Inspectors worked in groups of 2 and used trucks to travel between field locations. The vehicles were shared among shifts. Specialized equipment included 2 boom trucks and a rail car-mounted aerial boom. An additional boom truck was under procurement.

Inspection personnel maintained tasks in addition to physical examination of structures and other assets. Additional duties included vehicle maintenance, foul weather response (such as snow removal), response to customer complaints, project development, personnel direction, and specification design. Inspectors also cleaned the interior of box girders. Although odd tasks occurred on occasion, common issues involved pests such as birds and wasps. In extreme cases, STRC retained outside contractors for cleaning or other maintenance tasks or capital projects. In most cases, job-order contracts were utilized. Outside contractors had to be escorted, trained, and certified before allowed onsite to complete required tasks. While the use of contractors for structural inspection & maintenance was limited, managers reported that their use was trending upward.

After completing field work, inspectors compiled findings into reports and submitted them to technical support personnel. Inspection reports included color digital pictures of observed conditions. From there, copies were distributed to the review manager, the line maintenance manager, and the superintendent. (A copy of the inspection report also went into the permanent archives). After review, both the maintenance manager and the structural engineer received a copy of the report. National standards (NICET) required engineers to be involved in both program review and oversight activities. Later, the superintendent reviewed filed inspection reports. After review, conditions that required technical support and/or specialists were determined and assigned accordingly. In some cases, capital and/or maintenance programs were developed. Work orders were prepared as needed and then completed. Ultimately, final results were transmitted to the permanent archives.

The group utilized a specialized work order process. STRC used a flowchart-style diagram for all track & structure problem-solving and work procedures. To prioritize repairs, defects were rated on a scale of “1” through “4”, with a “4” being the most critical. Generally, supervisors built projects based on ratings. To facilitate this task, the group was in the process of implementing new IT equipment and a computerized system. In order to avoid confusion or questions surrounding maintenance methods and requirements, work orders referred to the appropriate standards related to the specific task at hand.

With respect to drafting functions within TRST, inspectors largely completed their own paperwork. The group did not maintain a computerized or CAD system of structures. As such, managers described the process as paper intensive. In addition, managers felt limited because there was no capability to mine structural drawing data. However, the group was in the process of establishing a computerized system for this purpose. Specifically, a software package known as “Inspection Tech,” which can handle drawings, reports, and queries, was under procurement.

TRST maintained dedicated, centralized storage for structural inspection records. Specifically, the group housed 5 years of reports in a secured and organized vault-type room. This arrangement allowed for quick access to information, when necessary. Records older than 5 years were removed to an off-site permanent storage facility.

Figure 3.3. Archival Storage Area for Structural Inspection Documents - WMATA

Secured file room at WMATA/STRC

Interior of secured file room at WMATA/STRC. Other sensitive TSST materials were also stored in this location

Storage cabinets (labeled by year) for STRC structural documents.

Interior of storage cabinets for STRC structural documents.

Because of the critical nature of the structural inspection group's workload, special project involvement was generally kept to a minimum. Occasionally, responses to weather or extreme situations necessitated commitments to special projects. However, group staff was more likely to participate on committees that required a structural representative. When necessary, structural inspection personnel provided input and review for community projects that may potentially impact agency assets or inspection activities.

However, the WMATA Office of Planning, Development, Engineering, & Construction maintained an "adjacent construction group" to handle most needs in this area.

Overall, the nature of structural inspection field work responsibilities precluded most direct supervision of staff. Managers made every effort to keep inspections on track. Inspectors were required to complete daily inspection reports, which indicated the tasks performed during the shift. Managers reviewed the reports and addressed abnormal findings as necessary. In addition, the Operations/Rail Reliability group monitored inspection schedules and completion rates. Again, conditions determined to be abnormal were addressed as necessary.

Fleet performance measures did not directly impact the structural inspection group. However, the overall performance of the group was monitored collectively. As such, negligence attributable to the structures group would negatively affect staff annual reviews.

TSSM/STRC managers felt that overall, the number of structural inspection personnel had not kept pace with staffing needs based on system expansions. Within STRC, 2 vacancies had existed for approximately 2 years. Management found that filling these positions was problematic because properly trained, NICET-certified applicants were difficult to locate. Further, supervisors expressed concern regarding training. For example, although federal standards required inspectors to complete 120 hours of training before working in the field, the availability of some inspector training courses was sometimes limited. In addition, safety training was found to be very time consuming, and managers felt that the interval between required re-certifications was too short. This and other training that focused solely on structures proved difficult to find.

STRC managers reported common issues with gaining access for required work located in close proximity to roadway rights-of-way. Permitting, scheduling, and vehicle traffic all presented challenges to the timely completion of inspections.

MARTA

Overview

The Metropolitan Atlanta Rapid Transit Authority (MARTA) was recognized as the 9th largest transit system in the US. The service area, with a population of over 1.5 million, covers the city of Atlanta and the counties of Fulton and DeKalb. On any given weekday, an average of over 460,000 people ride MARTA, with over 61% using the system to travel to and from work. MARTA operates 3 modes of transit: bus, rail, and paratransit. At the time of this writing, the MARTA revenue fleet was comprised of 556 buses (441-CNG, 145-Clean Diesel), 338 rail cars, and 110 paratransit lift vans. MARTA rail cars operate almost 23 million annual miles over 48 miles of track through 38 rail stations. The average age of rail cars is 16.5 years. Meanwhile, MARTA buses travel over 25 million miles per year on 120 routes. The agency also maintains 9 major facilities and employs 4,355 people. For fiscal year 2005, MARTA's capital budget was $445.8 million, its operating budget was over $306 million, and the total assets were valued at $4.7 billion.

MARTA was actively involved in a variety of special programs. Among these were the Clean Fuel Bus Program, the Small Bus Program, and planning studies, including the study of Bus Rapid Transit. In addition, MARTA was in the process of a major rail car rehabilitation effort. Specifically, over 200 rail cars will be completely rebuilt. Lastly, MARTA was renovating all 48 miles of rail track under the scope of an $80 million effort.

Peer selection criteria & research methods - MARTA

CUTR engaged MARTA as a peer agency for comparison based largely on two related criteria. First, MARTA was in the process of a major rail car overhaul project. Specifically, the ongoing project involved the complete rehabilitation of 238 vehicles, which comprised over 70% of its rail car fleet. With a similarly ambitious rail car modernization effort scheduled, MDT FESM management contacted their counterparts at MARTA and forged a relationship to gain knowledge and insight, especially in the areas of personnel needs and project management. An initial review of practices at MARTA revealed that further documentation was warranted.

After contracting with CUTR to review its personnel modification plan, FESM staff suggested that CUTR utilize the established relationship with MARTA and provided CUTR with preliminary findings and contact information. From there, CUTR initiated contact with MARTA personnel in positions deemed most relevant to the study and most comparable to the responsibilities of the FESM division. Availability and accessibility were also determining factors in the selection of specific interviewees.

For the phase 3 peer analysis, CUTR contacted MARTA engineering personnel interviewed during phase 1 and asked for suggested points of contact that were most relevant to the third portion of the study and most comparable to the responsibilities of structural inspection & analysis at MDT. As before, availability, willingness to participate, and accessibility were also determining factors in the selection of specific interviewees.

There was no true MARTA counterpart to the MDT FESM/SIA division. Rather, the Track & Structures group was 1 of 6 work groups within the Facilities & Maintenance of Way division at MARTA. In addition to rail track & structures, the director of this group provided oversight for automatic train control, electrical power & equipment, custodial & landscaping, and buildings & support equipment.

To collect more detailed information about relevant structural inspection & analysis practices, CUTR interviewed the following MARTA personnel:

- director – facilities & maintenance of way;
- assistant director of track & structures; and
- chief engineer – civil & structures inspection.

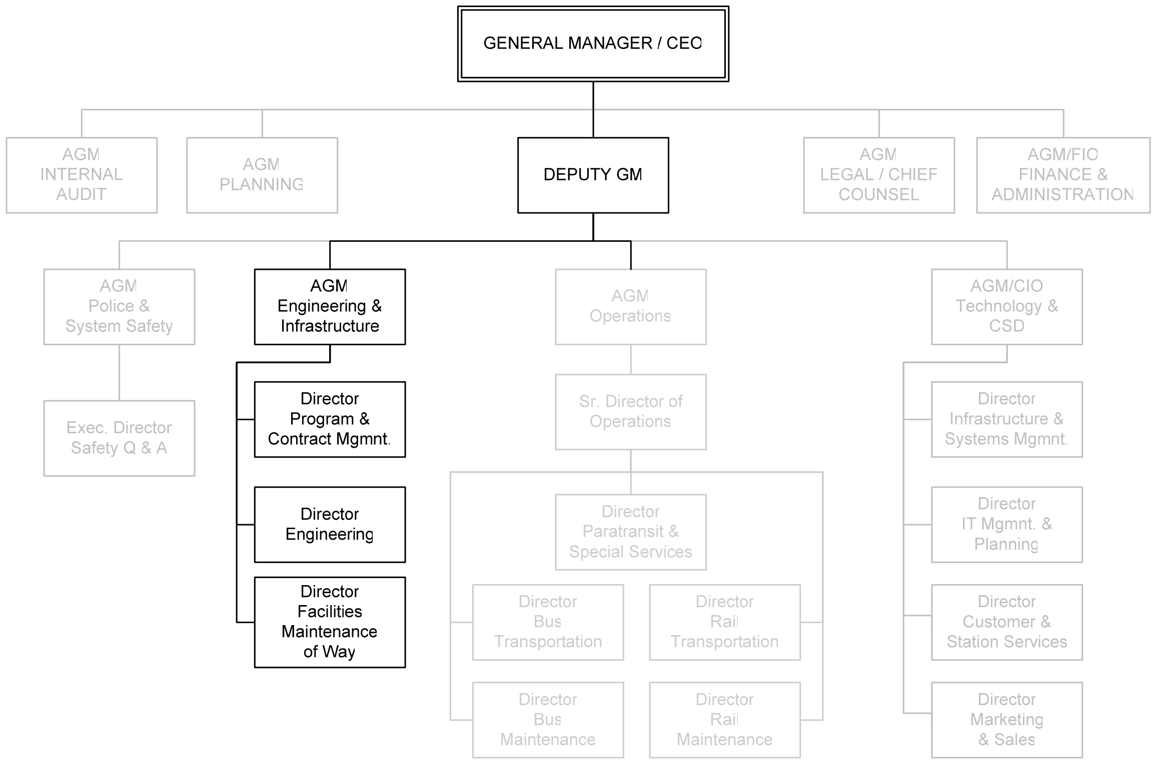
In the following sections, CUTR documented the knowledge gained at MARTA. Specifically, the text below described the organization and responsibilities of the track & structures inspection group. Official positions, group work flow, challenges, and other relevant issues were also presented below.

Organization & procedures – MARTA

At MARTA, an assistant general manager (AGM) for engineering & infrastructure managed 3 technical areas: program & contract management, engineering, and facilities & maintenance of way (see Figure 3.3). The AGM reported to the deputy director of operations.

Historically, the engineering group performed inspections, while the facilities maintenance group held responsibility for track and structures maintenance tasks. MARTA saw an opportunity for increased efficiency, and as result, structural inspections and maintenance were grouped into a single area within the facilities & maintenance of way program. The current arrangement resulted in quicker response to problems, greater continuity among assignments, and more effective communication between inspectors and maintenance personnel. In addition, communication between the structures area and the overriding facilities & maintenance of way group also grew stronger.

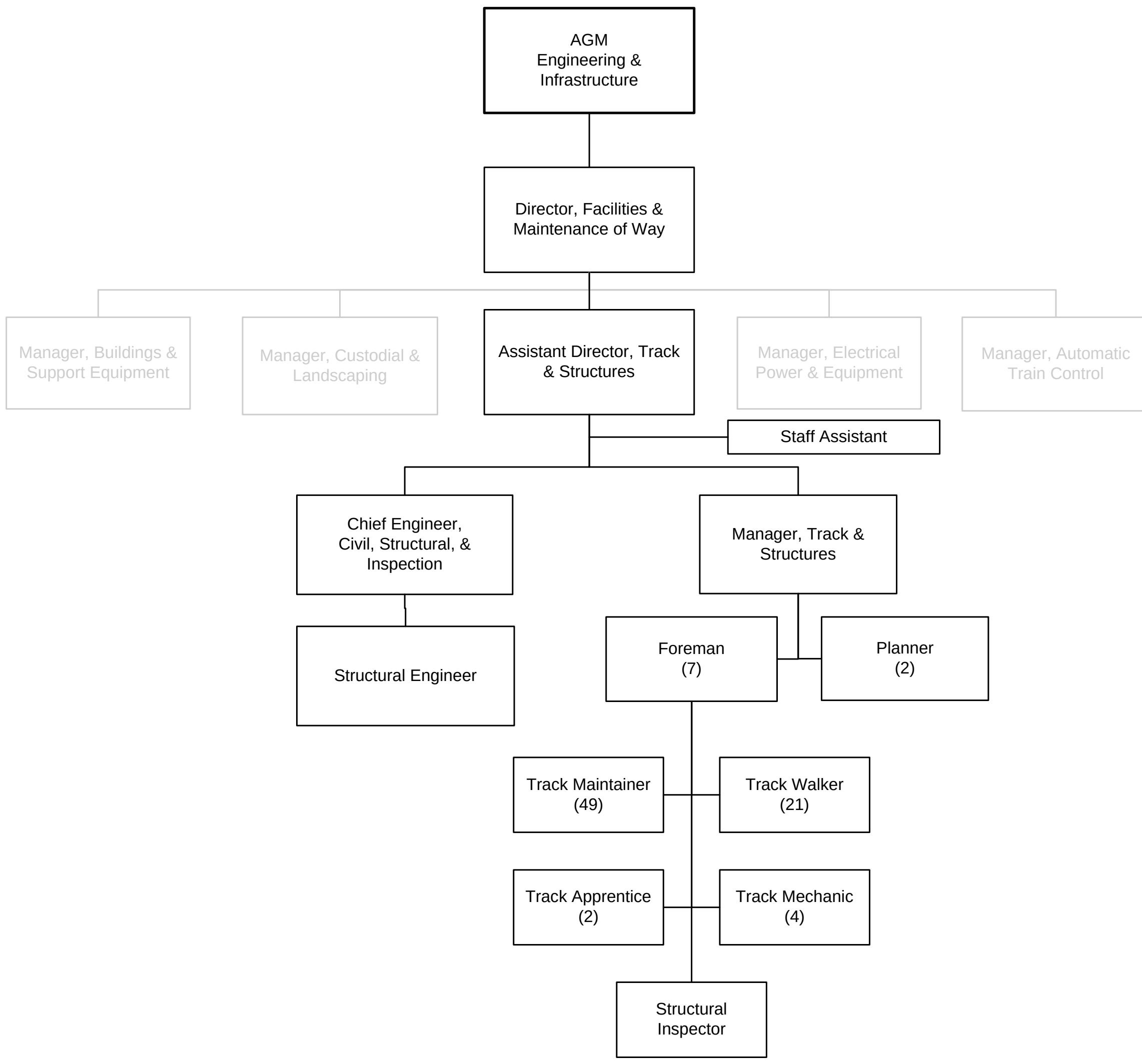
Figure 3.4. Organizational Chart, MARTA: Engineering & Infrastructure



The track & structures group at MARTA was among 5 areas under the umbrella of facilities & maintenance of way. An assistant director managed the group, which consisted of structural engineers, inspectors, planners, and track maintainers (see Figure 3.4). Specifically, the group maintained 15 positions dedicated to structural inspections, including 8 inspectors (1 inspector position was vacant at the time of this writing), 5 structural maintainers and 2 management staff. Inspectors and maintainers were represented positions; both groups were members of the local Amalgamated Transit Union. In addition, each inspector was required to be NBIS-certified.

The MARTA structural inspection program observed the following mission statement: *To ensure that rapid transit aerial structures, station structural systems, parking decks, tunnels, retaining structures, and other associated structural systems remain in a condition that will afford maximum safety to the* *traveling public*. As such, program efforts mainly focused on MARTA assets including 38 rail stations, 14.6 miles of aerial structures, 9.4 miles of tunnels, and 7 parking structures.

Figure 3.5 Organizational Chart, MARTA: Facilities & Maintenance of Way



Overall, inspections were scheduled on a bi-annual basis. Scheduled tasks accounted for 90-95% of group effort, while roughly 5% of working hours were spent on reactive maintenance. In cases of unexpected incidents, an unscheduled inspection was usually necessary to assess conditions or damage. According to management personnel, the structures & inspection group strove to focus most effort on planning and maintenance rather than on reacting to problems. In fact, as of this writing, structural issues had never been the root cause of service disruptions at MARTA.

Regular work completed by track & structures personnel generally followed a standard progression. First, inspectors examined conditions in the field and looked for structural and related defects. Then, inspectors reported findings, and categorized flaws based on the degree of deterioration among components. Managers reviewed findings and assigned repairs. In some cases, priorities were built into the process and triggered automatic responses to specific conditions. Repair work orders were issued through the maintenance management system, and the work was completed. When necessary, repair efforts were designed according to the unique needs of the project.

Structure management staff pointed out the importance of the succession plan with respect to maintaining quality control and following basic inspection principles. Quality control functions were built into the inspection process. Specifically, supervisors entered data and other information into the database in order to ensure accuracy. However, managers felt that this function could be completed by interns or other staff.

The MARTA engineering department provided drafting and CAD support to the track & structures group. Using a software package known as *Curator*, drafters maintained an electronic database of structural defects. Hard copies of drawings were also maintained in book format, which served both as a regular back-up and as the historical archive for all drawings. Hard copies were organized by year and maintained in dedicated, secure storage areas. For field inspections, inspectors received printed drawings and indicated inspection findings on the copy. Inspectors submitted the notated drawings with inspection reports. Drawings were scanned and the resulting electronic files were attached to inspection reports. As another method of quality control, inspectors noted inaccuracies, if any, that existed among the drawings. Drafters updated electronic structural drawings as necessary.

The results of structural inspections sometimes prompted engineering-related projects. In cases of large-scale projects likely to be costly and time-intensive, outside contractors were usually retained. In fact, the track & structures group relied heavily on engineering contractors. As described in the phase 1 report, MARTA maintained a general engineering contractor (GEC) work program for such tasks. When necessary, track & structures personnel were tasked with preparing scopes of work, including estimated GEC hours. The GEC agreement also allowed for common tasks to be completed with minimal administrative preparation. Additionally, track & structures management personnel met annually with the GEC to discuss future work program details, including funding, projects, and other planning efforts.

In addition to the GEC, the structures group used general job order contracts (JOCs) for a variety of maintenance and repair needs. The JOC method allowed the structural inspection group to maintain 1 point of contact with a contractor and to enter into a multi-year agreement. JOCs were similar to inter-local government agreements, and they were especially useful for lower cost, individual projects that required quick action. For example, the agreement minimized the complicated bid process, and project details could be improvised without the restraints typical of a larger contract. However, track & structure management personnel reported that JOCs were not without drawbacks. While completed quickly, the quality of paperwork, documentation, and record-keeping for JOC projects often suffered. Because of this, JOCs were ill-suited for complex projects. Managers also stressed the importance of auditing when involved in a JOC. Specifically, the MARTA staffer who initiated the project usually served in an auditor capacity for the project.

The issue of single-tracking and track availability for inspection & repair concerned track & structures managers. Specifically, because the Metrorail system provided 22 hours of service per day, full track inspection time was limited to the hours of 2 AM – 4 AM. As a result, single-tracking was necessary during regular service hours. However, only 1section of track was allowed to be single-tracked at any given time. This requirement caused difficulties in scheduling, especially for inspections far in advance. In addition, maintenance crews, contractors, railcar testers, and others all competed for time on rail tracks. The structural inspection group tried to coordinate inspections concurrently to other uses of the track. Although scheduling software was available, managers reported that it was difficult to use and precluded easy modifications. However, a new system, OPTRAM, was in the early stages of implementation at the time of this writing. Simply put, OPTRAM would assign work orders and other documentation to the specific segment of track in question.

The MARTA track & structures group highlighted several recent or planned technology upgrades. In addition to software implementations mentioned earlier, staff now used handheld electronic components to record and manipulate data. This advancement allowed inspectors to download data collected in the field directly into the maintenance management system. The devices included built-in tolerances that indicated to the inspector whether or not the condition was within an acceptable range. The previous track inspection software package allowed for just 3 condition categories: green – "OK," yellow – "MONITOR" for further deterioration, and red – "REPAIR" within 24 hours. The new technology also afforded much greater reporting consistency.

The track & structures group at MARTA also advocated continuing education. Staff expressed desire for supplemental training, and managers reported that in some cases, individuals competed for limited training space. Overall, MARTA preferred specialists in specific areas rather than training each employee about everything in detail.

A key element of the management philosophy that guided the track and structures group was sustainability. Specifically, MARTA established a 10-year benchmark for original equipment manufacturers to supply parts and training. MARTA believed that long term cost savings would be realized by maintaining current training among staff. In addition, the agency found that up-front training costs were more reasonable, especially if included as part of the procurement contract. Further, structure inspection management personnel pointed out that the details of training should be explicitly stated within the contract.

The following chapter of this report included a summary of the peer review findings as part of the comparison analysis to the MDT SIA division.

IV. MODIFICATION PLAN REVIEW & COMPARISON ANALYSIS

Introduction

Previous chapters of this research report presented current conditions within the MDT FESM/SIA division and ongoing practices at 2 peer agencies. Specifically, CUTR reviewed and documented structural inspection responsibilities at MDT, including detailed information obtained through staff interviews and culled from the division modification plan. Researchers also examined the current organization of the structural inspection & analysis division and the support personnel needs associated with recent and future system expansions. In Chapter III, the peer agency review included details about structural inspection conditions at WMATA and MARTA. Peer information included management philosophies, organization, staffing arrangements, inspection procedures, general concerns, and additional relevant information at each agency.

Having compiled data from MDT and peer agencies, CUTR proceeded to address the chief concern of this research effort: to determine the reasonableness of the proposed modifications to the SIA division. To accomplish this task, researchers reviewed the modification plan, compared and contrasted the peer agencies and MDT, and discussed the degree to which the enhancements would meet current and expected MDT structural inspection & analysis needs.

After a brief description of the methodology, the remainder of this chapter focused on 2 overall areas of interest. First, researchers presented a critical review of the MDT structural inspection & analysis modification plan (Plan #3). The section described the vision and justifications behind the plan, as well as the distinctive terms of the proposal, including anticipated salary costs and equipment needs. In the later part of this chapter, CUTR documented the processes and results of the comparison analysis. Specifically, researchers developed the knowledge gained during the peer and MDT reviews into a discussion of structural inspection & analysis division needs and the degree to which the proposed modifications adequately met those needs.

Methodology

Similar to the relatively unconventional methods described for selecting peer analysis candidates, a critical review of labor needs for a transit structures inspection group posed more challenges than researchers anticipated. While a host of data, time standards, and formulae generally existed to help determine technical staffing needs, specific data related to inspection personnel was more difficult to obtain. For a variety of reasons, data were often incomplete, unavailable, anecdotal, or otherwise unusable within strict analysis techniques. For example, peer agency managers described various attempts to track employee performance. Although the effort intended to help employees rather than to punish them, unions generally resisted such efforts, especially because such terms were not specified in collective bargaining agreements. Employee morale usually suffered as a result of these efforts. Managers were unwilling to release these data to researchers.

The search for generally-accepted structural inspection supervisory ratios went unfulfilled. Most often, supervisors determined ratios using their experience and knowledge of staff work habits and capabilities. Additionally, the nature of inspection field work precluded long periods of direct supervision. Experienced managers were also best-suited to devise the most beneficial organizational structure and management practices to meet the needs of their agencies. Further, employee productivity in the field of transit structures inspection was difficult to quantify. The time necessary to complete each inspection varied widely. As a result, employee performance reviews were highly subjective, and fleet performance data were a minimal factor in judging productivity. In addition, failures or service disruptions directly attributable to structural inspection failures were virtually non-existent. Supervisors were mostly concerned that tasks were completed properly and on schedule.

Based on the conditions described above, CUTR developed a specialized methodology to determine the appropriateness of the FESM/SIA modification plan. The overall terms of plan #3 were moderate, especially when compared to the previous phases of the project. As such, researchers felt that valid conclusions and useful recommendations would result from a comparative analysis. Specifically, CUTR compared current inspection responsibilities, practices, and organizational structures among MDT and the

2 peer agencies. Afterwards, CUTR looked for emulative practices among the peer agencies and made suggestions about the terms and reasonableness of the MDT modification plan.

Where applicable, further details about the methodology developed for this review were mentioned throughout the following sections.

Review of Plan #3 – SIA Modification

The following section examined the third and final portion of the overall MDT FESM divisional modification plan, which addressed personnel requirements for current service levels and transit growth projects. In general, plan #3 focused on SIA staffing and equipment needs to meet current and anticipated workloads. The plan also included overtime needs. While CUTR briefly summarized plan #3 and introduced its original components in Chapter II of this report, additional details are found below. Specifically, overriding goals driving most important structural inspection & analysis responsibilities were presented. In addition, CUTR described current conditions pinpointed by management personnel as justification for the proposed modifications. Lastly, specific elements regarding salary costs and equipment costs were presented.

Vision and justification

The advent of a number of major capital efforts, including the acquisition of several hundred new buses, the rehabilitation of the railcar fleet, and the extension of the Metrorail system, initially prompted managers to outline an ambitious, 3-part reorganization and modification plan for the FESM/SIA division. While the most significant modifications were found in phases 1 and 2, the vision for the future of the structural inspection group was similar: to acquire and maintain adequate staff in order to successfully meet all current responsibilities and future challenges.

The structural inspection program was obligated by law to ensure the safety, reliability, and integrity of bridges, superstructures, and other assets of the Metrorail and Metromover systems. Further, the group was required to maintain accurate and comprehensive inspection documentation for these assets. Previously, the SIA division added inspectors in response to system extensions; however, vital support personnel numbers had not grown to keep up with the increased workload. As a result of staffing deficiencies, several years worth of field inspection data recording tasks were reported to be behind schedule. As a consequence, remedial action reports and resulting repair orders were delayed, thus delaying the completion of repairs.

With the implementation of plan #3, SIA sought to increase drafting and administrative staff to keep up with additional responsibilities created as a result of past and forthcoming MDT systems expansions. Managers also sought to improve timeliness of reporting and documentation and to improve record-keeping and archival quality. In addition, a comprehensive transit group such as SIA should include dedicated support staff, rather than relying on inspectors to complete administrative or drafting tasks.

Proposed acquisitions

The overall objective of the SIA modification plan was to acquire experienced personnel and necessary equipment to perform drafting, documentation, and administrative support tasks associated with field inspection observations. A full complement of SIA personnel would allow the division to provide complete support for all existing systems and to meet future challenges.

Out of concern for the safety of inspectors, required field work located in close proximity to heavy traffic areas, such as expressways and state highways, was commonly scheduled during off-peak hours and/or on Sundays. As such, plan #3 also accounted for overtime costs to perform these inspections. A portion of the requested overtime was also intended to aid drafters in catching up on behind schedule documentation and reporting efforts.

Specific staff and equipment acquisition costs were described in the following sections.

Cadastral technician

*Aquire 1 cadastral technician (engineering drafter II) position***.** As indicated earlier in this report, the SIA division lacked an adequate number of staff to keep pace with the present drafting-related workload. Specifically, drafting responsibilities included creation of new drawings, the recording of observational inspection data, and generation of inspection reports. Drafters also provided librarian-type functions for the vast collection of Metrorail and Metromover field inspection books.

Overall, the addition of a cadastral technician to the SIA division would ease the workload of current drafting staff to a more reasonable and manageable level. The increase would allow cadastral services to more adequately complement SIA field inspection personnel. Specific duties of this position would involve making revisions to drawings, diagrams, manuals, and studies, as necessary. In addition, the drafter would organize and coordinate drawings for inspector review of new construction and new systems.

Administrative support staff
Aquire 1 secretary position. At the inception of this project, the SIA division had no dedicated administrative support staff. When possible, secretarial duties were handled by one of the drafters. Clearly, this situation was less than ideal, especially in light of the fact that drafters were already taxed to the limits of their abilities. The acquisition of an experienced, full time administrative position would complement the SIA division and alleviate drafters from the burden of completing secretarial duties in addition to their own responsibilities. The secretary would perform clerical duties and administrative duties, including: correspondence, filing, payroll, time sheets, budget support, and obtaining necessary supplies and office equipment. Additional required tasks would include arranging meetings and conferences, recording minutes, generating summary reports, distributing mail and other correspondence, and assembling materials as needed. The secretary would also assist drafters with librarian duties for the vast collection of Metrorail and Metromover field inspection books.

Proposed Costs

The following section described salary, overtime, and equipment costs associated with the FESM/SIA modification plan # 3. Overall, the total cost of salaries was calculated to be $97,919. Necessary equipment was valued at $26,460, and overtime costs were estimated to be $35,000. In total, full implementation of plan #3 would require the expenditure of $159,379.

Salary costs
The MDT SIA divisional modification plan called for 2 new positions and included necessary overtime costs for inspection personnel. The plan presented a total cost figure for each new position that represented the sum of annual salary and fringe costs. The cost for 1 cadastral technician (engineering drafter II) was $55,848, and the total cost for 1 secretary was $ 42,071 (see Table 4.1). Plan #3 overtime costs were determined to be $35,000.

Table 4.1. Projected Salary& Overtime Costs: MDT SIA Modification Plan

Position	Count	Unit Cost	Total Cost	Notes
Cadastral Technician (formerly known as Engineer Drafter II)	1	$ 55,848	$ 55,848	· To provide exclusive support to SIA division
Secretary	1	$ 42,071	$ 42,071	· To provide exclusive support to SIA division
Overtime needs			$35,000	· To cover non-peak and Sunday inspections
TOTALS	**2**		**$132,919**	

Equipment costs

Plan #3 outlined standard equipment and supply costs necessary to support the division and the newly acquired positions. Specifically, the plan allowed for the purchase of a desktop computer ($1,500) and office furniture ($1,200) for each new staff (see Table 4.2). The plan also included the cost of 128 square feet of additional office space ($15,360). Common office equipment, including a scanner, a fax machine and a photocopy machine, was also stipulated by the plan. In total, equipment costs were slightly more than $26,000.

Table 4.2. Projected Equipment Costs: MDT SIA Modification Plan

Item	Count	Unit Cost	Total Cost	Notes
Scanner	1	$ 4,000	$ 4,000	· Item to support needs of SIA division staff
Facsimile ("fax") machine	1	$ 500	$ 500	· Item to support needs of SIA division staff
Photocopy machine	1	$ 1,200	$ 1,200	· Item to support needs of SIA division staff
Desktop computer	2	$ 1,500	$ 3,000	· Items to support each proposed SIA staff acquisition
Office furniture setup	2	$ 1,200	$ 2,400	· Items to support each proposed SIA staff acquisition
Office space square feet	128	$ 120	$ 15,360	· Necessary space allowance for each proposed new SIA staff position
TOTAL COSTS			**$ 26,460**	

Comparison Analysis

Overview

In order to determine the reasonableness of plan #3, CUTR completed a comparison analysis based on the peer review and the review of the current state of SIA at MDT. The following sections described the need for a comparative analysis and the methods devised to complete it. Afterwards, the current states of MDT SIA and the peer agencies are compared and contrasted. Lastly, CUTR presented a series of findings based on the analysis.

Background

The SIA modification plan identified just 2 full time staff needs: 1 drafter and 1 secretary. Ideally, additional support staff numbers would be calculated based on the incoming workload (in this case, tasks generated by inspector observation results). But, the division retained no administrative support and drafters were severely backlogged with drafting as well as secretarial duties. As such, the need for additional staff was obvious. CUTR chose to forgo statistical analyses in favor of a comparative transit agency review. However, a discussion of potential determinants for SIA manpower is included below.

Personnel needs for positions such as inspectors were historically difficult to determine through standard manpower calculations. Frequently, performance data were not tracked, and as a result, work time standards often did not exist. Few, if any, data sources were available for comparison. In addition, the nature of inspection positions involved a considerable amount of field work, which often was not directly supervised. Managers generally relied on job completion status and resulting reports to ensure that work was completed properly and on schedule. With a considerable amount of paperwork and recording to complete, inspectors commonly did not maintain precise work logs.

Comparison among structural inspection group staff was difficult because each asset presented unique challenges. While adherence to standard practices was mandated, several factors influenced the pace at which tasks could be completed. Further, many of these factors were beyond inspectors' control. As such, employee evaluations were often subjective and unique to each staff member. While this condition was confounding for supervisors, research attempts to compare productivity between agencies was even more difficult. Further, supervisory styles and agency priorities potentially influenced employee production in ways that were unable to be analyzed statistically.

Methodology

In the past, CUTR completed manpower analyses for MDT and other transit agencies. For example, a bus mechanic manpower analysis was completed for MDT in 2003. In that study, researchers noted the lack of industry-wide work standards in transit but, several types of data were maintained by MDT and made available to CUTR for the investigation. Researchers used the available vehicle performance data, mechanic work hours, and projected vehicle mileage data to devise a methodology for predicting maintenance staffing levels. For example, a typical calculation from the previous research effort involved the number of mechanic work hours per mile determined from total work hours and total miles. Further, a figure for the required number of full time mechanics was determined through a function of total vehicle miles and the number of miles per mechanic. Unfortunately, similar data were either not available or not relevant to the present study.

As a result of the unique characteristics related to transit structures inspection work, CUTR devised a somewhat unconventional methodology to address the specific personnel needs identified by the FESM/SIA modification plan. Proper execution of this research effort required CUTR to establish a substantial foundation of information. Specifically, prior to assessing the reasonableness of the SIA modification plan, researchers compiled, reviewed, and documented the following information:

- current responsibilities of MDT SIA personnel;
- current organizational structure of the MDT SIA section;
- details of ongoing and future MDT projects that demanded support from the MDT SIA section (if any);
- anticipated future responsibilities of the MDT SIA section, especially areas likely to require dedicated support;
- details of the FESM division modification plan, which included a plan to modify the SIA section;
- suggested SIA modifications and personnel acquisitions;
- anticipated labor and equipment costs associated with implementation of the SIA modification plan; and
- relevant structures inspection practices, responsibilities, and management philosophies currently employed by 2 peer transit agencies.

Once gathered, CUTR utilized the preliminary data as the basis for analysis of the SIA section modification plan. Specifically, researchers compared the current state at MDT to conditions at the peer agencies. The analysis also focused on similarities among the peers, and determined which, if any, offered emulative practices. Further areas of interest involved management philosophies, organizational structures, methods utilized to measure employee productivity, and other techniques related to personnel.

Discussion

The goal of this analysis was to determine the reasonableness of proposed modifications to MDT FESM/SIA without using conventional manpower needs analysis methods or standard transit performance data. In the absence of these common tools, CUTR looked closely at current conditions and structural inspection practices among the peer transit agencies (WMATA and MARTA). The comparison was extensive, and researchers documented several notable similarities and differences throughout the section.

Several similarities were found to exist among structural inspection groups at MDT, WMATA, and MARTA. Each agency was actively engaged in a number of capital improvement projects, many of which would impact structural inspection groups. All 3 agencies offered multiple modes of transit, including double-tracked heavy rail systems, and faced challenges associated with rapidly advancing transit technologies. While MDT was the only agency that maintained an automated guideway mover system, it was also the only agency without subterranean rail lines. None of the structures groups adhered to a strict ratio of managers to inspectors, but management representatives at each were consciously aware of the benefits of maintaining a low number. Managers at each agency also recognized the potential for negative outcomes associated with overworked, understaffed, or incomplete structures groups. Further, each structural inspection official stressed the importance of maintaining strong communications between management and staff, as well as between higher level agency management and the structures group.

Researchers also observed a variety of differences among structural inspection operations. For example, wide variation existed among the organizational structures of inspection groups. Other differences were related to management philosophies, work methods, reporting practices, determining personnel needs, and overall goals and priorities.

Structural inspection groups observed similar goals and objectives. Common goals focused on assuring that structural conditions were consistently safe, thus guaranteeing reliable service to customers. Each group served in a preventive capacity, guarding against catastrophic failures. In fact, little time was spent actively responding to grave problems because no large-scale structural failures had been reported among the agencies to date. Structural inspection personnel were not judged in terms of common fleet performance measures. Rather, overall group performance was indicated in terms of completed inspections and lack of failures.

Each agency organized its structural inspection group to include 1 overall position of oversight, at least 1 inspector supervisor, and a group of inspectors. The supervisor ratio was between 4:1 and 5:1 at each site. In addition, each agency located the structural inspection group within an overarching group responsible for rail infrastructure and/or systems maintenance, among others. Each structures group had direct input into structural repair and maintenance efforts. At MARTA and WMATA, structural maintainers were grouped within the inspection program and reported to the same higher level supervisor. The peers believed that this type of organization provided for better communications and quicker response to repair needs. They also believed that a common mission between maintenance and inspection personnel resulted in an overall increase in productivity. At MDT, the structural inspection program was organizationally separated from the maintaining group (facilities & maintenance of way). However, the groups were located within the same office, which facilitated interaction between the groups and allowed for easy communication.

Each structures group worked closely with engineering personnel. At MDT, SIA was 1 of 3 groups within an overarching field engineering division. In addition, the chief/SIA was a licensed professional engineer (PE). The track & structures group at MARTA included a chief/civil engineer and a structural engineer. At WMATA, a structural engineer and a track engineer worked with the structures group under the line management area. The agencies differed in their placement of engineers, however. At WMATA and MARTA, engineers within the structural group occupied their own area and provided support to maintenance and inspections as necessary. Further, WMATA specifically chose skilled, non-engineering personnel for oversight and management positions in order to allow engineers to maintain focus on engineering tasks.

Overall, MDT, WMATA, and MARTA maintained similar structural inspection and analysis practices in some areas and exhibited clear differences in others. A national set of standards governed all inspections, which were completed according to 2-year cycles. Work flow among structures groups generally followed a common pattern, which began with field inspections and observational documentation, then proceeded through data entry, report generation, and repair requests, and finished with archival storage. Although specific techniques and nomenclature varied, each agency utilized a system of prioritization for observations and repairs. Software at MDT allowed for automated prioritization of conditions. WMATA utilized a well-defined system for decision-making and specialization of the work order process. MARTA used a more rudimentary system, but the implementation of new technologies was ongoing, including the use of handheld field data collection instruments and modernized scheduling software. Each structures group incorporated some degree of quality control (QC) and quality assurance (QA) into its inspection and reporting processes. No structures group retained QC or QA staff within it.

Due to the critical nature of inspections, structures groups at each agency maintained limited involvement in special projects. However, each group provided input upon request. Specifically, WMATA structural personnel sometimes participated in planning and development (but not implementation) of long-range capital improvement projects. At both WMATA and MARTA, the structures groups had no involvement in adjacent construction projects. In fact, WMATA maintained a separate group to manage adjacent issues. However, this was among the duties of the chief/SIA at MDT.

Inspection staff did not perform structural repairs at any agency. Again, each structures group generated repair orders and coordinated with maintenance personnel. In addition, because inspectors were union-represented, inspector supervisors were precluded from conducting any inspection tasks. WMATA inspectors occasionally performed non-inspection duties, such as “foul weather response,” vehicle maintenance, project development, and the design of specifications. Inspectors regularly cleaned out the interiors of steel-box girders during inspections. At each agency, cases of extreme accumulations prompted the use of outside contractors for the task.

Overall, only MARTA relied heavily on contractors. The agency maintained a general engineering consultant and made extensive use of job-order contracts. MDT and WMATA generally limited contractor use within the structures area to large-scale projects or to extensive cleaning efforts.

Management personnel within each structures group reported many of the same concerns. As mentioned earlier, steel-box girders experienced frequent pest infestations. Each manager desired additional inspectors, and each manager reported difficulty in finding qualified applicants. Supplemental training for existing personnel also posed challenges including sufficient funding, availability of training, and ability to utilize working hours on non-inspection responsibilities. Managers commonly expended a great deal of effort coordinating single track access for inspectors because of the challenges surrounding the arrangement for such. Obviously, MDT was concerned about recent and future system expansions with no new additional staff authorized as of this writing. MDT managers were also concerned about the lack of space and questionable security regarding structural document archives.

Statutes mandated the maintenance of inspection archives, including observations, reports, and drawings. In addition to performing inspections, one of the major tasks of the MDT structural inspection group was to maintain inspection books and archival structural diagrams. This responsibility, which was charged to engineering drafters/cadastral technicians, included updating existing documents to include the most recent inspection findings and maintenance efforts, and preparing new drawings when necessary. Drafters at MARTA also maintained structural diagrams in an electronic database, but these positions were maintained within the engineering group rather than the track & structures group. In addition, the WMATA structures group did not retain drafters. However, the group was tasked with maintaining a central and secure archival documents storage area.

Findings

The overall purpose of the comparative review was to establish a baseline of information from which to determine the "reasonableness" of the SIA modification plan. Researchers examined the peers for important similarities, influential practices, and other experiences. However, this task proved to be more challenging that originally anticipated. In the absence of relevant performance data, peer comparisons were the most effective means for researchers to demonstrate the merits and/or drawbacks of the divisional plan terms.

Researchers found current SIA staffing levels in the areas of drafting and administrative assistance to be insufficient to meet divisional needs. With only 2 drafters working to input data received from 4 inspectors, this was not surprising. In addition, one of the drafters was forced to complete essential secretarial duties because SIA had no dedicated administrative support personnel. Because neither peer structural inspection program included drafting personnel, making a direct comparison was problematic. However, both peers did retain dedicated secretarial/support staff.

Regarding inspection personnel, conditions were somewhat different but no less of a concern. SIA managers did not identify a shortage of inspectors and did not include a request for additional inspectors in plan #3. However, researchers felt that current staffing levels among inspection personnel represented an absolute bare minimum allotment. A long-term, unanticipated absence by just 1 inspector would likely impair the ability of SIA to maintain its inspection schedule. The loss of more than 1 inspector would prove to be an even greater impediment. Additionally, when future rail systems expansions are implemented, the amount of rail infrastructure will increase substantially. At that time, SIA will have no choice but to add a number of inspectors to its ranks.

In comparison to the first and second phases of the overall FESM modification plan, the terms of plan #3, which called for the addition of 2 supporting staff positions and required the expenditure of approximately $160,000, were modest.

Based on the findings and observations compiled during the course of this research effort, CUTR maintained that an adequately staffed SIA division would allow for considerable gains in effectiveness and productivity. Under the terms of plan #3, the existing backlog of drafting and administrative support would be significantly reduced. As such, CUTR believed that the personnel additions outlined in the modification plan were sound and reasonable.

As mentioned above, retaining a capable, diverse, and experienced complement of staff was a critical aspect of the FESM/SIA modification plan. Continually increasing demands for services further strained the ability of the existing SIA group to keep pace. The dubious situation was exacerbated by a lack of clerical, administrative, and other support personnel, which pressed cadastral technicians to perform these tasks when necessary. In addition, a division should maintain a full complement of administrative staff, including support personnel. As a result, plan #3 included provisions to acquire 1 clerical support staff and 1 engineering drafter.

Total Compensation Analysis

The main objective of the SIA modification plan was to acquire 2 necessary staff: 1 engineering drafter and 1 secretary. For each new position, the modification plan included a detailed job description, required skills and experience, and an annual salary figure (which represented costs for labor and fringe).

In order to ensure the external competitiveness of the proposed positions, researchers performed a brief examination of the labor market. Through this analysis, CUTR provided MDT with comparative data to ensure that wages for the proposed positions were set high enough to attract qualified applicants, but remained at a reasonable level to prevent labor costs from disproportionately exceeded those of competing employers.

Methodology

Based on MDT salary figures and job descriptions, CUTR utilized a commercial salary survey produced by the Economic Research Institute (ERI) to conduct a salary comparison analysis of the requested positions.

In the past, CUTR realized success with ERI products as a current and accurate source of salary data. ERI conducted surveys and other research on salaries, benefits, and compensation. The institute also gathered compensation data from official government sources and collected human resources data. The ERI database included regional salary and cost of living data, as well as job responsibility descriptions, for over 5,700 position titles in 298 US and Canadian cities. The database was updated quarterly; CUTR used the most recent update, October 2006, for this analysis.

For the salary analysis, CUTR used the Salary Assessor, an ERI software tool that worked with the salary and cost-of-living databases, to generate compensation details and comparative analyses. The ERI package included 3 salary figures: base salaries, total compensation, and incentives. Because plan #3 presented labor cost figures as salary-plus-fringe amounts, CUTR reported only the ERI total compensation figures for this analysis. The Salary Assessor calculated the mean and median for salary figures. The mean was the overall average salary, while the median was the average salary that occurred at the 50th percentile. Because the mean annual total compensation figures were sometimes found to be slightly skewed, CUTR used the median annual total compensation figures for the analysis.

ERI allowed the user to adjust compensation data based on geographic location. Unadjusted compensation figures were based on a national average, which weighted each location in the database equally. However, users were able to input a specific location of interest (Miami, Florida) that automatically adjusted the figures based on city size (larger cities' data weighted more heavily than smaller towns) and cost-of-living, which included home costs and taxes.

For this analysis, CUTR reviewed the ERI list of position titles and compared them to current and proposed MDT field engineering positions. Researchers also searched the database and compared positions according to descriptions and educational requirements. Based on these factors, CUTR selected the most applicable titles and added them to the Salary Assessor Benchmark List. Researchers entered MDT compensation data for each position, and the assessor calculated the market index for each position.

The *market index* provided a quick look at the agency's competitive pay position within the marketplace. The index was figured by dividing the MDT compensation amount by the overall ERI median annual salary (this figure included all levels of experience). The resulting figure indicated the percentage of the median total compensation that MDT offered for that position. Figures above 100 indicated that MDT paid more than the overall median compensation for that position, while figures under 100 indicated the amount under the median that the agency paid.

The Salary Assessor also presented compensation data according to years of experience. The maximum years of experience for each position varied according to the availability of salary data. For both positions considered here, salary data were available for 1-14 years of experience. Data were presented in chart form, with a low percentile, the survey median (or mean), and a high percentile. The percentiles were adjustable, so researchers were able to determine which percentile MDT compensation fell into.

Compensation Analysis by Position

The following sections described the total compensation analysis for each position established under the proposed MDT SIA division.

Cadastral technician
Researchers found the ERI database position of "Drafter CAD 2" to be most similar to the proposed cadastral technician (engineering drafter II) position at MDT. According to ERI, the "Drafter CAD 2" was often highly specialized and had greater involvement with software programs involving computer-aided drafting. The position may also be responsible to develop specialized program applications, complete project or product designs, analyze data, and deal with software vendors. This position provided specialty drafting as needed by the organization.

For this position, survey compensation data were available for up to 14 years of experience. ERI reported that the median annual total compensation for a "Drafter CAD 2" position with 10 years of experience was $55,048 (see Table 4.3). Ninety percent of the 10-year positions reported total annual compensation greater than $46,791, while only 10% earned more than $65,782. The overall median total compensation figure for all years of experience was $49,731.

For comparative purposes, the total compensation for the engineering drafter ii position proposed in plan #3 ($55,848) was very close to the median amount for a "Drafter CAD 2" with 10 years of experience. As such, the MDT salary for this position fell at approximately the 50th percentile. In addition, the market index for MDT related to this position was 115.3.

Secretary
Researchers found the ERI database position of "Secretary 3" to be most similar to the proposed secretary position at MDT. According to ERI, the "Secretary 3" position handled a variety of complex situations involving the clerical or administrative function of the office that should not be brought to the attention of an executive official. The position involved most general clerical functions, including scheduling appointments, receiving and delivering mail, preparing correspondence, and responding to inquiries. Further, the "Secretary 3" worked in a supportive role to prepare reports, summaries, and information gathering. Additional responsibilities included answering and directing telephone calls, greeting and directing visitors, and placing calls as necessary.

For the secretary position, ERI survey compensation data were available for up to 14 years of experience. ERI reported that the median annual total compensation for the "Secretary 3" position with 4 years of experience was $41,643 (see Table 4.3). 90% of the 4-year positions reported total annual compensation to be greater than $35,396, while only 10% earned more than $49,763. The overall median total compensation figure for all years of experience was $46,380.

Table 4.3 Proposed Staff Acquisitions: Total Compensation Comparative Analysis

MDT Position Title	Engineer Drafter II	Secretary
MDT total compensation	**$ 55,848**	**$ 42,071**
ERI position title	Drafter CAD 2	Secretary 3
ERI years of experience	10	4
ERI total compensation (10th percentile)	$ 46,791	$ 35,396
ERI total compensation median (ERI yrs. exp.)	**$ 55,048**	**$ 41,643**
ERI total compensation median (all avail. years)	$ 49,731	$ 46,380
ERI total compensation (90th percentile)	$ 65,782	$ 49,763
MDT total compensation percentile	**50th**	**50th - 55th**
ERI market index	115.3	91.4

For comparative purposes, the total compensation for the proposed MDT secretary position ($42,071) was slightly higher than the 50th percentile total compensation for a "Secretary 3" with 4 years of experience. In addition, the market index for MDT related to this position was 91.4.

Findings

Based on ERI market data, the total compensation amounts recommended in plan #3 for the engineering drafter II and secretary positions were deemed to be reasonable and competitive.

For the engineering drafter II position, MDT total compensation was roughly equal to the median total compensation for all drafters with 10 years of experience. As a result, MDT ranked in the 50th percentile for total compensation among all similar drafter positions. When compared to all levels of experience (from 1-14 years) among drafter positions, the MDT total compensation amount was roughly 15% higher than the market index.

The MDT total compensation for the recommended secretary position was roughly equal to the median total compensation for all secretaries with 4 years of experience. As a result, MDT ranked between the 50th–55th percentiles for total compensation among all similar secretary positions. When compared to all levels of experience (from 1-14 years) among secretary positions, the MDT total compensation amount was roughly 8½% lower than the market index.

V. CONCLUSIONS & RECOMMENDATIONS

This research effort was designed to address a number of key questions regarding the modification and improvement of the FESM/SIA division at MDT. Specifically, CUTR conducted a multi-step investigation to determine the reasonableness of the FESM/SIA modification plan. The plan addressed structural inspection & analysis personnel deficiencies and other challenges associated with ongoing and planned agency growth. For this study, researchers examined the current state and organizational structure of SIA, reviewed practices at peer transit agencies, assessed the modification proposal, devised a research process, and conducted comparative and total compensation analyses.

The following chapter is organized into 2 general areas. First, CUTR presented a series of conclusions based on each step of the investigation. Later, researchers included a series of recommended actions based on the overall findings and results of this study effort.

Conclusions

CUTR observed several conclusions as a result of this research effort. It was not surprising to learn that transit structural inspection groups faced common challenges, maintained similar responsibilities, and observed many of the same work standards. However, these groups commonly engaged in a variety of methods to achieve similar goals. For example, SIA retained the lowest number of structural inspection staff, but was the only structural inspection group to include drafters. Both peer structures groups employed dedicated administrative support personnel, while MDT did not. SIA was the only group among the peer agencies to provide inspection services for 2 different transit modes.

SIA was challenged to fully meet existing or anticipated demands for services. Specifically, the allotment of cadastral services personnel was insufficient to meet SIA divisional needs. Further, the division retained no dedicated administrative staff. As such, secretarial responsibilities were filled by already overtaxed cadastral staff.

A detailed list of observational conclusions resulting from this research effort was cataloged below.

1. Background

1.1. The Metrorail system began service in 1984-85. At this time, MDT also implemented the structural inspection & analysis program to support the system.

1.2. In 2003, the Metrorail system was expanded to reach the Palmetto Station. The current Metrorail system included 22 stations.

1.3. The majority of the 27.4 mile Metrorail system operated on 5 elevated, double-tracked structures, commonly referred to as "bridges." Few portions of the system were constructed on the surface. The system did not include underground segments or stations.

1.4. Metrorail bridges consisted of 100-foot segments. The construction design of bridge segments on the original Metrorail system was known as "double-T" concrete girders. Girders used for the Palmetto extension were known as steel box girders.

1.5. In 1986, MDT implemented the Downtown Loop of the Metromover automated people mover system. 2 extensions (Omni, Brickell) began operations in 1994.

1.6. Overall, the Metromover system consisted of a 4.4 mile elevated, concrete guideway and included 21 stations.

1.7. The structures group originally employed 2 inspectors. With the implementation of the Metromover and Metrorail expansions, SIA staff was expanded to include 2 additional inspectors and an inspector supervisor.

1.8. With the advent of the Metromover system extensions, SIA also assumed responsibility for inspecting Metrorail stations (which had formerly been the responsibility of the facilities maintenance division).

1.9. Three future expansions of the Metrorail system were under development. Specifically, they were referred to as the North Corridor, the East-West Corridor, and Miami Inter-modal Center. When implemented, the total length of these extensions would nearly double the current mileage of the system.

1.10. Although construction designs were not yet finalized, it was likely that future Metrorail extensions would be constructed using the steel-box girder design.

2. Organization of SIA Division

2.1. The SIA division was one of 3 groups within the field engineering & systems maintenance division (FESM).

2.2. The chief/SIA division provided oversight and reported to the chief/FESM.

2.3. SIA retained 4 inspectors and 1 inspector supervisor. The supervisor reported directly to the chief/SIA.

2.4. SIA retained 2 drafters. The division did not include any dedicated support staff.

3. SIA Division Responsibilities

3.1. The main objective of SIA was to prevent catastrophic structural failures. The program focused on early detection of flaws and potential hazards.

3.2. SIA provided structural inspection and analysis support for elevated Metrorail segments and Metrorail stations, and elevated Metromover segments and Metromover stations.

3.3. For the Metrorail system, inspectors were responsible for the sides and undersides of girders and all supporting piers. SIA was not responsible for inspections on the topside of Metrorail bridges, including tracks or rail system hardware.

3.4. For the Metromover system, SIA was responsible for inspecting all areas of the guideway structure, including the topside of the guideway.

3.5. SIA maintained, updated, and provided storage for technical drawings of the Metrorail and Metromover systems.

3.6. Visual inspections of rail and mover infrastructures involved gaining close access to structures. In some cases, the use of specialized equipment was necessary. Double-T girders were exposed so, inspectors only had to reach the appropriate height. In the case of steel-box girders, inspectors had to crawl inside of the structure to observe conditions.

3.7. Inspectors donned protective gear prior to entering steel box girders. The interior of steel box girders was a dark, confined space that posed many hazards to inspectors, such as poor ventilation, accumulations of pests (living and dead) and pest remnants, electrical fires, and lightning.

3.8. Inspections were completed according to 2-year cycles. Inspectors documented conditions into field books; including anchor bolts, cracks, debris, exposed steel, honeycombing, failed patches, rust stains, cracks, drilled holes, pier clearance, guideway pads, exposed plates, and the presence of rust and/or corrosion.

3.9. Inspectors submitted findings to cadastral technicians (engineering drafters). Drafters input inspection results into an electronic database, which included graphical representations of structures. Drafters generated repair orders based on inspection findings.

3.10. Inspectors did not perform repairs. SIA submitted repair reports to the track & guideway group for remedial action. SIA verified repair actions and input results into the electronic database.

3.11. The chief/SIA directed staff, reviewed repair reports, coordinated with other MDT divisions, planned inspection schedules, and managed contractors, when necessary.

3.12. SIA did not employ a secretary or other administrative support staff. When necessary, secretarial tasks were completed by one of the SIA drafters.

4. SIA Division Modification Plan (Plan #3)

4.1. The SIA division modification plan addressed personnel, overtime, and equipment needs.

4.2. Total costs to implement the plan were anticipated to be approximately $160,000.

4.3. The plan proposed the addition of 2 staff: 1 cadastral technician and 1 secretary. The total cost to acquire these positions was approximately $98,000 (including fringe).

4.4. The plan accounted for necessary equipment to establish the proposed personnel acquisitions. In addition, the plan allotted for necessary office equipment for use by division staff. Total equipment costs were about $26,000.

4.5. In the interests of inspector safety, structures located close to (or spanning) expressways or in the medians of high traffic state roads were commonly inspected during weekend or other off-peak hours. The SIA modification plan included $35,000 to cover these overtime costs.

5. Peer Agency Review

5.1. The two peer agencies reviewed in research effort were WMATA (Washington, D.C.) and MARTA (Atlanta, Georgia).

5.2. The WMATA Metrorail system operated 5 lines on 106 miles of track through 86 stations. The system operated on a combination of surface level, subterranean, and aerial structures.

5.3. At least 3 existing Metrorail lines were undergoing expansion at the time of this writing. In addition, 2 completely new rail lines were under development.

5.4. WMATA organized track structures and systems maintenance responsibilities under 1 large group (TSSM). TSSM was divided into 3 groups: 2 groups focused on systems maintenance concerns, 1 group focused on rail line management (TRST).

5.5. The WMATA/TRST group was responsible for inspections, maintenance, and rehabilitation of the rail system.

5.6. Within WMATA/TRST, the structures group (STRC) was directly responsible for all phases of structural inspections and structural repairs. STRC was organized into 3 groups according to rail line. 2 of the groups each handled 2 lines, while the third focused effort on 1 line.

5.7. STRC was structured so that 14 field inspectors reported to 1 of 3 maintenance managers, who in turn reported to the superintendent/STRC.

5.8. Specific STRC responsibilities included structural inspections, analysis, and maintenance for stations, bridges, tunnels, pedestrian facilities, escalator and elevator support structures, bus garages, parking garages, ventilation and other shaft structures, fencing, and retaining walls.

5.9. STRC maintained cradle-to-grave inspection files for the items listed above. Over 3,000 reports per year were processed. The storage facility housed 5 years worth of reports in a secured, organized location.

5.10. STRC conducted inspections on a 2-year cycle and completed over 3,200 inspections per year. Inspectors worked in pairs and used specialized equipment when necessary. Inspectors completed daily inspection reports to document their activities.

5.11. STRC inspectors performed other tasks as necessary, including: snow removal, cleaning (steel box girder interiors), and participation in project development. Inspectors also entered their own data into a computerized reporting system.

5.12. STRC did not perform drafting tasks or employ drafters within the group. STRC did not utilize computerized drawings or CAD. However, computer hardware and software upgrades were ongoing.

5.13. STRC used a specialized flow chart to prioritize repairs and aid in problem-solving and decision-making.

5.14. Concerns among STRC management included: personnel shortages, difficulty finding qualified applicants, difficulty finding adequate certification training, scheduling inspections for structures in high-traffic and otherwise dangerous locations.

5.15. It is interesting to note that WMATA structural inspectors reported that fatigue cracking and other premature deterioration occurred more frequently in steel box girders.

5.16. The MARTA rail system operated 2 lines on 48 miles of track through 39 stations. The system operated on a combination of at grade, below ground, and elevated tracks.

5.17. MARTA had no active expansion projects, but expansions to each line were under consideration.

5.18. MARTA organized its track & structures group within the facilities & maintenance of way division. The group was responsible for repairs and inspections.

5.19. MARTA track & structures personnel included structural engineers, planners, track maintainers, track mechanics, and structural inspectors. Specifically, the group dedicated 15 staff to structures, including 8 inspectors, 5 maintainers, and 2 managers.

5.20. The MARTA track & structures group did not include drafters. In fact, drafting tasks were provided by the MARTA engineering department. Drafters used electronic storage capabilities for drawings.

5.21. MARTA structural inspectors were responsible for rail aerial structures, station structural systems, parking decks, tunnels, and retaining structures.

5.22. MARTA structural personnel completed inspections according to 2-year cycles

5.23. MARTA maintained a general engineering contract and relied on contractors for many common tasks through a job-order contract system.

5.24. Within the MARTA track & structures group, several technology upgrades had been completed recently or were ongoing. Implementations included the use of handheld devices to collect observational data, a drafting program to manage a database of drawings and structural defects, and scheduling software to facilitate single-tracking when necessary. The handheld system allowed for much greater precision when describing conditions and prioritizing repair efforts.

6. Comparison Analysis

6.1. Typical data used for a manpower-type analysis were generally not available for structural inspection positions, and work-time standards did not exist. In addition, fleet performance data were not directly relevant to the field.

6.2. Structural inspection groups at each transit agency reviewed for this study (including SIA) recognized that system growth would impact their ability to meet responsibilities as intended.

6.3. While each structural inspection group maintained largely similar responsibilities, many differences existed among their methods for meeting their tasks.

6.4. Each structural inspection group was organized under a larger, overarching group. However, the organization and composition of each group varied to some degree.

6.5. Peer agency structural inspections groups included structural maintenance personnel. Peers believed this arrangement would result in better communications between groups, greater productivity, and quicker responses to maintenance needs.

6.6. SIA did not include maintainers within its structural organization. However, SIA and maintenance offices were located within the same general office area. SIA reported that this arrangement also resulted in facilitated communications, improved productivity, and allowed for better overall maintenance responses to problems.

6.7. Very little performance data related to structures & inspections groups were available. As such, most comparative data were subjective. For example, in the case of organizational structures, managers believed that their arrangements resulted in productivity gains, better communications, and quicker maintenance responses, but no data to support these claims existed.

6.8. Among the 3 structures groups reviewed for this study, only SIA retained drafters within the group. SIA relied on drafters to generate repair orders, as well as to perform common drafter tasks.

6.9. Each structures group expressed concerns about inspector training. Specifically, each group desired supplemental training or certification training for inspectors, but the availability of training was often limited. Funding for training was also limited at best. And, because of full workloads, structures groups often found it difficult to send inspectors for training during regular working hours.

6.10. SIA experienced a significant space and storage problem. This was not the case among peer groups. While SIA struggled to find adequate and secure storage space, the peers had considerable areas devoted to this. Further, office space for SIA inspectors and the inspector supervisor was less than ideal (the supervisor had no separate office). Again, no such concerns were reported by the peers.

7. Total Compensation Analysis

7.1. CUTR used data and software tools produced by the ECONOMIC RESEARCH INSTITUTE (ERI) to conduct a total compensation analysis for each position requested in the SIA modification plan.

7.2. For the engineering drafter II position requested in plan #3, the total compensation offered by MDT was determined to be competitive with the overall labor market for this position.

7.3. The MDT total compensation for the engineering drafter II position was roughly equal to the median total compensation for all drafters with 10 years of experience. As a result, MDT ranked in the 50th percentile for total compensation among all similar drafter positions.

7.4. When compared to all levels of experience (from 1-14 years) among drafter positions, the MDT total compensation amount was roughly 15% higher than the market index.

7.5. For the secretary position requested in plan #3, the total compensation offered by MDT was found to be competitive with the overall labor market for this position.

7.6. The MDT total compensation for the desired secretary position was roughly equal to the median total compensation for all secretaries with 4 years of experience. As a result, MDT ranked between the 50th–55th percentiles for total compensation among all similar secretary positions.

7.7. When compared to all levels of experience (from 1-14 years) among secretary positions, the MDT total compensation amount was roughly 8½ % lower than the market index.

Recommendations

The MDT structural inspection & analysis division modification plan presented a concise, proactive approach to the challenges associated with ongoing and imminent agency growth, modernization efforts, and implementations of advanced technologies. Specifically, the plan addressed personnel deficiencies, inspector overtime requirements, and equipment needs.

FESM/SIA management engaged CUTR to review the modification plan and to determine the reasonableness of its provisions. At the conclusion of the research effort, CUTR suggested actions and recommended next steps in the effort to facilitate implementation of the plan. Based on the body of knowledge gained during the course of this project and the analysis completed, researchers presented several recommendations that went beyond simply stating whether or not the terms outlined in the modification plan should be accepted or not.

The following section provided a series of recommendations derived by CUTR as a result of the completion of this research project.

1. The SIA modification plan represented a clear attempt by FESM/SIA managers to head off potential problems likely to result from insufficient SIA personnel levels. At a minimum, current staffing inadequacies will remain an annoyance and continue to delay reporting and archiving duties. At worst, critical repairs could be delayed to such a point that passenger safety and service reliability may become compromised.

   At this juncture, any attempt to maintain the status quo within FESM/SIA should not be considered an option. Failure to address staffing concerns raised in the SIA modification plan will almost certainly result in an unsustainable and undesirable situation. As such, CUTR recommends that the terms of the SIA modification plan be accepted and implemented as soon as possible.

2. Specifically, the results of this research project have led CUTR to recommend that SIA acquire: 1 secretary, 1 cadastral technician, and all necessary office equipment introduced in the modification plan and listed in this report. CUTR also recommended that requested overtime funding be approved in order to allow cadastral technicians to catch up with drafting work and inspectors to complete hazardous inspections during off-peak and weekend hours.

3. In the event that the terms of plan #3 were not immediately allowable, MDT FESM/SIA should initiate the required standard processes for affecting these changes as soon as possible.

4. Peer agency structural inspection groups maintained specific goals and objectives and defined a clear mission statement. SIA should consider developing a written mission statement and identifying goals and objectives to serve as a point of reference and guidance for the group.

5. CUTR also recommends that MDT strongly consider significant modernization efforts for SIA office and storage facilities. Current facilities provided insufficient space for staff and materials. Further, MDT should recognize the current storage method for field inspection books as not only unacceptable, but also as a security risk. The accuracy and availability of the inspection books is not only vital to the inspection program; it is also mandated by law. In addition, the books must be available in case of an audit, and often, the books are the only source of construction specifications. CUTR recommends that field inspection books be organized, cataloged, and removed to a secured location as soon as possible. According to the modification plan, newly-acquired personnel will be largely responsible for carrying out this recommendation.

6. CUTR found that new technologies (both hardware and software) have begun to permeate field inspection areas of transit. MDT should investigate potential technology upgrades for SIA and implement them wherever possible. Specifically, new items, such as handheld devices, have the ability to facilitate data collection and data entry. The agency should review current equipment used by inspectors and drafters to ensure that the most modern equipment is in use. If necessary, work stations should be upgraded to reduce technical issues and ensure faster, more efficient work and results.

Appendix

As noted throughout this research effort, the FESM modification plan consisted of 3 parts, each of which corresponded to one of 3 divisional areas. While the field test engineering and systems maintenance sections proposed comprehensive action plans, modifications suggested for the structural inspection & analysis division (SIA) were minimal. Although initially curious, researchers found no basis for concern about this disparity during the data collection period. However, reviewer commentary for the phase 3 draft report disclosed underlying complexities, which resulted in the discrepancy. As such, further discussion was warranted.

The following appendix provides specific details regarding the circumstance explained above. First, researchers presented relevant historical information about SIA. Later, expanded SIA modification proposals are described and briefly analyzed. Finally, researchers suggested actions based on these recent findings.

Background

Upon its inception, SIA retained an engineer (II) position, who served at the direction of the chief/SIA. The position required specialization in civil or structural engineering. In January 1995, the chief/SIA retired, and the standing engineer (II) absorbed all division chief responsibilities, while continuing to maintain all engineering duties. Approximately 20 months later, the engineer (II) resigned from MDT. Both positions then remained vacant for a period of approximately 6 months.

By January 1997, the SIA engineer (II) position was reclassified to the title of "professional engineer" in order to meet additional responsibilities associated with the implementation of the Metromover Omni and Brickell extensions. At this time, 2 additional rail structural inspection specialist positions were also created. By 2001, the professional engineer position was reclassified as chief/SIA. As such, the official engineering position was eliminated from SIA, and the division chief became officially responsible for all structural inspection-related engineering duties.

In July 2002, MDT created the rail structural inspector supervisor position to supervise the inspector specialists. Further system expansion in April 2003 (the Metrorail Palmetto Extension) added to SIA responsibilities. However, the chief/SIA resigned in early 2003, and the position remained vacant for approximately one year. During that time, the SIA divisional offices were relocated from a 1,000-plus foot^2 space at the central administration facility to an approximately 450 foot^2 location at the William H. Lehman Metrorail maintenance facility. SIA also experienced unexplained technical difficulties in 2003, which resulted in the temporary loss of a considerable portion of inspection analysis and reporting capabilities. Later the following year, one of the 2 SIA engineering drafters resigned, and the position (by then re-designated as "cadastral technician") remained vacant until April 2006. As a result of this unfortunate combination of circumstances, SIA fell behind schedule in its responsibilities; this problem persists to the present day.

Updated SIA Personnel Needs

When FESM managers prepared and submitted the modification plan reviewed for this project, the current chief/SIA had only held the position for a short time. As a result, some of the specific personnel needs of the division were not included among the original modification requests. The following section presents anticipated growth among SIA responsibilities along with corresponding personnel needs and required duties.

SIA personnel needs are likely to further increase as the transit system undergoes expansion. Specifically, design, construction, and implementation needs associated with three planned Metrorail extensions will add significantly to existing structural inspection program duties. For example, bridge inspections are required immediately following the completion of each project and before the system is officially placed into service. As such, SIA will need to prepare new inspection drawings in advance of each new segment reaching completion.

To ensure accuracy among structural inspection data collection and analysis efforts, the current chief/SIA proposed that the engineer (II) position be re-established within SIA and that the position be filled as soon as possible. The proposed engineer (II) position will report directly to the chief/SIA and will oversee data collection, recording, and analysis efforts. Further, the engineer (II) will assure quality and accuracy of new bridge inspection drawings and will ensure divisional compliance with national bridge inspection standards. The engineer (II) should have a background in structural and/or civil engineering, as well as retention of advanced computer database design and management skills. The position holder will aid in programming and creation of structural inspection systems that are unique to the agency. The scope of work to be performed by the SIA engineer (II) also includes collating, organizing, and production of the field inspection catalogs, review of inspection documents, re-coding key items, supervision of drafting work, completing special field investigations as necessary, preparation of evaluation & disposition reports, and preparing schedules, progress reports, and other administrative requirements, as necessary.

The re-instatement and acquisition of the engineer (II) position will allow the chief/SIA to more fully devote attention to necessary divisional oversight and administrative tasks. Relieving the chief/SIA of most engineering tasks will afford more effective communications and interactions between SIA and other areas of MDT, as well as with other departments of Miami-Dade County and FDOT. In addition, the chief/SIA and the engineer (II) will have the opportunity to collaborate on various tasks as needs arise. As such, the overall quality of SIA efforts and its value to MDT will likely be vastly improved.

Analysis & Recommendation

As described in the main report, CUTR found that peer transit agencies included engineering staff within their structural inspection and analysis programs. In addition, researchers identified the most significant determinant of personnel needs to be the active managing officer of the group in question. While no work time standards were found to exist for structural inspection programs, it is reasonable to assume that SIA responsibilities will increase with further transit system expansion. In addition, the initial findings of the project found current staff to be working at the reasonable limit of their collective capabilities. As a result, CUTR finds the establishment of an engineering (II) position within SIA to be reasonable and justified, according to the terms of the position outlined above.