Miami-Dade Transit Metrobus Maintenance Review & Recommendations

Phase Two: Final Report

Review of MDT Metrobus Maintenance Practices and Conditions

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Executive Summary

Project Purpose

The work was intended to assist Miami-Dade Transit (MDT) in documenting its bus maintenance needs and in developing a plan to address those needs. The assessment included a review of the current condition of the Metrobus maintenance system, a comparison with other transit properties' bus systems as well as with best practices identified in past research, and a recommended plan of action to carry the Agency forward.

The first phase of the work involved a detailed analysis of MDT bus maintenance personnel and bus operators' attitudes and concerns about current and potential benefits, incentives, and working conditions. The results included a series of recommended actions that could enhance the employee benefits and incentive program and improve overall levels of employee satisfaction.

Project Schedule

Phase One of the project began in November 2002 and focused on surveying attitudes and concerns of maintenance staff and bus operators regarding employee benefits, incentives and satisfaction. The Phase One Final Report was completed in March 2004. During the project, CUTR provided assistance to MDT in the preparation of *MDT Metrobus Fleet Management, Revision II :: January 2005.* Phase Two of the project commenced shortly after Phase One began and continued throughout 2005.

Project Approach

The approach to the project included the formation of a Metrobus Maintenance Task Force composed of key personnel within MDT in addition to the project team. Status reports and presentation of data collected to date occurred on a regular basis early in the project. Extensive analysis of Federal Transit Administration (FTA) Section 15 data, as reported in the National Transit Database (NTD), was ongoing throughout the project. Performance reports prepared and distributed by MDT were also reviewed in detail. Many members of MDT staff were interviewed and tours were conducted at all divisions. Site visits were conducted at three peer properties, including: Maryland Transit Administration in Baltimore, Maryland; Greater Cleveland Regional Transportation Authority in Cleveland, Ohio; and, the Regional Transportation District in Denver, Colorado.



Findings

Best Practices

- Management sought and received employee feedback concerning preferred incentives and benefits to increase employees' effectiveness.
- MDT promotes a cooperative working environment between bus maintenance personnel and bus operators through feedback in problem diagnosis.
- MDT has a written maintenance program and a Bus Maintenance Procedures Manual. Both items are updated regularly by bus maintenance control with assistance from support services, bus maintenance, and FESM.
- MDT uses a 3-tiered approach to bus maintenance.
- Performance measures and indicators are in place to assist MDT in achieving identified objectives.
- MDT currently lacks adequate training resources for all levels of staff.
- The Pilot Apprenticeship Program initiated in 2003 provided the first graduates to MDT in the fall of 2005.
- MDT contracted with Florida International University (FIU) to complete a *Times Standards Study* within bus maintenance.
- While MDT has developed agency-specific objectives and actively strives to meet the objectives, the objectives focus almost exclusively on fleet maintainability.
- MDT's current existing workplace design throughout the maintenance shops limits bus maintenance productivity.
- Lack of routine facility and specialized equipment maintenance negatively impacts bus maintenance activities.
- While MDT has no written policy on specialization, some maintenance technician positions are specialized in the sense that they are "pick positions" that require specialized skills to be accomplished successfully.
- The maintenance division has no specific policy that directs the supervisor's degree of oversight and/or control of assigned staff.



- MDT is in the process of making significant improvements to the established Preventive Maintenance Inspection (PMI) program.
- MDT operates a relatively new, somewhat homogeneous fleet.
- MDT is struggling with adapting to the change required by significant growth of the fleet in response to expanded service mandates.
- Supervisors focus almost exclusively on meeting peak requirements, which precludes them from looking beyond the current duty shift.
- In terms of the use of advanced technology, MDT has integrated the use of laptop computers for diagnostics. Other functions, such as repair orders and fleet status, are completed and tracked manually.
- The impact of a harsh summer climate on the fleet is a major obstacle to MDT in maximizing the efficiency of bus maintenance operations.
- Information sharing with peer agencies is limited.

Peer Review

- The selection of peer agencies was based on three comparative analyses and yielded the Maryland Transit Administration in Baltimore, Maryland (Baltimore); the Regional Transportation District in Denver, Colorado (Denver); and, the Greater Cleveland Regional Transportation Authority in Cleveland, Ohio (Cleveland) as the most similar peers.
- Miami vehicles logged more miles per vehicle operated in maximum service (VOMS) than Baltimore, Cleveland, and Denver during the 2000-2004 period of study.
- Miami reported the largest number of full-time vehicle maintenance employees in 2004 as compared to the peer agencies. Only Miami and Baltimore 2004 full-time vehicle maintenance employee levels exceeded those of 2000.
- Despite the commitment of record maintenance hours (Miami was the only agency of the four that showed an increase in 2004 vehicle employee work hours in comparison to 2000), Miami achieved fewer passenger miles per vehicle employee work hour than Baltimore and Denver, fell below the 2004 average of the four agencies and showed a 20% decline in performance in 2004 compared to Miami's performance in 2000.
- Miami's total system failures per VOMS exhibited a clear downward trend decreasing from 35.6 failures per VOMS in 2000 to 19.8 failures in 2004, a 45.5%



reduction. Nonetheless, Miami reported nine times more failures per VOMS than Denver, five times more than Cleveland, almost four times more than Baltimore, and over two times the average of the four properties.

- Annual vehicle revenue miles per total system failure were calculated to examine vehicle performance at the four agencies. All agencies displayed considerable improvement in performance from 2000 through 2004, with average revenue mileage growth per failure of over 200%. Miami increased the number of miles between failures from 1,283 miles to 2,375 miles, an 85% improvement. While Miami's increase is significant, it fell well below the 283.3% and 518.7% growth in revenue miles between failures at Denver and Baltimore, respectively.
- In 2004, Baltimore logged three times more revenue miles between failures than Miami; Cleveland logged four times as many; and, Denver reported nine times as many.
- Only Baltimore and Miami showed growth in annual vehicle miles. Since 2003, Miami has logged more vehicle miles annually than each of the peer agencies.
- In 2004, while Miami's vehicles available for maximum service declined, VOMS increased by 31%, suggesting that Miami improved fleet utilization.
- Despite Miami's 2004 growth in inspection and maintenance labor hours per VOMS (29.2% growth versus 2003), Miami provided fewer inspection and maintenance labor hours per VOMS than the peer agencies and was 18.1% below the average of the four agencies.
- Bus operators' involvement in problem diagnosis was found to be relatively minimal among the peer transit agencies. Baltimore bus operators attend monthly bus safety meetings and complete pre-trip inspections. Cleveland bus operators rarely use bus defect cards, and Denver reported minimal operator input. Cleveland has a *Problem Identification and Corrective Action* (PICA) program, which encourages employees to identify problems in any area. Denver has regular staff meetings, quarterly supervisor-management meetings, and an "open-door" policy.
- While peer agencies indicated that they do not have written maintenance plans, Baltimore technicians are exposed to written maintenance procedures during the formalized training process. Cleveland has written procedures for specialized areas. Denver's procedures in the bus maintenance plan focus on management functions.
- Baltimore has undertaken the development of work standards. Cleveland has developed "in-house" guidelines, and general efforts at Denver include its focus on mechanic training and certification programs.



- Baltimore's MAXIMO system will be utilized to track individual employee's training certifications. All mechanics attend brake training school. In addition to brakes, current in-house training includes engine diagnostics and OEM-sponsored training. Baltimore offers the ASE certification program, which allows maintenance employees to ultimately achieve the level of Master Technician. A pay increase is associated with this achievement. Technicians must recertify at the master level every five years. At Cleveland, a grading system for training functions somewhat like an apprenticeship program. Cleveland also conducts "train the trainer" sessions for in-house training. Denver has an extensive training program that is tied to employee advancement. Mechanics enter at the bottom of a six-step pay scale. As training and certification are completed, employees move up in pay. Certification is a two-step process, which includes written and applied components.
- Baltimore, Cleveland, Denver, and Miami include vendor training packages with new bus procurement contracts.
- Baltimore maintenance staff met with local junior colleges about cooperative training for existing employees.
- Each of the three peer agencies indicated they have developed and use performance measures that are guided by the agency's overall objectives. Such performance measures are incorporated into the agency's decision-making process, with respect to developing planned policies, procedures, rules, and programs. Common performance measures among the agencies included: on-time performance, vehicle availability in peak service, PMI on-time adherence, and miles between mechanical road calls.
- Both Baltimore and Cleveland have older facilities located in crowded urban areas, which offer little room for expansion. Cleveland is in the process of modernizing some of its facilities, and a new maintenance facility is under construction. In contrast, bus maintenance facilities in Denver, a region which has experienced tremendous growth over the past few decades, tended to be newer and specifically designed for the tasks at hand. The oldest shop among the Denver facilities was built in 1977. Shops are updated regularly, and there is considerable space for expansion, if necessary.
- In terms of specialization, Baltimore has three degrees of union-level repairmen, i.e., "A," "B," and "C." Only "A" level repairmen are allowed to diagnose problems. Cleveland and Denver also use a combination workforce.
- Denver had a slightly higher supervisor-to-technician ratio than Miami, Baltimore, and Cleveland.



- Baltimore, Denver, and Miami were centrally managed, while Cleveland operated under a district management concept.
- Baltimore, Cleveland, and Denver were at varying stages in integrating computer technology into their bus maintenance programs for reporting, tracking, cost-benefit analysis and report generation.
- A significant difference in the structure of the peer agencies was in the nature of the technicians' advancement. Baltimore and Denver developed tenure and certification requirements for advancement to higher level positions with additional compensation. Cleveland required proficiency for assignment to specialized shops. Miami relied exclusively on seniority for advancement.
- Although customer satisfaction surveys may potentially be an indicator of employee productivity, neither Miami nor the peer agencies had information from customer surveys that directly related to the bus maintenance program.

MDT Bus Maintenance

- Communication methods and frequency vary by shop and are influenced by a variety of factors. Regular communication between bus maintenance and bus operators appeared to be based on proximity with increased communication occurring at locations with the closest proximity of the two groups of employees. Communication between shops, within shops, and with Support Services and FESM was irregular at best.
- An important goal that was identified by the Bus Maintenance Implementation Team was making problem-solving more proactive by increasing the amount of time shop supervisors spent on the shop floor with bus technicians.
- Bus maintenance control provides critical support to bus maintenance.
- Bus triage the process of prioritizing buses requiring maintenance and optimizing the order of repairs was highly variable and especially dependent on the skill level of individual supervisors.
- The manner in which bus defect cards were submitted and processed was found to be variable and less efficient than it should be.
- Direct supervision of and communication with hostlers was reported to be minimal.
- Bus maintenance staff and vehicles were equally distributed among the four divisions with the exception of the Medley Division, which was smaller and responsible for fewer vehicles than the other divisions. The Medley Division was



managed by a project manager pursuant to the Miami-Dade County/Penske Trucking contract.

- Miami bus maintenance supervisors generally agreed that bus operator training for wheel chair lifts was inadequate.
- There was an ongoing debate about whether or not to assign each service truck to a specific geographic area.
- Bus maintenance supervisors generally agreed that the benefits of using laptop computers for bus maintenance procedures outweighed the problems. Problems that were identified included: incompatibility with connections on newer buses, insufficient storage space for recharging, lack of proficiency on the part of technicians, durability in the harsh maintenance environment, and maintaining the latest software updates.
- A minimum tool requirement for bus technicians negatively impacts productivity; general tool practices vary within the agency; and, a lack of specialty tools at the shops impedes efficiency.
- Supervisors at only one facility identified attempts to use manpower data for employee productivity purposes. Maintenance management staff applied such information to improve morale among new employees by assigning work of specific interest.
- Within bus maintenance, over the past three years, absenteeism for technicians, hostlers, helpers, and supervisors ranged from 14.6% to 19.6%.
- Some supervisors reported that retrofits commonly lacked extensive procedural documentation. As such, in the event that a knowledgeable employee leaves the agency, specific retrofit details stand a good chance of being lost.
- Shop-specific data collection efforts conducted by the O&I shops were infrequent and sporadic. Some bus performance data were collected on an informal basis and minimally documented. Data were rarely used to evaluate the impact of remedial actions.
- Warranty work was a frequent cause for buses to be taken out of service. The removal of vehicles to an off-site location for the warranty work further compounded the loss of the vehicle.
- "Buses down for parts" was one of the most serious issues facing bus maintenance, regardless of shop.



- MDT was in the process of evaluating the structure and focus of the "Unit Room."
- Some areas encountered difficulty with seasoned supervisors who were resistive to change, particularly in the use of computers and advanced technology.
- Supervisors have become accustomed to inspecting vendors' work closely. Many vendors have experienced high turnover rates, resulting in inadequately trained technicians producing less than acceptable work.
- Two past reporting efforts that were slated to be re-introduced include the Unit Room Production Report and the Engine Reliability Report.
- MDT now allows buses to return to service with defects identified during a PMI as long as the defects are not safety defects.
- Some decline in bus availability was noted at all shops in FY 2005.
- No significant differences in areas, such as parts use and fleet performance, were noted among the shops.

MDT as a Top-20 Transit Agency, 2000-2004

Ranking: Performance Data

- Expanded service in terms of vehicle revenue miles and hours along with increased unlinked passenger trips moved MDT into top-10 rankings in the service area.
- While manpower efforts continued to fall below top-10 rankings, the increases in inspection and maintenance labor hours and full-time employee work hours were positive.
- MDT ranked 12th in terms of vehicles operated in maximum service in 2004 compared to 18th in 2000.

Ranking: Performance Indicators

- Unfortunately, positive growth in the fleet, recent increases in manpower, and expanded service were accompanied by a shift in ranking from 8th to 5th for total system failures.
- Not only did MDT consistently report more failures per vehicle operated than other top-20 agencies, but also MDT logged the fewest revenue miles between failures. In terms of fleet reliability, MDT performed at a less than satisfactory level.



- MDT ranked 10th to 13th in full-time employee work hours per VOMS during 2000 through 2002 and then moved to 4th in 2003 and 2nd in 2004, which represents a significant increase in manpower allocation. Nonetheless, MDT's ranking for inspection and maintenance hours per VOMS increased only slightly in 2004 (from 16th and 17th in 2001 and 2003 to 13th), and the increase in ranking was only modestly better than the ranking of 14th in 2000. Furthermore, the relationship between MDT's inspection and maintenance labor hours to total labor hours ranked 16th, essentially remaining unchanged throughout the reporting period. The increases in manpower produced little, if any, increase in vehicle inspection and maintenance, which calls in to question workforce productivity.
- MDT ranked between 1st and 4th in the relationship between VOMS and VAMS throughout 2000 to 2004, indicating significant use of the available fleet.
- MDT ranked between 1st and 3rd in Vehicle Miles and Hours per VOMS throughout the reporting period, which indicates that MDT generally operates vehicles for more hours and more miles than most other top-20 agencies.
- When revenue hours and miles are viewed as a percentage of total hours and miles, MDT's ranking falls to 6th and 8th indicating that MDT's vehicle hours and vehicle miles are less efficient than some of the other agencies.
- While MDT ranked 9th in unlinked passenger trips per VOMS, which was similar to previous rankings, MDT's ranking for passenger miles per VOMS moved from 2nd in 2003 to 6th in 2004, despite increases in revenue miles and hours per VOMS. It appears that increased revenue miles and revenue hours were not accompanied by increased passenger miles.
- MDT's vehicle maintenance cost per revenue mile ranked 17th (from 14th in 2001 through 2003) for the first time since 2000. MDT's maintenance cost per revenue mile was less than the cost incurred by 16 of the other top-20 properties in 2004.

Metrobus Equipment Performance by Fleet Type, FY 2004-2005

- The NABI 02 buses, which represented 11.2% of the FY 2005 fleet, consistently provided the largest percentage of miles throughout FY 2004 and FY 2005, until September 2005. The NABI 02 was followed by the NABI 03 (10.2% of the fleet in FY 2005) and the NABI 04, which entered service in October 2004 and accounted for 11.2% of the fleet.
- The NABI 99 (9.5% of the fleet) and the NABI 00 (9.8% of the fleet) recorded the largest percentages of road calls throughout FY 2004 and FY 2005, until September 2005. In September 2005, the NABI 02 logged the largest percentage of road calls.



- The newer NABIs, i.e., NABI 02 through NABI 05, appeared to be the most efficient fleet types.
- The NABI 98 showed improvement beginning in late FY 2004 that remained relatively consistent throughout FY 2005.
- The NABI 99 and NABI 00 displayed inefficient performance throughout the entire reporting period and shared that category with the older Artics and Flxibles.
- The overall performance of the minibuses appeared to be good; although, the efficiency of the Optare 03 declined in mid FY 2005.
- In FY 2005, the NABI 02 and NABI 03 logged a smaller percentage of miles but a larger percentage of road calls.

Metrobus Equipment Performance by Fleet Type by Division, FY 2004-2005

- The Artic 94 performed similarly at Central bus and Coral Way. Only in January 2004, did the percentage of road calls fall below the percentage of miles, and that occurred at Central bus.
- The Artic 95, which operated only out of Central bus, showed improvement in July 2005, as the percentage of road calls fell to its lowest level.
- The Flx 90 was operated at Central bus and Coral Way for only two to three months. Data from the two facilities were sparse but appeared to be consistent.
- Specific mileage and road call data for the Northeast Facility in FY 2004 were unavailable.
- The Flx 93c performed slightly better at Central bus than at Coral Way and Northeast.
- Only Northeast operated the Flx 9350, Flx 9411, and Flx 9450. The percentage of road calls consistently exceeded the percentage of miles for the three fleet types.
- Throughout FY 2004, the NABI 97 fleet performed slightly better at Central bus than at Coral Way. In 2005, some improvement in terms of the relationship between the percentage of miles and road calls for the NABI 97 was noted at all three facilities.
- The NABI 98 fleet, which had performed slightly better at Coral Way than Central bus, was moved to Medley in April 2004. NABI 98 performance at Medley was, at



best, inconsistent, with the percentage of road calls exceeding the percentage of miles during the last 13 months.

- Improvement in NABI 99 performance was noted primarily at Central bus and Northeast. Early positive performance at Coral Way in FY 2004 deteriorated until June 2005, at which time slight improvement was noted.
- Despite two rather high road call percentages reported by the NABI 00 at Medley in the summer of 2004, the NABI 00 fleet at Medley achieved a slightly better percentage of miles to road calls than at Central bus and Coral Way in FY 2005.
- The NABI 02 percentage of miles exceeded the percentage of road calls at Central bus, Coral Way, and Northeast during all months except one. In September 2005, the NABI 02 percentage of road calls exceeded the percentage of miles at Coral Way.
- There were four months during which the percentage of road calls exceeded the percentage of miles for the NABI 03. Three of the four instances occurred at Coral Way in April 2004, July 2005, and August 2005. The fourth instance was recorded in March 2005 at Northeast. There were no occasions identified where the NABI 03 percentage of road calls exceeded the percentage of miles at Central bus or Medley.
- Despite the fact that the percentage of miles exceeded the percentage of road calls at all locations during all months, the rate of road calls for NABI 04 buses shows a gradual upward trend in the 12-month period of operation.
- There is insufficient information on the NABI 05 buses that were operated slightly more than two months at Central bus, Coral Way, and Northeast to draw any conclusions.
- The Minibus BB 99 fleet was transferred from Coral Way to Medley in April 2004. The percentage of road calls exceeded the percentage of miles at Medley during 16 of 18 months with little improvement at the end of FY 2005.
- Central bus and Northeast appeared to be less successful than Coral Way and Medley in maintaining a higher percentage of miles than road calls with the Minibus BB 01.
- Central bus and Coral Way operated Minibus BB 02 fleets fairly consistently. Coral Way achieved a few more months where the percentage of miles exceeded the percentage of road calls for the Minibus BB 02.
- Central bus, Coral Way, and Northeast operated Optare 03 fleets. While the FY 2004 percentage of miles consistently exceeded the percentage of road calls for the



Optare 03 fleets, FY 2005 proved to be a difficult period for all three facilities. During FY 2005, the Optare 03 percentage of road calls exceeded the percentage of miles for seven months at Central bus, nine months at Northeast, and five months at Coral Way.

Determining Manpower Needs

- From 2000 through 2004, MDT reported fewer VOMS, fewer vehicle maintenance employees, and fewer annual vehicle miles than the average of the top-20 transit agencies studied.
- MDT recorded more vehicle miles per employee (12.6% to 22.4% above the average) and more vehicle miles per employee per VOMS (25.0% to 46.4% above the average) than the average of the top-20 agencies. This indicates that MDT's ratio of employees and VOMS to vehicle miles logged was lower than the average.
- MDT reported fewer labor hours for inspection and maintenance (16.1% to 67.9% below the average), fewer labor hours per VOMS, and fewer labor hours per employee (25.9% to 71.9% below the average). Not only was MDT's ratio of employees to vehicle miles and VOMS lower than average, MDT's employees produced fewer hours than those produced on average by the top-20 transit agencies.
- Combined, these factors accounted for MDT reporting more vehicle miles per labor hour (19.5% to 46.3% above the average) than the agencies' average.
- The analysis of the 2000-2004 NTD data clearly shows that MDT is a top-20 agency that has expanded service at record levels in the past five years. Nonetheless, the analysis also shows an agency that is falling behind in maintenance performance, which is compounded by the impact of the high mileage accumulated annually by the vehicles.
- While, in 2004, MDT did restore labor hours allocated to each vehicle operated in maximum service to the 2000 level, the 2004 labor hours per VOMS remained 16% below the average of the top-20 agencies. In addition, labor hours per employee, which were 72% below the top-20 average in 2003, did improve and fell to only 26% below the top-20 average in 2004.
- The June 2003 Manpower Study concluded that each maintenance mechanic could provide 1,554 productive manhours annually. However, an analysis of the inspection and maintenance labor hours from 2000-2004 indicates productivity of only 824 to 1,103 hours per employee a year, while the top-20 agency average was 1,336 to 1,407 hours per employee a year.



- Since it appeared that the June 2003 methodology needed to be modified to incorporate productivity into the manpower calculation, 2000-2004 data were recalculated, using a reduced productive annual manpower figure of 1,500 manhours (more closely resembles manhour levels used in Metrorail and Metromover). Additional manhours ranging from 144,000 to 268,000 could have been available annually had labor hours per employee reached 1,500 hours.
- Increasing employee productivity to 1,500 hours per year would reduce the number of vehicle miles per inspection and maintenance hour from a range of 71.3 - 107.4 miles to a range of 50.5 - 56.6 miles, a significant improvement. Improved productivity would also place MDT in a more competitive position with the top-20 agencies.
- For year to year planning, to determine future labor hour needs based on current performance, projected vehicle miles for the upcoming year can be divided by the actual "vehicle miles per inspection and maintenance labor hour" achieved in the current year. Those labor hours, when divided by labor hours per employee (1,500 hours), equal the number of employees required to meet projected vehicle inspection and maintenance needs.
- It appears that bus technicians comprised 48-54% of the Inspection and Maintenance workforce. The required number of positions for each of the classifications within the group of inspection and maintenance employees could be prorated in a similar manner.
- Advantages of using this methodology extend beyond the ability to identify appropriate levels of manpower to fulfill inspection and maintenance needs. Inspection and maintenance positions can be prorated by classification type, MDT can compare system performance and maintenance effort with that of other agencies, and a measure of productivity is incorporated into all inspection and maintenance positions, not just bus technician positions.
- Employee requirements for maintenance administration, servicing of vehicles, as well as accident and vandalism repair could be established using factors such as shift coverage levels and/or work loads rather than mileage-based parameters.



Phase Two Recommendations

- Make the Phase One Final Report, *Analysis of Concerns and Attitudes held by MDT Bus Operators and Maintenance Personnel Regarding Current and Potential Benefits, Incentives, and Conditions* available to employees and implement recommendations.
- Formalize bus operator feedback in problem diagnosis. Components of a successful program might include the following types of activities:
 - Establish a team effort at every shop to oversee the program and establish program objectives and performance indicators.
 - Maintain an official record of pre-trip inspections, bus defect cards, and road calls.
 - Track the nature of problem, location, bus operator, date and technician for the last PMI, date and technician for the last repair, and the resolution of the problem.
 - Report progress to bus operators and maintenance staff on a monthly basis.
 - Create a specialized training program for bus operators that includes common terminology, frequent problems, and troubleshooting tips.
 - Mandate problem diagnosis training as part of the orientation program for new bus operators and maintenance staff and provide an annual refresher course.
- Update the written Maintenance Program and the Bus Maintenance Procedures Manual. Prepare official copies for each bus maintenance employee and require a signed receipt. Establish a mechanism for ongoing update and distribution of the documents, perhaps at Toolbox Safety Meetings.
- Review existing agency-specific objectives for bus maintenance and update them to ensure they are measurable, time limited and appropriate to MDT's conditions and needs. These objectives will form the basic elements of the management plan. Once the plan is in place, establish performance indicators to measure progress by shop and by department.
 - While meeting peak vehicle requirements is a significant goal within bus maintenance, it is only one of many goals required to operate a successful bus maintenance operation. Commonly accepted effective measures include on-time performance for meeting peak vehicle requirements, adherence to PMI



schedules, equipment standardization, operator involvement, and customer acceptance.

- Conduct an inventory of training needs for all levels of staff and coordinate the training program with Human Resources.
 - Prior research has shown that well-trained maintenance employees are happier and take greater pride in their work. The results of the MDT employee survey conducted for Phase One found that MDT maintenance employees were very interested in additional training opportunities.
 - Technology is advancing rapidly. MDT should ensure that manuals and other graphic job aids are available to maintenance personnel for personal reference and should make certain that maintenance personnel are aware of their existence and location. Further, MDT should consider making these materials available electronically and provide in-shop access to employees.
 - Establish training resources within the shops. Review the use of existing office space or consider using mobile or portable facilities. Ensure training space availability is one of the criteria for new maintenance facilities.
 - Implement creative training measures, such as periodic lunchtime seminars, videos, and use of the Intranet. Use a simple method for tracking attendance/participation and verifying comprehension (brief tests). Create incentives for employees (monetary, gift, reward, other) who participate. Consider providing online training that can be done at home or after the regular work day. Employees could participate at their leisure and work toward a goal or a reward.
 - Establish or assign in-shop instructors. Rather than an informal approach that consists of referring one employee to another, develop a formal plan to recognize selected technicians as certified in-house trainers. This approach will also help to bridge the gap that occurs as the best mechanics become supervisors. Instead, they will remain on the floor in a technician capacity, but will be formally recognized as having expertise in certain field(s). A compensation plan could be instituted to reward expertise and encourage highly qualified technicians to remain in positions that take full advantage of their skills.



- *Immediately* modify the Apprenticeship Program to require completion of a CDL license, safety instruction, and EPA certification prior to graduation. (Comprehensive 90-day Review Long-range Goal)
- Review Times Standards Study that was completed by FIU and incorporate time standards for bus maintenance activities where appropriate.
- Initiate a "maintenance facilities modernization initiative." Specifically, make it an agency goal to modernize maintenance facilities to meet the needs of the future. While the initiative must identify goals and objectives, it could also be seen as an ongoing process that is open-ended. Modernization efforts could include a review of available space and utilize innovative ways to create or reorganize space for specific maintenance procedures, training activities, meetings, operator-technician interaction, etc. For example, consider the use of portable buildings as training rooms, and investigate opportunities to expand existing facilities or when building/acquiring new facilities. The initiative will create guidelines for necessary things that must be included, such as wireless networks, training space, meeting rooms, lounges, and storage areas.
- *Immediately* establish a facilities maintenance program for bus maintenance that includes routine maintenance and repair of all buildings and assigned equipment. (Comprehensive 90-day Review Long-range Goal)
 - Require facilities to inspect and repair all hydraulic lifts. (Comprehensive 90-day Review Short-range Goal)
- Investigate the use of "specialty shops" to handle specific repairs or routine activities, such as PMIs, brakes, and retrofits.
- Continue ongoing work to improve the PMI process to ensure timely and complete inspections of the entire fleet. Establish an acceptable method to ensure that *all defects* noted during the PMI are repaired prior to returning a bus to service.
- MDT's recent bus procurements have enabled MDT to establish a relatively new and homogeneous fleet, which affords MDT the opportunity to maximize maintenance performance, realize savings from reduced inventory needs, and require less specialized technician training. By maintaining a detailed history of performance characteristics and completing trend analyses of current functioning, MDT should be able to anticipate and, thereby, eliminate potential future problems as newer fleets come on line.
- Implement and utilize advanced technology in as many areas as possible.
 - Replace the magnetic bus status control room boards with a modern, efficient system that is able to display all relevant information and to easily perform



queries and generate necessary reports. Ideally, this information would be accessible remotely. Bus maintenance control could also input reports directly into the new system. Critical activities, such as PMIs, could be automatically flagged.

- Utilize portable, wireless, handheld devices wherever possible to eliminate paper. Bus defect cards could be replaced with a handheld device programmed to utilized drop-down menus for defects, conditions, related factors, etc. Make units available at optimal locations for operators to use or assign a maintenance technician or clerk to field operator-identified defects.
- Use portable, wireless, handheld devices on the "hotline." Entries could be immediately transmitted to the supervisors' computer/control room. Expand the use of barcodes and readers to expedite identification and eliminate entry errors.
- Implement a streamlined method for repair orders using advanced technologies. The goal should be for data to be entered at the source of generation and as close to the time of origination as possible. Procure the most appropriate equipment to do this, i.e., handheld devices or laptop computers, which could be acquired through the bus procurement process. Although more costly, consider the use of hardened/durable equipment, which is commonly used by public safety officials.
- Provide a sufficient number of laptop computers for bus maintenance diagnostics. The laptops must be compatible with connections on newer buses, durable in a harsh environment, contain the latest software updates, and have an assigned storage and recharging location. Train technicians to become proficient in the use of the laptops.
- Utilize/install wireless networks in all repair facilities.
- Thoroughly and properly train technicians in the use of advanced technologies and how to enter repair order information electronically.
- Utilize advanced technology to modernize the tracking of Support Service's rebuilt component inventory. Tracking could include available components, components being rebuilt, and status of rebuild.
- Provide each body shop with a modern digital camera, including all necessary peripheral equipment.
- Use advanced technologies for communications between chiefs, superintendents, supervisors, and the general superintendent. The goal should



be instant communication. Replace pagers with agency-assigned cell phones that have instant communication capabilities.

- Research cost effective methods and technology to maximize AC performance and reduce bus down time resulting from failures in AC equipment.
- Share information with peer agencies and seek out information from peer agencies when undertaking new initiatives. Take advantage of web-based programs that are transit specific, such as an on-line Web Board sponsored by the Transportation Research Board's Committee on Transit Fleet Maintenance and a variety of on-line Forums established by the American Public Transportation Administration.
- Create a simple and effective customer feedback mechanism and incorporate findings, where appropriate, to improve bus maintenance operations.
- Provide training to bus maintenance supervisors.
 - Require all bus maintenance supervisors to complete a remedial bus maintenance technical program, which includes a certification process, in the near term followed by annual refresher training.
 - Require all bus maintenance supervisors to participate in a management training program for supervisors, preferably through Miami-Dade County.
 - Review and revise bus maintenance supervisor Job Essentials and Specifications to clarify the supervisor's role and responsibilities, including the nature and level of oversight of subordinates. (Comprehensive 90-day Review Short-term Goal)
 - Require each supervisor to review all PMIs and repairs completed by technicians under the supervisor's oversight. The supervisor's name and signature should be attached to all paperwork associated with PMIs and repairs completed under the supervisor's oversight to indicate the supervisor's acceptance and approval of the technician's work.
 - Provide Enterprise Asset Management System (EAMS) training for all supervisors. (Comprehensive 90-day Review Long-range Goal)
- All aspects of the bus fueling system should be streamlined. There are currently three areas tasked with some aspect of the fueling system. Materials management procures the fuel, bus maintenance accepts delivery and dispenses the product, and Bus maintenance control oversees the fuel management system and tracks statistical information. Immediately reassign acceptance of delivery to materials management, which will eliminate the need for the bus maintenance supervisor to



leave the shop floor two to three times a shift. Create a task force to study and improve this process.

- Assign clerks to the bus maintenance shops to handle administrative tasks *as soon as possible*. Enlist the assistance of bus maintenance supervisors to identify their assigned duties. (Comprehensive 90-day Review Long-range Goal)
- Implement the "odd day scheduled" bus maintenance clerk to work a 40-hour week, scheduled Tuesday through Saturday. The addition of this clerk will improve productivity and eliminate early week overloads for regular Monday through Friday clerks.
- Formally address the differences between Bus maintenance control and Penske procedures through an action team method. Identify objectives, set goals, track progress, and work toward a reasonable solution.
- Prioritize ADA compliance.
 - Create an in-house certification process for technicians to develop expertise in wheelchair lift repair.
 - Develop a training program to educate bus operators in the operation of the various types of lifts currently in use. Components of the training program could include instructional videos, demonstrations/briefings in the dispatch area, and short training sessions. ADA training could be provided to new operators during the orientation period followed by annual refresher training for all operators. Dispatch area briefing sessions could be held on an ongoing weekly or bi-weekly basis. Consider incorporating a certification process into the program.
 - Document all activities and training related to ADA compliance.
- Identify all repeat failures by garage and vehicle type. Implement an auto-response mechanism that flags repeat failures and calls repeat failures to the attention of supervisors, chiefs, and superintendents.
 - Track the nature of the repeat failure, location, bus operator, date and technician for the last PMI, date and technician for the last repair, and the resolution of the problem.
- Establish a cooperative relationship with Field Engineering & System Maintenance and Bus maintenance control to troubleshoot parts failures.
- Revise the tool policy in bus maintenance to mirror existing policies at rail and mover.



- Consider incorporating performance factors into contracts for parts, rebuilt components, and warranty work. Determine the cost to the agency of the vendor's failure to perform a service or deliver a product on-time as requested. Establish performance factors up front to minimize the negative impact to the agency. Continued failure on the part of the vendors to perform in the agreed upon manner could result in a reduction in costs to the agency or the loss of agency business on the part of the vendor. Denver was quite successful in developing a vendor rating mechanism that enhanced vendor performance.
- Take active steps to improve employee attendance. Reissue employee guidelines regarding attendance to all bus maintenance employees. Provide a refresher course for all supervisors and managers that includes attendance guidelines, approved actions for dealing with frequent absences, and a summary of each employee's status. Each manager/supervisor should meet with assigned subordinates, review attendance patterns to date, and reiterate agency guidelines. Employees with perfect attendance over a specified period of time should be acknowledged.
- Implement goals identified by the Comprehensive 90-day Review. MDT could benefit from incorporating most of the mid-range and long-range goals in the near term. Provide employees with continual status reports of progress to date and incorporate changes in the maintenance plan.
- Continue the efforts of the Bus Maintenance Implementation Team. As with the Comprehensive 90-day Review, provide employees with continual status reports of progress to date and incorporate changes in the maintenance plan.
- Incorporate productivity standards into the calculation of manpower requirements for vehicle inspection and maintenance.
- MDT needs to establish and monitor performance metrics for bus maintenance beyond the percent of the fleet that makes daily "pull-out." Establishing a few essential performance metrics and working to improve results in the areas recommended in this report will serve to develop within the agency an efficient and effective bus maintenance operation. If undue priority is placed only on making pull-out, many old practices will continue that will subvert the improvement of the operation.



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1. Introduction

The work described in this report represents a comprehensive review of Miami-Dade Transit's (MDT) Metrobus Maintenance Program and is designed to identify and document program needs and to assist with the development of a plan of action to address such needs.

The first phase of the work involved a detailed analysis of MDT maintenance personnel and bus operators' attitudes about concerns current and and potential benefits. incentives. and working conditions. results The included a series of recommended actions that could enhance the employee benefits and incentive program and improve overall levels of emplovee satisfaction. CUTR completed the Phase One analysis and published the results under separate cover in late 2004.

During the project, CUTR assisted MDT in preparing an update of the Metrobus Fleet Management Plan, which was required as a result of service expansions mandated in the People's Transportation Plan.

The second phase (Phase Two) of the work includes a detailed review of all aspects of the current Metrobus Maintenance Program not only with actual maintenance programs of other transit properties but also with best practices identified in past research.

1.1 Background

MDT expressed concern that the performance of the Metrobus fleet was declining despite continual reinvestment

of capital in upgrading the fleet. Miles between service interruptions continued to fall below established standards, and there was a general perception that "repeat failures" occurred routinely. Criteria used to allocate manpower requirements, based on a combination of the number of vehicles assigned and the total scheduled miles operated, have been in place for an extended period of time, but have not been updated to meet the actual needs of today's modern The Metrobus fleet is set to fleet. increase to а 999-peak vehicle requirement by 2007. As such, several productivity and performance issues require action to meet the anticipated demands on the bus maintenance division.

1.2 Objectives

CUTR's detailed review of the aspects of the MDT Metrobus Maintenance Program focused on several areas: overarching philosophies that serve as a quide for managerial decisions within the bus maintenance division; influential factors that affect bus maintenance productivity; emplovee issues that influence the performance of the essential transit equipment; and, the analysis of three (3) peer transit agencies: Maryland Transit Administration in Baltimore, Maryland (MTA), Greater Cleveland Regional Transportation Authority in Cleveland, Ohio (GCRTA), and Denver Regional Transportation District in Denver. Colorado (RTD) in comparison to MDT.

1.3 Approach

In order to accomplish the stated objectives, namely the review of all aspects of the current Metrobus



Maintenance Program comparatively with maintenance programs of other transit properties and with best practices identified in past research, CUTR developed a structured approach to the project. Major steps in the process were as follows:

1.3.1 Literature Review

Researchers gained knowledge through the study of several TCRP and similar TRB reports, other scholarly literature (including conference procedures and papers), and Internet websites.

Prior research projects often sampled numerous transit agencies and culled large volumes of information directly from them using various types of surveys, on-site visits and interviews, and in-depth case studies.

CUTR reviewed the bulk of this material and identified several best maintenance practices and gave strong consideration to bus maintenance practices that garnered frequent positive feedback from survey respondents, such as transit maintenance management personnel and/or other researchers.

1.3.2 Task Force Members

In Phase One of the project, CUTR formed a Metrobus Task Force that included the Chief of Major Overhaul as the chair with members that included all division chiefs and superintendents from Metrobus Maintenance as well as representatives from other disciplines, Operations. includina Bus Bus maintenance control, and Information Technology. The original task force continued their participation in the project as it moved into Phase Two.

As a part of Phase Two, CUTR began an effort to collect data and document relevant MDT Metrobus the Maintenance processes and systems. Individual meetings were held with each task force member and frequent meetings were held with the task force to obtain members' assistance and participation in data analysis and decision-making processes. Input from the task force was critical in the determination and selection of three peer properties, where site visits were conducted to collect relevant information maintenance practices on and procedures.

1.3.3 Task Force Meetings

Throughout CUTR the project, coordinated with the Task Force chairperson to schedule and hold regular task force meetings. The purpose of the meetings was to update members on the project status and discuss current project-related concerns and information needs. The regular meetings afforded task force members the opportunity to provide input and feedback, as well as discuss necessary next steps in the process of completing the objectives. In addition, the meetings served as a forum for development of project materials. Unfortunately, during Phase Two, major reorganization within MDT resulted in a change of the chairperson as well as some of the task Meetings became force members. infrequent and were, subsequently, discontinued altogether. Briefings were held with the assistant director. Bus Services, and a presentation of the findings to date was delivered to the assistant director, Bus Services along



with the bus maintenance chiefs late in the project.

1.3.4 Project Changes

In planning this project, researchers intended to conduct onsite visits to Original Equipment Manufacturers (OEM) to review relevant documentation, if available. As the investigation proceeded, it soon became clear that personnel from Bus Maintenance and Bus maintenance control were able to provide a wealth of information related to this area, based on their experiences throughout long careers with MDT. It was determined that onsite visits to OEMs would provide minimal added value and, as such, were abandoned.

1.3.5 Peer Selection

CUTR worked with the Metrobus Maintenance Task Force to select three peer properties for comparison based on agencies with similar fleet size that had experienced significant growth.

In order to fulfill MDT's requirements, CUTR performed three comparative analyses. The first analysis involved comparing MDT's bus operations with similar transit agencies. The second analysis focused on the inventory management programs peer of agencies. For these analyses, CUTR selected transit agencies similar to MDT, collected relevant National Transit Database (NTD) data, and performed a benchmarking analysis. The third analysis compared MDT's bus fleet with fleets of other transit agencies through use of the 2003 Transit Vehicle Database produced by the American Public Transportation Association (APTA).

1.3.6 Peer Site Visits

CUTR made all necessary contacts and arrangements to visit the selected peer A standard list of data properties. needs, in the form of a questionnaire, was developed in advance of the visits expedite to the process. This questionnaire was developed in cooperation with the Metrobus Task Force and the Materials Management Oversight Committee. Each site visit consisted of an approximately 2-hour meetina with bus maintenance personnel followed by tours of selected bus maintenance facilities. Upon completion of the site visits. CUTR summarized the site visit data and presented an overview of the findings to the Metrobus Task Force.

1.3.7 MDT Site Visits

CUTR worked directly with the chair of the Metrobus Task Force to conduct site visits at MDT. As with the peer property site visits, a standard list of data needs, in the form of a questionnaire, was developed in advance to expedite the process. This questionnaire was developed in cooperation with the Metrobus Task Force.

A CUTR researcher spent the week of March 14 through March 18, 2005 working in conjunction with the acting superintendent general for Bus Maintenance. The researcher participated in meetings, oversight activities, and planning sessions with the acting general superintendent, who was specifically assigned to assist Bus Maintenance in transitioning to improved performance.



CUTR researchers also conducted day long site visits at the following MDT operations:

- Central O&I Division Wednesday, May 11, 2005
- Coral Way O&I Division Thursday, May 12, 2005
- Northeast O&I Division Wednesday, May 18, 2005
- Medley Division Thursday, May 19, 2005
- Bus maintenance control Tuesday, June 21, 2005
- Major Overhaul Wednesday, June 22, 2005

1.3.8 Data Analysis

Extensive data were used in the analysis of MDT's bus maintenance program.

A primary source of data was the National Transit Database (NTD). NTD data from years 1996-2000 and 2003 were used for the selection of peer properties.

NTD data from years 2000 through 2004 were used to evaluate MDT, compare MDT with the selected peer properties, and to evaluate MDT as a top-20 transit agency.

Data obtained directly from MDT were used to compare overall performance and vehicle "parts use" across MDT's maintenance divisions.

MDT's performance data were also used to evaluate a variety of performance factors on a system-wide basis.

1.3.9 Final Results and Presentation

CUTR prepared a final report that documents the steps taken during Phase Two of the project and describes the findings in detail. Included are recommendations for remedial action.

1.4 Report Organization

Following the Introduction, the Literature Review summarizes knowledge gained through the study of several Transit Cooperative Research Program (TCRP) and similar Transportation Research Board (TRB) reports, other scholarly literature, and Internet websites. The Literature Review also describes best industry practices among transit bus maintenance programs.

The report continues with a presentation of the Peer Review that was conducted, including peer selection methodology and the results of site visits to the agencies identified.

Individual sections of the report are devoted to the Support Services area of the MDT Bus Maintenance Division, Miami-Dade Transit's Comprehensive 90-day Review and Bus Maintenance Implementation Team, and a detailed analysis of Miami-Dade Transit as a Top-20 Transit Agency.

Metrobus Equipment Performance is then analyzed from a variety of perspectives, followed by a section devoted to Determining Manpower Needs. Findings & Conclusions constitutes the final section of the report.

2. Literature Review

The following section describes best industry practices among transit bus maintenance programs. This effort provides a baseline for comparison of MDT's bus maintenance program to agreed-upon industry generally standards. Researchers gained knowledge through the study of several TCRP and similar TRB reports, other scholarly literature (including conference procedures and papers), and Internet websites.

In many cases, prior research projects sampled numerous transit agencies and culled large volumes of information directly from them through the use of telephone, mail, and electronic surveys, on-site visits and interviews, and indepth case studies. As such, CUTR reviewed the bulk of this material and identified several best maintenance practices (see Table 2.1), which are based primarily on common, successful experiences reported by bus maintenance personnel from various transit agencies. In addition, CUTR strong consideration gave to bus maintenance practices that garnered frequent positive feedback from survey respondents, such as transit maintenance management personnel and/or other researchers.

Best transit bus maintenance practices cover a wide range of concerns. Such best practices include communications, employee issues, planning, methods, and industry standards. A transit agency that strives to observe maintenance procedures considered to be best practices will typically address many, if not all, of the procedures outlined in Table 2.1. Each practice is described in greater detail throughout the remainder of this section. (It is important to note that CUTR's intention was not to suggest best practices related to specific mechanical repair procedures).

Table 2.1 Common BEST PRACTICES Observedby Transit Bus Maintenance Programs

- 1. Address employee incentives and benefits program needs
- Promote a cooperative working environment, especially between bus maintenance personnel and bus operators, and between bus maintenance and management
- Plan and establish a thorough maintenance program and adhere to the program as closely as possible; follow a 3-tiered approach to bus maintenance, which includes daily, intermediate, and long range tasks and goals
- 4. Establish performance measures and performance indicators, set goals, and strive to achieve those goals
- 5. Offer adequate, appropriate, and ongoing training for both new hires and existing employees
- 6. Develop agency-specific objectives and actively strive to meet the objectives
- Make every effort to utilize an appropriate and adequate workplace design, including retrofitting existing facilities or constructing new facilities
- 8. Employ the most appropriate type of maintenance workforce and apply the most appropriate level of oversight to maximize employee efficiency
- Establish and follow a strong Preventive Maintenance Inspection (PMI) program
- 10. Purchase new buses as frequently as necessary
- 11. Maintain the ability to adapt to changes quickly and to meet challenges as they arise; if necessary, develop and test innovative solutions, and when possible, put them into practice; utilize advanced technology to the most feasible extent possible
- 12. Consider the impact of local conditions bus maintenance factors
- 13. Compile and utilize information from peer transit agencies and private industry

2.1 Employee Incentives and Benefits Programs

Prior research studies frequently revealed transit bus operators and bus maintenance employees to be among the most difficult employee groups for a



transit agency to recruit and retain (1). Phase One of this project dealt exclusively with these employee groups' attitudes and concerns surrounding current and potential benefits. incentives. and working conditions. CUTR completed a thorough literature review. which identified successful programs employee benefits and described incentives and benefits that were likely to be well-received by employees.

This section is not intended to revisit the entire body of discovery presented in the Phase One Final Report. However, several noteworthy points from Phase One, which are applicable to a discussion of best maintenance practices, should be mentioned. CUTR presented several recommendations at the conclusion of Phase One. These ideas were based on knowledge gained through a comprehensive employee survey; common, successful methods found to be in practice at peer transit agencies; and, the findings of several prior research studies. CUTR found that a similar theme underlying each of these indicated sources clearly that as about maintenance concern bus employee satisfaction grew among transit agencies, satisfaction among their employees also grew. Further, as the level of satisfaction among bus maintenance employees intensified, agreed most sources that bus maintenance program effectiveness also As such. increased. one can reasonably conclude that transit agency management's attention to the concerns and attitudes of its maintenance employees, especially attention in the form of implementing new incentives

and/or benefits programs or revising/improving existing, flawed, or defunct programs, should be considered a best maintenance practice

2.2 Cooperative Working Environment

Strong and open lines of communication are imperative to realize success in most professions. This is especially true with regard to the field of transit bus maintenance because several distinct groups have the potential to impact the overall performance. While each group works toward the larger goal of meeting the needs of transit customers, the daily responsibilities of bus mechanics, bus maintenance managers, administrators, and bus operators are largely different from one another. In addition, the dynamics of each group are unique. In order to be successful, bus maintenance programs must address challenges to productive cooperation by actively promoting effective communication.

Zimmerman made 20 site visits to transit agencies and completed 57 telephone maintenance interviews with bus managers (2). He found most to be in agreement that bus operators' input was a kev factor to making proper diagnoses of mechanical problems with the vehicle. Zimmerman concluded that successful bus maintenance programs seek such operator participation. Further, he found that agency management played a key role in driver participation rates. Specifically, driver involvement tended to be higher among transit agencies that actively encouraged or enforced such diagnostic policies. Examples of such critical communication included requiring drivers to perform pre-trip



"walk-arounds" and to fill in bus defect cards at the end of their shift, using a reporting booth staffed by trained maintenance staff and placed at a strategic location for drivers to easily describe problems, and training drivers about maintenance practices and mechanical functions. Zimmerman also stressed that strong communication between management and employees is crucial in order to gain useful feedback and to properly assess bus maintenance program efficiency.

2.3 Maintenance Program Plan

Materials reviewed for this studv generally indicated that most bus maintenance programs utilize some form of maintenance program plan. Although not a necessity, such plans are commonly found in written form. Clearly, the development and implementation of а thorough maintenance program plan offers many benefits and should be recognized as a best practice. In addition, prior research efforts showed that the plans frequently included several other common best practices. For example, program plans encourage transit agencies to establish performance measures, identify and follow agency-specific objectives, utilize advanced technologies, and seek examples and information from peer agencies.

Pierce and Moser examined 36 transit agencies and documented common bus maintenance variables that critically impact service (3). Bus maintenance managers generally agreed that bus maintenance programs should address these variables, and specific effort should be made to control them. As such, a desirable bus maintenance program is one that is thorough enough to measure many vital performance areas. Examples of common variables measured to indicate maintenance performance include: road calls, vehicles per mechanic, annual bus mileage, age of the fleet, maintenance training, and fleet mix.

It is important to note that this practice does not advocate the establishment and application of a standard group of maintenance performance measures. Zimmerman reiterates Rather. that many characteristics of a transit agency distinct. and successful are а maintenance program should be tailored to meet the agency's specific needs (2). Operating plans of the most effective bus maintenance programs were found to be wide-ranging. In addition to a focus on the common performance measures, such programs also consider greater details and incorporate policies to address them. For example, many bus maintenance managers surveyed need for recognized the greater interagency communication and cooperation in sharing information on successful programs, particularly on technology innovations that improve fleet management. While such information sharing practices may not occur on a frequent basis, to be most effective, the program should identify their importance and establish the practice incorporating bus of а maintenance Intranet between agencies.

Additional elements of a thorough program plan may include ideas from private industry, strong preventive



maintenance inspection programs, a prescribed method to deal with road calls, and other innovative practices. Bus maintenance programs considered thorough might also identify regular procurement of new buses to increase cost effectiveness, the use of advanced technology to manage critical maintenance functions, orderly and timely replacement of parts, and managing human resources to create a cooperative labor environment as program components.

Several studies also advocate the importance of establishing a 3-tiered approach to bus maintenance (2), (3), (4). This approach is commonly based on APTA guidelines, which describe daily, intermediate and long-term maintenance practices. Survev respondents and case studies also cite these measures as common practice among their maintenance programs. Daily functions include repairing minor problems, fueling and cleaning. Intermediate maintenance generally involves 6,000-mile inspections and necessary lubrications. Long-range tasks include additional inspections, vehicle and/or component rehabilitation to varying degrees, and replacement of component parts as necessary.

Furth also emphasized the role that modern technology plays in transit bus operating and maintenance plans (5). Specifically, he found that many transit agencies are beginning to rely more heavily on technology to assure that their programs are as thorough as possible.

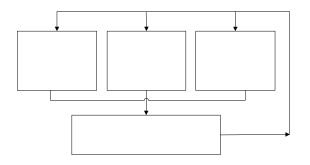
2.4 Performance Measures and Indicators

As shown in the previous section, transit maintenance programs often bus establish indicators and measures to gauge performance. Maze and Cook pointed out that in cases where an agency measures performance, one can logically assume that a management plan with objectives is in place (6). These authors also suggested that performance measures and indicators are fundamentally necessary for an agency to measure its progress toward They point out that its objectives. deviations from standard indicators and measures should be immediate cause for concern, prompting management to take corrective steps.

While Zimmerman (2) and Pierce and Moser (3) illustrated that the most successful bus maintenance programs establish performance indicators and measures, Schiavone expanded on the concept considerably (4). Specifically, he identified four common areas of maintenance performance, including: management philosophy, employee productivity, equipment performance, and controlling costs. Again, transit agencies' methods were found to vary, with some opting for more general measures, while others attained a much greater level of detail. In addition. definitions of performance factors often vary by agency. However, the common thread is the importance placed on collecting and analyzing such data so that performance can, in fact, be measured.

Schiavone found that the most common sources of reference to measure

performance usually involved study of National Transit Database (NTD) data, bus maintenance work orders. OEM service manuals, and OEM flat-rate manuals (time standards). Further. Schiavone argued that the true test of an effective maintenance performance monitoring system is the ability to determine whether a mechanical failure was caused by a malfunction of the equipment or through faultv workmanship. He established that common and effective measures include on-time performance for meeting peak pullouts, adherence to PM schedules, equipment standardization, driver involvement, and customer acceptance.



Again, Schiavone pointed out that while transit agencies may be effectively compared by the contents of their bus maintenance programs, the comparison of actual performance numbers between transit agencies is far more difficult. The main reason for this is that other than the NTD data, the public transit industry often lacks standard definitions for variables.

2.5 Employee Training

The employee survey completed during the first phase of this project found that maintenance and operations employees were overwhelmingly interested in additional training to further their skills

(1). This finding echoed those of several past studies, which often show emplovees (regardless that of occupation) desire additional training to make them more proficient in their respective fields. Further, Andrle noted that people like to do what they do well and suggested that bus maintenance officials should especially take note of this fact (7). Well-trained technicians not only tend to be happier in their positions, they take greater pride in their work, which has a positive impact on maintenance performance. Programs to provide better and/or additional transit maintenance training are also important because transit vehicles, especially buses, have become exponentially more technologically complex over the past 10 years.

According to Zimmerman, larger transit agencies tended to have a greater commitment to training programs, with more classes offered by bus and/or component manufacturers (2). He also noted that adequate job descriptions were an important factor regarding ongoing training among existing employees. Specifically, these written job responsibilities and time standards helped employees and management officials better understand expectations and realize results. Further, job aides, such as well-written and well-designed manuals that include clear, graphic representations, were found to be important materials for maintenance programs to have on hand. Zimmerman argued that reference materials should also be written in "easy-to-read" English, as well as in other languages relevant to the region.

	MANAGEMENT PHILOSOPHY	9	EMPLOYEE PRODUCTIVITY	EQUIPMENT PERFORMANC Pullouts	
•	Setting an example	•	Work procedures	Road calls	
•	Degree of oversight	•	Time Monitoring		
	Employee specialization		Faulty Workmanshin	 PM intervals 	



CUTR

Finegold, et. al. documented survey results from over half of the transit agencies in the United States and Canada and selected six agencies for further case study (8). Results showed a great degree of concern among transit officials about the rate at which transit technologies were out-pacing the skills of maintenance employees. Further, the study found that common structures among transit agencies, in general, and maintenance departments, in particular, tend to impede training and skillsdevelopment efforts. However, researchers also argued that larger agencies were better positioned to deal with such issues. Specifically, in-house capacity, while potentially used for other under-utilized, purposes or was generally available, as were full-time training personnel. Feingold, et. al. also reported that over 90% of respondents used a combination of on-the-job training and vendor instruction. Far fewer agency-local college partnerships were found, leading researchers to recommend that transit agencies seek such agreements, if not already in place. The study also recommended that management and trainers work with unions to establish continuing training programs.

2.6 Agency-specific Objectives

Based on interdependence with other measures and their fundamental place among management and measuring performance, it is clear that establishing objectives, as well as actively striving to meet them, should be regarded as a best practice among transit bus maintenance programs.

Objectives, or goals, are the basic elements of a management plan. In fact, Maze and Cook point out that measuring performance (as described earlier) implies that management had previously established objectives (6). The authors suggested that properly framed objectives should be time-limited. measurable. and appropriate to the specific agency's conditions and needs. The following section details this practice.

Maze and Cook referred to their "Management-byapproach as the Objective" (MBO) method for performance measurement of bus maintenance. MBO is a series of actions that management personnel select for the transit agency to follow to pre-determined achieve а list of objectives. Such objectives should be comprehensive, with clearly defined expectations. Once the management plan is in performance place, a measurement system can be The authors also stated established. that performance indicators must have clear and accurate definitions and be easy to understand. Most importantly. performance indicators should reflect management objectives.

Maze and Cook described vehicle performance and maintenance system performance as interdependent. They indicated that performance also indicators are usually specific to the Top management individual user. officials need indicators that evaluate overall performance. Bus maintenance shop managers, interested in the internal performance of the shop, look for performance indicators that help to



monitor specific aspects of the task at hand.

Maze and Cook conducted extensive surveys and interviews. In general, maintenance managers indicated that performance the most important indicators included: miles per road call (fleet reliability), regular and total overtime maintenance labor hours per month (work productivity), the number of repeat repairs in the same month (work quality), maintenance cost per vehicle mile (fleet maintainability), maintenance cost per vehicle (fleet maintainability), road calls per vehicle per month (fleet maintainability), maintenance labor cost per vehicle mile (fleet maintainability), and average fuel and oil cost per bus versus the entire fleet (fleet maintainability).

2.7 Workplace Design

According to Zimmerman, the effectiveness of a maintenance program is directly affected by the "adequacy" of the maintenance facility (2). He argued that a poorly designed facility can lead to more breakdowns, decreased safety, low employee morale, a poor "work product," and a reduced vehicle lifespan. Zimmerman realized that a properly designed facility does not quarantee a successful maintenance program; however, he recognized its status as a primary factor in the level of success that is achieved. Common problems identified were that facilities were not originally designed for bus maintenance, the garage design was poor, and the space to accommodate the volume of buses operated by the agency was inadequate.

Zimmerman elaborated on common garage design problems. For example, a deficient number of available service lanes can impede bus maintenance productivity. In addition, many bus maintenance facilities lack adequate storage space for buses and/or parts, especially large components. Such storage issues may cause items to be stored outside, where hazards include weather damage, vandalism, or other damage.

Space inadequacy and poor design may also plague the yard area surrounding the bus maintenance facility. Such issues often result in difficulty in moving vehicles around the yard. Specifically, there may not be straight drive-through ability or adequate space to make necessary turns.

Interior facilities also should allow ample space for training, employee lounges, and meeting rooms. Transit managers, surveyed for the study, recommended that facilities should include a common lounge shared by maintenance employees and bus operators to help increase communication and promote an informal exchange of ideas and problems.

In terms of establishing the type of workforce and degree of employee oversight, bus maintenance program managers have several options. Those programs engaged in best practices generally determined which type of workforce was most appropriate, implemented the workforce, and then applied the appropriate amount of oversight of employees.



Overall, there are four workforce types that can be utilized by bus maintenance programs (2). The program may value specialized personnel, in which case workers are assigned tasks in their area of expertise. On the other hand, the prefer program may generalized maintenance employees who are trained in a wide variety of repairs. Maintenance management personnel may actively seek a combination workforce, which allows managers the flexibility to assign specific tasks to highly skilled workers, while common repairs are handled by generalized staff. Lastly, the transit agency may opt to forgo in-house maintenance and contract the bulk of the work out to a private firm.

Several prior research studies, including Zimmerman (2), Schiavone (4), and Feingold et. al. (8) reported on various examples of workforce types and employee oversight practiced at peer transit agencies. In general, they found that maintenance managers must be flexible enough to assign tasks to the most highly skilled workers, while maintaining the appropriate amount of oversight. Errors in both assignments and management can result in a host of problems that may exacerbate the tenuous maintenance situation. For example, too strict of oversight could alienate employees, resulting in a drop morale and ultimately. in lower maintenance productivity. On the other hand, control that is seen as too loose may invite employees to take advantage of a situation and/or abuse the confidence placed them bv in supervisory staff.

Zimmerman describes management controls as direct (simple, independent measures) and indirect (statistical summaries of data) (2). Direct controls are described as "simple ratios or indices," which are most appropriately daily or weekly used in making decisions. Indirect controls, are collected, statistically summarized, and used in long-term decision-making. Productivity gains are more likely to be the result of indirect controls. Time comparisons and scheduling are described as key components of a strong management control operation.

Andrle suggested that the tools of management science and psychology be used to provide personal incentives to maintenance employees (7). Specifically, these methods help to better organize work schedules, reward good performance, instill pride in a job well done, and aid junior personnel in overcoming fear of failure. He believes this action is crucial to meeting the "elusive goal of improved productivity."

2.8 New Bus Purchases

Zimmerman noted that the age of the fleet affects maintenance requirements (2). Specifically, older bus fleets tend to require greater maintenance attention. In addition, a fleet that contains a wide variety of vehicle types can generally be expected to demand a wider range of maintenance needs. As such, transit agencies should strive for a newer, more homogeneous bus fleet in order to reduce maintenance costs. Further. Zimmerman found that bus maintenance managers show a preference for their agencies to purchase buses from one manufacturer on a continuing basis.



This practice affords greater opportunity for the agency to realize improved maintenance performance. Among the specific positive results of this practice are reduced inventory needs, less specialized mechanic training, and a potentially stronger relationship with the manufacturer. In addition, inspections can be made to be more general rather than having to recognize the individual requirements of equipment supplied by a variety of manufacturers.

Zimmerman also pointed out that low bid requirements for capital purchases often undermine a transit agency's attempts to build a homogeneous fleet.

2.9 Adaptability to Change

Transit bus maintenance programs are constantly challenged to meet everincreasing demands. Vehicle technology is improving at a rapid pace, and many transit agencies are in the process of expanding their fleets. In addition to the daily responsibilities of making a sufficient number of vehicles ready for service, bus maintenance management personnel must handle unexpected situations and immediate requests from higher-level management. As such, another common best practice is maintaining the ability to adapt to changes and special requests quickly and effectively, while still meeting daily responsibilities.

Finegold, et. al. concluded that one of the keys to a successful transit maintenance program is its ability to adapt to change (8). As technologies advance, the skills of maintenance personnel must advance with them. Effective maintenance programs

anticipate such advances and adapt to them. Moon, et. al. reinforces the need for transit agencies to make key decisions regarding new technologies (9). Further, they describe several key questions that should be considered prior to the implementation of something new. Such concerns address budgets, training, and evaluation methods. Moon et. al. also identifies the rapid advances in transit vehicle technologies and encourages maintenance program managers prepare for future to upgrades.

Further, Abrams, et. al. pointed out that modern challenges facing the transit maintenance industry are rarely easy to define and categorize (10). These challenges often span several fields of expertise that depend on each other to resolve a solution. As such, transit agency maintenance programs must be willing to reach across traditional barriers to form innovative solutions, when necessary.

Once a bus maintenance program is able to adapt to necessary changes, it follows that maintenance personnel innovations. must test Again. Zimmerman indicates that the support of top-level management is critical to this practice, and appropriate training must follow successful and accepted new innovations (2). Schiavone (4) and Finegold, et. al. (8) illustrate several examples of transit bus maintenance programs that developed, tested, and ultimatelv adopted innovative procedures in order improve to maintenance program performance.



2.10 Local Conditions

Arlinghaus and Nystuen studied the effects of local conditions on bus maintenance programs. Specifically. they identified and documented several factors related to climate (11) and terrain (12) that influence bus performance. The authors categorized climate as "harsh," "intermediate," or "benign," and they categorized terrain as "steep," "intermediate," or "flat." Such designations allowed the authors to group transit agencies among their peers for various comparisons. Thev determined that such terrain and climate variables have a significant impact on bus performance and bus maintenance functions and priorities. In addition. these factors tend to be fairly complex, both obvious and easilv having identifiable effects as well as deeper, inconspicuous impacts. As such, these factors should be considered when transit agencies attempt to maximize the efficiency of their bus maintenance operations.

2.11 Other Transit Agencies and Private Industry

Bus maintenance programs frequently address issues that arise for which no internal written maintenance practices are currently available. As such. managers and maintenance personnel often look to other industry practices for efforts assistance. These mav eventually become part of a future program maintenance plan. Unfortunately, the results of such efforts are not typically shared with the rest of the transit industry. Consequently, many transit systems, facing the same issues, expend valuable time and resources seeking the information from other transit systems, and some "reinvent the wheel." It follows that engaging in a best practice for information sharing has the potential to improve bus maintenance efficiency.

Every literary source for this review involved documentation of standard practices at other transit agencies. In some cases, private industry information was also documented, and when necessary, case studies were utilized. Such case studies occasionally included comparisons to private industry. For example, United Parcel Service (UPS) is often cited as an example of a private company whose practices are frequently emulated by the public transit industry. The company operates an international package delivery system, with over vehicles 75.000 in service. Maintenance operations for US vehicles are governed by central rules and repair policies.



3. Peer Review

3.1 Peer Agency Selection

CUTR worked with the Metrobus Maintenance Task Force to select peer properties for comparison based on agencies with similar fleet size that had experienced significant growth. CUTR performed separate cluster analyses¹ to determine comparable properties for Metrobus. However, the selection process posed some difficulties due to MDT's unique mix of buses, heavy rail cars, automated guideway vehicles, and related wayside equipment.

CUTR presented the cluster analysis results to the task force. With input from the task force, CUTR revised the criteria used in the analysis. After a review of existing data, the task force agreed to select peer properties based on the following revised criteria:

- Peer properties should operate multiple modes of transport (such as bus, heavy rail, and light rail)
- Buses operated at peer properties should be manufactured by NABI and/or Flxible
- Buses operated at peer properties should be diesel-fueled, preferably built by Detroit Diesel

In order to fulfill MDT's requirements, CUTR performed three comparative analyses. The first analysis involved comparing MDT's bus operations with similar transit agencies. The second analysis focused on the inventory programs management of peer agencies. For the analyses, CUTR selected transit agencies similar to MDT, collected relevant NTD data, and performed a benchmarking analysis. The third analysis compared MDT's bus fleet with fleets of other transit agencies through use of the 2003 Transit Vehicle Database produced by APTA.

MDT reported 29.4 million annual vehicle miles (AVM) and 283.5 million annual passenger miles (APM) for bus 2001). operations (NTD CUTR determined that peer agencies should have AVM and APM similar to that reported by MDT. The preliminary analysis identified 12 agencies that reported 20-30 million AVM and 200-300 million APM in 2000. CUTR then applied the cluster analysis technique to further narrow the number of peer properties.

Researchers selected the following parameters as grouping variables in the cluster analysis because they characterized the level of service provided by the transit agencies:

- Vehicles operated in maximum service (VOMS)
- Vehicles available for maximum service (VAMS)
- Annual vehicle miles
- Annual passenger miles
- Vehicle maintenance hours

¹ The purpose of a cluster analysis is to organize a set of observations into groups, based on common properties. The outcome of the analysis is a set of two or more mutually exclusive observations, typically displayed as hierarchical trees. The main advantage of using cluster analysis is to limit and minimize subjective intervention during the selection of similar agencies.



Number of full-time maintenance
 employees

In order to judge the efficiency of operations and maintenance, the investigators incorporated the following performance factors into the analysis:

- VOMS as a fraction of VAMS
- Annual passenger miles per VOMS
- Vehicle maintenance hours performed per VOMS
- Annual passenger miles per maintenance hour
- Annual passenger miles per number of full-time maintenance employees

After completing the analysis, the following eight agencies clustered with MDT:

- 1. San Francisco Municipal Railway, California (SF-Muni)
- 2. Denver Regional Transit District, Colorado (Denver RTD)
- 3. Metro Atlanta RTA, Georgia (MARTA)
- 4. Massachusetts Bay Transportation Authority, Massachusetts (Mass BTA)
- 5. Baltimore MTA, Maryland (Baltimore MTA)
- 6. Portland Tri-County Metro District, Oregon (Portland Tri-Metro)
- 7. San Antonio VIA Metropolitan Transit, Texas (San Antonio VIA)
- 8. Milwaukee County Transportation System, Wisconsin (Milwaukee CTS)

CUTR then completed a thorough comparative analysis of these eight agencies using service as well as performance measures to determine the three most comparable to MDT. MDT ranked sixth in both the number of vehicles in maximum service and number of vehicles available for maximum service. In addition, MDT was third in vehicle miles traveled, which could be an indication that MDT used its fleet more intensively than other similar transit agencies. (A higher ranking in *vehicle miles* coupled with a lower ranking in the *number of vehicles* implied that each vehicle travels more miles.) In 2000, MDT provided more than 27 million vehicle miles.

From 1996 to 2000, MDT experienced relatively fast overall growth in vehicle miles, exceeding the growth of many peer transit agencies. However, most of this growth occurred during 1996-97. Growth slowed after 1998, and it turned slightly negative in 2000 (MDT's vehicle miles declined 0.58% from 1999 to On average, MDT's vehicle 2000). miles grew 2.5% a year, third overall after Denver RTD and Milwaukee CTS. Measured in terms of median growth rates of vehicle miles, MDT ranked sixth (1.4% annual growth rate), while San Antonio VIA led with a growth rate exceeding 6%.

MDT scored among the lowest (7th) of peer agencies in terms of percentage of fleet operating in maximum service. The ratio of vehicles operated in maximum service per vehicles available for maximum service with a VOMS/VAMS of 80%, ahead of San Francisco Muni (76%) and Denver RTD (66%). In terms of passenger miles, MDT ranked third among peer agencies with 270,213,000 miles.

Throughout the five-year period from 1996 to 2000, MDT remained among the top three transit agencies in terms of passenger miles provided. The average



annual growth rate for all transit agencies during this time was 2.8%. At 2.6% per year, passenger miles at MDT grew slightly slower than average and were prone to a large degree of volatility, with growth ranging from 10.6% in 1998 to -4.9% in 2000.

In 2000, MDT had 666 vehicles in its fleet and ranked sixth among the peer transit agencies. Over the period of 1996-2000, MDT's total fleet size grew by 7.8% (more than the average growth among peer agencies), with the highest growth experienced by Denver RTD (51%).

CUTR chose to use annual passenger miles divided by the number of vehicles operated in maximum service (VOMS) to compare the level of intensity of use of the vehicles in operation across the transit agencies. This parameter showed how heavily each vehicle was operated and could be used as a proxy for service intensity of the fleet. In 2000, MDT reported 510,000 passenger miles per VOMS, which ranked second among the nine agencies. MDT also spent 743,038 hours maintaining its fleet in 2000. This figure puts MDT exactly in the middle of the ranking among the agencies. MARTA ranked highest with 1,119,544 hours of maintenance (50% more than MDT). During the same period, San Antonio VIA spent only 389,134 hours on maintenance (48% less than MDT) and occupied the best ranking for this parameter. Over the period of 1996-2000, MDT reduced its maintenance hours by 6.4%, the highest reduction among peer agencies during the period.

Absolute measures of maintenance hours, however, do not account for the fleet size, and, thus, are not always robust measures of operational characteristics of the fleet and its technical and physical condition. Larger transit agencies with more buses may have higher total maintenance costs (measured in terms of maintenance hours) than a smaller agency with a smaller fleet. This, however, does not necessarily indicate that a typical bus at the larger agency requires more maintenance than a typical bus of the smaller agency. Total maintenance hours can be a misleading measure, because the measure may not provide adequate information about the average maintenance per bus. As such, a relative measure of maintenance per bus was required for proper comparison of the agencies of different sizes.

MDT ranked third in 2000, spending on average 1,402 hours to maintain each vehicle operating in maximum service. From 1996 to 2000, five out of nine transit agencies experienced a decrease in their maintenance hours per VOMS. Among all peer agencies, MDT had the reduction hiahest (14.7%) in maintenance hours per VOMS. Total maintenance hours at MDT decreased by 6.4%, while the number of vehicles operated in maximum service increased by almost 10%. This led to a significant reduction in maintenance hours per VOMS.

Another important maintenance characteristic was the number of fulltime maintenance personnel employed by a transit agency. In 2000, MDT had 364 full-time bus maintenance



employees, ranking it exactly in the middle of the agencies. MARTA led the aroup with 459 bus maintenance employees. From 1996 to 2001, the number of MDT's full-time maintenance employees decreased by slightly more than 5.5%, the second highest reduction among the peer agencies (Milwaukee CTS led with an 8.4% decrease). Four agencies, including MDT, decreased the number of full-time bus maintenance employees. while the other five agencies increased the number of fulltime bus maintenance employees. Portland Tri-Metro experienced the highest increase (16.6%) in full-time maintenance employees.

Despite the reduction in the number of full-time bus maintenance employees, MDT reduced the number of bus mechanical failures by 8.2% during the period of 1996 to 2001. During this time, seven out of nine agencies experienced a decrease in the number of service interruptions caused by mechanical failures of buses. Denver RTD had the highest decrease (60%).

In 2000, MDT ranked third among the peer agencies in passenger miles per each full-time maintenance employee (743.3 million passenger miles). This number also grew by almost 20% over the five-year period, which is the second fastest growth among the agencies after Milwaukee CTS, with more than 26% growth.

MDT intended to double its bus fleet over a five-year period, so the agency was interested in studying the experiences of other transit agencies that had implemented a similar expansion. To identify transit agencies that doubled their fleet over a short period of time (4-5 years), CUTR looked beyond the cluster analysis peer agency results. Using 1998-2001 NTD data, CUTR identified transit agencies that experienced the highest growth rates and ranked vehicle fleet growth rates, vehicle miles traveled, and passenger miles. (MDT projected significant increases in each of these areas).

results showed The three transit agencies that doubled the number of vehicles available for maximum service (Lompoc Transit, California, Bay County Council on Aging, Florida and Howard Maryland). Transit Services, Area Tompkins Area (New York) Transit had the highest growth in the fleet size: the agency tripled the number of vehicles available for maximum service. Lompoc Transit not only doubled its fleet, but the number of vehicle miles increased more than five times and passenger miles increased more than 15 times.

Unfortunately, the fleet size of each of these agencies was small, and they considered were not relevantly comparable to MDT. As a result, CUTR eliminated these smaller agencies from Using 2001 data, further analysis. CUTR identified agencies most similar to MDT in terms of total fleet, vehicle miles and passenger miles. This process vielded more reasonable potential candidates for comparison to MDT.

Overall, CUTR identified five transit agencies that were most similar to MDT:

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



- 2. Maryland Transit Administration (MTA), Baltimore, Maryland
- 3. Metropolitan Atlanta Rapid Transit Authority (MARTA), Atlanta, Georgia
- 4. Massachusetts Bay Transportation Authority (MBTA), Boston, Massachusetts
- 5. Tri-County Metropolitan Transportation District of Oregon (TriMet), Portland, Oregon

GCRTA was most similar to MDT in terms of fleet size and vehicle miles traveled. MARTA related closely to MDT in all three parameters.

After reviewing the overall conclusions of the analyses conducted, the task force asked researchers to redirect their focus from peer agencies with comparable fleet size to peer agencies not only with fleets of comparable size, but also with similar fleet composition.

In order to perform this analysis, peer transit agencies with fleets most similar to MDT needed to be identified. Researchers procured the most recent available fleet data for transit agencies from the APTA. The 2003 Transit Vehicle Database, produced in June 2003, contained 2002 data presented in excel format on APTA member agencies in North America (14). In order to ensure that the appropriate agencies were selected, CUTR performed a cluster analysis that grouped all agencies into clusters based on the dearee of similarity or distance.

Due to the different nature of their operations, separate cluster analyses were performed specifically regarding buses to determine comparable properties to MDT's Metrobus. The data used for the analysis contained information on the bus equipment of 266 transit agencies in North America.

For the purpose of deciding which variables to choose to compute the distances between the agencies, each variable was examined for the frequency of reported non-zero data. Choosing variables that had significant zero-value observations decreased the power of the analysis, since the distances between the agencies would not be distinct and, therefore, no distinct clusters would be formed. As a result, only variables that displayed the highest mean values (indicating that these types of equipment were among the most widely used by different transit agencies) had highest and the frequency of non-zero values, were retained for the analysis.

The data set was reduced to 129 transit agencies, after eliminating the Canadian transit agencies as well as obvious outliers (extreme observations). In order to account for the size of different agencies, it was necessary to incorporate a fleet component variable into the analysis. The two data sets containing data on equipment and fleet were merged. The fleet data were obtained from an extensive data set containing over 6,100 records describing the fleets of over 200 agencies. This data set was aggregated around bus types and merged with the equipment data set.

MDT uses six bus types defined by the bus manufacturer:

1. AI – American Ikarus



- 2. BBB Blue Bird Corporation
- 3. DTD Dodge Division, Chrysler Corporation
- 4. FLX Flxible Corporation
- 5. NAB North American Bus Industries (formerly, Ikarus USA)
- 6. SPC Supreme Corporation (Startrans)

FLX and NAB buses are the most frequently used buses by MDT; therefore, only the agencies that reported a non-zero number of both FLX and NAB buses were retained for the cluster analysis in order to ensure proper comparison to MDT. The cluster analysis was performed using the following grouping variables:

- 1. Number of vehicles with operator two-way radios
- Number of vehicles with public address system
- 3. Number of vehicles with automated stop announcement equipment
- 4. Number of vehicles with air conditioning
- 5. Number of vehicles with interior advertising
- 6. Number of vehicles with automated vehicle location equipment
- 7. Number of FLX buses

The cluster analysis identified the following group of transit agencies that placed in the same cluster with MDT:

APTA ID	Transit Agency
111	Maryland Transit Administration
	Baltimore, Maryland
48	Regional Transportation District
	Denver, Colorado
192	Greater Cleveland Regional
	Transportation Authority
	Cleveland, Ohio

The analysis was performed using multiple clustering algorithms including: maximum distance between clusters, minimum distance between clusters, log likelihood, average distance between clusters. average distance within clusters, method of closest neighbor (single linkage), method of furthest neighbor (complete linkage), centroid method, median clustering, Ward's method and McQuitty's similarity method. Essentially, all of the algorithms used generated the same group of peer agencies with the only difference being in the distances between the peers. In all the cases (except for the method of minimum distance between clusters and average linkage within clusters), the analysis vielded a distinct cluster of MDT's peer agencies.

The results of the clustering were validated with the use of principle component analysis. A principle component is defined as a set of variables that define a projection that encapsulates the maximum amount of variation in a dataset and is orthogonal (uncorrelated) to the previous principle component of the same dataset. The purpose of the principle component analysis is to reduce the dimensionality of the data by capturing the parameters that explain the most variance while filtering out noise. The results of the generally analysis confirmed the efficiency of the initial set of variables chosen for the cluster analysis.

Data used to identify peer agencies were obtained from the 2002 National Transit Database. The data presented in Table 3.1 provide an overview of Miami-Dade Transit and the three peer



agencies that were the subject of the study: Baltimore MTA, Cleveland RTA and Denver RTD. All agencies operate in urban areas of significant population and geographic size that score an urbanized area ranking no higher than 22nd. All are multi-modal and provide bus service, demand response service and some form of rail service.

Table 3.1 National Transit Database: Agency Profiles, 2002

Factor	Miami-Dade Transit	Baltimore MTA	Cleveland RTA	Denver RTD		
Population	4,919,036	2,076,354	1,786,647	1,984,889		
Square Miles	1,116	683	647	499		
Urbanized Area Ranking (465)	5	19	22	21		
Service Area Square Miles	285	1,795	458	2,406		
Service Area Population	1,900,000	2,077,667	1,412,140	2,400,000		
Modes	Bus, Heavy Rail, Demand Response, Automated Guideway	Bus, Heavy Rail, Commuter Rail, Demand Response, Light Rail	Bus, Heavy Rail, Demand Response, Light Rail	Bus, Demand Response, Light Rail, Vanpool		
Annual Passenger Miles	400,387,405	629,710,189	245,428,209	385,040,887		
Annual Unlinked Trips	82,952,362	115,678,655	55,744,904	80,923,475		
Average Weekday Unlinked Trips	270,858	391,988	188,785	273,512		
Average Saturday Unlinked Trips	151,711	204,637	74,759	127,885		
Average Sunday Unlinked Trips	103,092	93,590	73,121	77,931		
Annual Vehicle Revenue Miles	45,795,062	39,347,868	25,044,787	46,619,454		
Annual Vehicle Revenue Hours	3,170,211	2,637,947	1,899,559	3,197,768		
VOMS/VAMS	878/1,384	1,132/1,436	696/978	1,192/1,480		
Base Period Requirement	390	281	313	429		
Total Operating Funds Expended	\$271,270,471	\$326,868,105	\$217,278,209	\$274,219,538		
Total Capital Funds Expended	\$65,566,755	\$183,393,902	\$66,393,055	\$164,651,134		
Salaries, Wages and Benefits	\$177,241,039	\$202,991,509	\$160,930,113	\$134,983,431		
Materials and Supplies	\$29,260,992	\$30,752,353	\$23,096,468	\$21,303,596		
Purchased Transportation	\$21,630,635	\$72,648,078	\$1,731,280	\$67,014,252		
Other Operating Expenses	\$37,791,586	\$18,800,352	\$23,584,913	\$28,356,033		
Source: 2002 National Transit Database						

3.2 Peer Site Visits

CUTR made all necessary contacts and arrangements to visit the selected peer properties. A standard list of data needs, in the form of a questionnaire, was developed in advance of the visits expedite the process. to This questionnaire developed was in cooperation with the Metrobus Task Force and the Materials Management Oversight Committee. Emphasis was placed on the following areas:

- Management philosophy
 - Ratio of employees to managers
 - Degree of oversight and control

- Preventive maintenance
 Guidelines
- Bus maintenance control practices
- Employee productivity
 - Repair orders
 - Road calls
 - Computer capabilities
 - Mechanic classification
- Equipment performance
 - Bus performance data
 - Vendors
 - Parts issues

MDT initiated contact with bus maintenance managers at each of the peer properties. MDT provided this list of contacts to CUTR. Research staff established communication with the initial contact person at each agency via telephone. In some cases, the initial contact was the proper agency staff to directly aid in this research effort. In all cases, each agency staff member who ultimately assisted CUTR was a seasoned transit veteran with multiple vears of bus maintenance and management experience.

After establishing contact via telephone, CUTR devised an introduction letter that briefly described the project and the data needed to complete it. The letter, which was mailed and faxed to each agency contact, indicated CUTR's intention to complete site visits to the agency and asked contacts to provide their availability for the visit. In order to allow each contact sufficient time to compile information, a preliminary list of data needs and questions was also included with the letter and fax. Agency staff was advised that each meeting



would require at least two hours of their time.

CUTR also informed top management at each agency about the project and asked for approval to visit each contact person as indicated. In the interest of expediency, CUTR included a response deadline, that if not met would be considered passive approval to proceed with the project as indicated. In one instance, top level agency management contacted CUTR for additional details on the project. Prompt response by CUTR yielded direct approval to proceed by this agency head.

CUTR completed site visits to Cleveland RTA, Denver RTD, and Baltimore MTA over a four week time period during August and September 2004. Each site visit consisted of a two-hour meeting maintenance personnel with bus followed by tours of selected bus maintenance facilities. Specifically, CUTR with the general met superintendent, maintenance at Denver RTD, the director of fleet management at Cleveland RTA, and the deputy director of bus maintenance and the chief of quality assurance at Baltimore MTA.

Upon completion of the site visits, CUTR summarized the site visit data and presented an overview of the findings to the Metrobus Task Force.

Prior to the site visits, the organizational structure of each agency was examined. During the site visits, those structures were reviewed with staff, and specific tables of organization were assembled to identify reporting relationships and determine the nature and numbers of staff responsible for bus maintenance functions. Researchers also explored the most recent data available for each agency provided in the 2002 National Transit Database and completed an analysis of the performance measures resulting from that data as established by the Federal Transit Administration (FTA).

Researchers used a standardized list of during questions interviews the conducted at the peer properties. Those standardized questions were translated into specific areas of Information obtained as a discussion. result of the interviews was assembled under appropriate headings. Agency responses were reviewed in terms of their relationship to common agency practices, material gleaned during the literature review materials and management best practices that had been identified.

For the purpose of this report, CUTR reexamined the National Transit Database for relevant maintenance performance data concerning MDT and the three peer properties during the time period from 2000 through 2004. The NTD data will be used throughout the examination of the peer agencies to help inform the discussion.

Researchers found that peer agencies differed dramatically in structure, not only in comparison with MDT, but also in comparison with each other.

In terms of the structure of the agency, Miami-Dade Transit operates as a department within Miami-Dade County.



The director of Miami-Dade Transit reports to the County Manager's Office and, ultimately, the Miami-Dade County of County Commissioners. Board MDT's structure is unique in relationship to the peer agencies, which are more closely aligned with state or regional aovernment. Bus maintenance functions were consolidated under the assistant director, bus services, who reported to the deputy director of The Miami-Dade Transit operations. organizational structure is outlined in Figure 3.1.

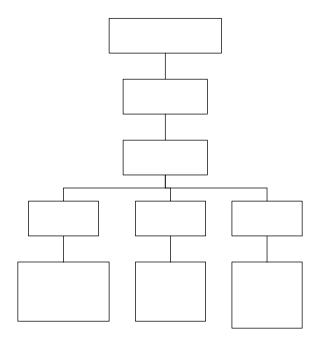


Figure 3.1 Miami-Dade Transit Organizational Structure

Maryland Transit Administration (MTA) in Baltimore operates as a state agency under the Maryland Department of Transportation, an umbrella organization, including the airport, seaport, Motor Vehicle Administration, and State Highway Administration. The administrator of MTA reported to the secretary of the Maryland Department of

Transportation, who in turn answered to the Governor of the state of Maryland. 2001. the Maryland Transit In Administration Citizens Advisorv Committee was established. Members were appointed by the secretary of transportation and served three year terms. Bus maintenance functions were consolidated under the guidance of the director of bus maintenance who reported to the deputy administrator. The Baltimore MTA organizational structure is presented in Figure 3.2.

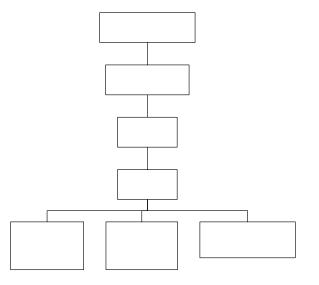


Figure 3.2 Baltimore MTA Organizational Structure

In 1974, legislation established the Greater Cleveland Regional Transit political Authority (GCRTA), а subdivision of the state. The chief executive officer (CEO)/general manager of the GCRTA reported to the Manar Data Costeres, a 10 member board. Bembers Counted overlapping three-year teronomission four Cleveland residents appointed by the Cleveland Mayor and approved by the city council; three members were elected by mayors and

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city managers of municipal corporations other than Cleveland within Cuyahoga County: and, three members were Cuyahoga appointed by County Commissioners (one of three must reside in Cleveland). GCRTA also had a Citizens Advisory Board that consisted of 20 volunteer members appointed by the RTA Board of Trustees. Ten were selected by board members and ten were selected from a list of candidates. Bus maintenance was managed at the district level within the operations division that reported directly to the general manager. Figure 3.3 details the Cleveland RTA organizational structure.

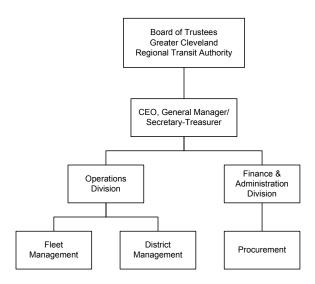


Figure 3.3 Cleveland RTA Organizational Structure

The Denver Regional Transit District was created by the Colorado General Assembly in 1969 and, subsequently, expanded in 1975. The Denver RTD general manager reported to a board of directors, which consisted of 15 members publicly elected (one from each of 15 districts). Members serve a four-year term with elections staggered so that eight seats were open in one

general election and seven in the next. As a public transportation system, RTD operated in a seven-county service area and served 38 municipalities in six counties and two citv/countv jurisdictions. While the administrative headquarters was in Denver, there were four operating facilities: two in Denver, one in Aurora, and one in Boulder. Bus maintenance was managed under the direction of Operations Division Maintenance, which reported to the general superintendent of maintenance. The Denver RTD organizational structure is outlined in Figure 3.4.

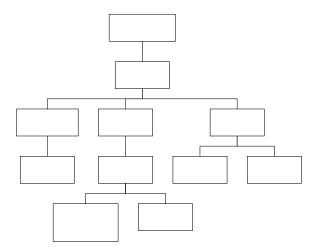


Figure 3.4 Denver RTD Organizational Structure

While the organizational structures of the peer agencies do vary, researchers appear to have achieved the desired results in terms of selecting agencies similar to MDT in terms of level of service.

3.2.1 Level of Service

Tables 3.2 through 3.7 provide a comparison of the four agencies using the same level of service variables that were used in the peer selection



methodology. Level of service variables include:

- Vehicles operated in maximum service (VOMS)
- Vehicles available for maximum service (VAMS)
- Annual vehicle miles
- Annual passenger miles
- Vehicle maintenance hours
- Number of full-time maintenance employees

Miami consistently lagged behind the transit agencies (Baltimore, peer Cleveland, and Denver) in the number of vehicles operated in maximum service for most years from 2000 to 2004. In 2003, the number of MDT VOMS was 20.0% below the number of vehicles at number-one-ranked Baltimore. In terms of VOMS, Miami ranked the lowest among the peer agencies during 2000, 2001 and 2003, and ranked third in 2002. As a result, MDT's VOMS for those years was below the average of the four transit agencies (MDT numbers were included in the calculation of the average). MDT's VOMS was 13.0% below average in 2000 (530 VOMS at MDT vs. the average of 609), 8.4% below average in 2001 (547 VOMS at MDT vs. the average of 597), 2.7% below average in 2002 (564 VOMS at MDT vs. the average of 580), and 11.1% below average in 2003 (506 VOMS at MDT vs. the average of 569).

In 2004, however, due to a large increase in the number of VOMS at MDT, Miami passed the peer transit agencies in this parameter. With 663 vehicles in maximum service in 2004,

Miami ranked first among its peers and was 10.2% above the peer agencies' average in terms of VOMS (average of 602 vehicles in maximum service). A side-by-side comparison of MDT with its peers in terms of VOMS is presented in Table 3.2.

Table 3.2 Vehicles Operated in	Maximum Service
--------------------------------	-----------------

			_		_
	Baltimore	Cleveland	Denver	Miami	Average
2000	649	619	639	530	609
2001	630	614	598	547	597
2002	634	544	577	564	580
2003	633	548	589	506	569
2004	633	544	566	663	602
Source: National Transit Database (NTD) 2000-2004					

From 2000 to 2004, the overall number of vehicles available for maximum service (VAMS) at Miami increased from 666 in 2000 to 819 in 2004, a 23.0% increase. Even with decreases in 2003 and 2004, the overall trend for the fiveyear period is clearly upward. The largest increase in VAMS was observed in 2002, when the number of vehicles increased by 32.4% compared to 2001. In 2004, however, VAMS decreased by 14.4% (from 957 vehicles in 2003 to 819 vehicles in 2004). MDT's 2004 VAMS exceed peer VAMS, which have consistently declined throughout the five vear period.

Vehicles available for maximum service are presented in Table 3.3.

Table 3.3 Vehicles Available for Maximum Service					
Baltimore	Cleveland	Denver	Miami	Average	

	Dailiiii0ie	Cieveianu	Denver	Widiii	Average
2000	787	752	962	666	792
2001	792	758	833	732	779
2002	845	748	782	969	836
2003	740	701	738	957	784
2004	750	544	719	819	708
Source: National Transit Database (NTD) 2000-2005					

MDT vehicle miles increased from 27,871.1 thousand miles in 2000 to 36,037.7 thousand miles in 2004, a



29.3% increase. The growth was gradual from year to year without extremely large fluctuations, with the largest spike observed in 2004 when vehicle miles increased by 12.4% (from 32,075.9 thousand miles to 36,037.7 thousand miles).

Only Baltimore and Miami showed growth in annual vehicle miles, with increases of 5.4% and 29.3%. respectively. Cleveland reported 10.1% fewer annual vehicle miles (from 27,317.8 to 24,551.4), and Denver's reduction in annual vehicle miles from 33,875.4 to 30,819.6 equaled 9.0%. Since 2003, Miami has logged more vehicle miles annually than each of the three peer agencies, as reflected in Table 3.4.

	Baltimore	Cleveland	Denver	Miami	Average
2000	21,597.4	27,317.8	33,875.4	27,871.1	27,665.4
2001	21,774.8	26,792.6	32,485.5	29,365.8	27,604.7
2002	22,521.1	23,015.0	31,239.8	30,559.2	26,833.8
2003	22,155.6	25,457.6	30,114.8	32,075.9	27,451.0
2004	22,773.2	24,551.4	30,819.6	36,037.7	28,545.5
Source: National Transit Database (NTD) 2000-2004					

For the period of 2000 to 2004 MDT passenger miles increased by almost 10.0%, from 270.2 million miles in 2000 to 296.9 million miles in 2004. The growth was consistent and relatively smooth with the largest spikes observed in 2001 when passenger miles increased by 4.9% and in 2004 when passenger miles grew by 6.3%.

Since 2001, Miami has reported more annual passenger miles than the three peer agencies. As with annual vehicle miles, only Baltimore and Miami show growth in 2004 compared to 2000. Reductions in passenger miles at Cleveland and Denver were 11.5% and 17.6%, respectively, as shown in Table 3.5.

Table 3.5 Annual Passenger	[.] Miles	(000s)
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	Baltimore	Cleveland	Denver	` Miami	Average
2000	261,833.7	198,957.8	288,036.8	270,212.7	254,760.3
2001	260,988.0	179,985.8	247,582.5	283,461.5	243,004.5
2002	261,604.2	171,543.3	240,851.8	273,614.0	236,903.3
2003	260,831.2	189,098.1	226,011.6	279,410.6	238,837.9
2004	268,604.7	176,055.3	237,306.2	296,888.7	244,713.7
Source	e: National Tra	nsit Database	(NTD) 2000	-2004	

"Employee work hours" as defined by the NTD represent the following:

- Total hours worked by transit agency employees during the report year, regardless of starting date
- Work hours are not equal to and are typically less than total hours paid to transit employees
- Work hours are "duty hours," hours during which employees perform work for the transit agency
- Hours related to fringe benefits, such as holiday and sick leave are not considered as work hours

MDT's vehicle employee work hours grew from 743,038 hours in 2000 to 1,026,924 hours in 2004, an increase of 32%. Except for one year (2003) when work hours decreased slightly (0.7% decrease), employee work hours have been growing steadily each year with the largest single-year increase of 30.5% recorded in 2004 (work hours increased from 786,741 hours in 2003 to 1,026,924 hours in 2004). The trend of growth in employee work hours is identical to the growth in the number of MDT full-time employees presented later in the analysis. This suggests that the growth in the number of employee work hours was mostly attributed to the growth in the number of employees at MDT during the same time period.



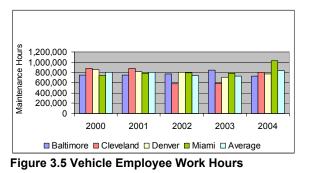
Vehicle employee work hours are presented in Table 3.6.

Table 3.6 Vehicle Employee Work Hours

	Baltimore	Cleveland	Denver	Miami	Average
2000	752,039	876,555	854,180	743,038	806,453
2001	747,819	877,716	812,336	779,834	804,426
2002	770,412	577,177	799,543	792,237	734,842
2003	843,798	591,814	707,114	786,741	732,367
2004	726,075	799,285	770,141	1,026,924	830,606
Source: National Transit Database (NTD) 2000-2004					

In 2000, MDT ranked last among the peer agencies in terms of vehicle employee work hours and was almost 8.0% below the peer average. Later in the observed period, partly due to an increase in work hours at MDT, and partly due to a decrease in peer average. Miami exceeded the peer agencies' average. Starting in 2002, the number of vehicle employee work hours at MDT consistently exceeded the peer average, ending 23.6% above average in 2004. In both 2002 and 2003, MDT ranked second among peer agencies in terms of vehicle employee work hours, and ranked first in 2004, exceeding the second-ranked Cleveland by 28.5%.

MDT was the only agency of the four that grew employee work hours in 2004 compared to 2000. Decreases of 3.5%, 8.8% and 9.8% were reported at Baltimore, Cleveland, and Denver, respectively. A graphic presentation of vehicle employee work hours throughout the study period is provided in Figure 3.5.



The number of full-time employees (FTE) at MDT increased from 364 employees in 2000 to 476 employees in 2004, an increase of 30.8%. The largest single-year increase in the number of employees was observed in 2004, when the number of FTE increased by almost 26.0% compared to 2003 (MDT had 378 full-time employees in 2003). In other years within the period, the number of employees increased slightly, generating a upward trend. small Notably, the growth pattern of the number of full-time employees at MDT is very similar to the employee hours worked.

Miami reported the highest number of FTEs in 2004 as compared to the peer agencies. Only Miami and Baltimore 2004 FTE levels exceed those of 2000. Decreases at Cleveland and Denver in 2004 versus 2000 FTEs equal 5.5% and 11.2%, respectively.

Full-time vehicle maintenance employees are outlined in Table 3.7.

Table 3.7 Full-time Vehicle Maintenance	
Employees	

	Baltimore	Cleveland	Denver	Miami	Average
2000	403	387	443	364	399
2001	401	387	439	374	400
2002	413	323	424	384	386
2003	423	313	398	378	378
2004	429	365	394	476	416
Souro	o: National Tra	noit Databasa		2004	

Source: National Transit Database (NTD) 2000-2004



3.2.2 Efficiency of Operations and Maintenance

In order to gauge the efficiency of operations and maintenance, researchers used the following performance factors:

- VOMS as a fraction of VAMS
- Annual passenger miles per VOMS
- Vehicle maintenance hours
 performed per VOMS
- Annual passenger miles per vehicle maintenance hour
- Annual passenger miles per number of full-time maintenance employees

Tables 3.8 through 3.12 provide a comparison of the efficiency of the four agencies.

Miami's overall number of vehicles available for maximum service as a percentage of vehicles operated in maximum service has seen a slight upward trend during the period of 2000 to 2004. VAMS/VOMS has increased consistently from 2000 to 2003. reaching the level of 1.89 in 2003, (50.0% higher than this parameter was in 2000 - 1.26 VAMS/VOMS). An increase in VAMS/VOMS indicates a decrease in fleet utilization percentage (i.e., percentage of fleet that is operated in maximum service). In 2004, however, VAMS/VOMS dropped by 34.4% (from 1.89 in 2003 to 1.24 in 2004). As a result. VAMS/VOMS in 2004 ended 1.6% lower than it was in 2000 (1.26 in 2000 compared to 1.24 in 2004). This decrease in VAMS/VOMS in 2004 indicates significant improvement in the MDT fleet utilization percentage that year.

The peer average fell as well, from 1.30 in 2000 to 1.17 in 2004, despite peaking at 1.45 in 2002. It appears that all agencies improved fleet utilization over the five-year period, as reflected in Table 3.8.

Table 3.8 VOMS/VAMS

	Baltimore	Cleveland	Denver	Miami	Average
2000	1.21	1.21	1.51	1.26	1.30
2001	1.26	1.23	1.39	1.34	1.31
2002	1.33	1.38	1.36	1.72	1.45
2003	1.17	1.28	1.25	1.89	1.40
2004	1.18	1.00	1.27	1.24	1.17
Source	e: National Tra	nsit Database	(NTD) 2000-	2004	

MDT passenger miles per vehicle exhibited a downward trend during the observed period decreasing by 12.2% from 2000 (509.8 thousand miles per VOMS) to 2004 (447.8 thousand miles per VOMS). In 2003, the number of vehicles operated in maximum service by MDT decreased by 10.3% resulting in a 13.8% increase in passenger miles per VOMS that year (passenger miles per VOMS grew from 485.1 thousand miles per VOMS in 2002 to 552.2 thousand miles per VOMS in 2003). This increase in 2003, however, was followed by an 18.9% decrease the next year and, thus, did not reverse the overall downward trend in passenger miles per vehicle.

A downward trend was also noted at Denver and, to some extent, at Cleveland. Despite small declines at Baltimore in 2002 and 2003, annual passenger miles per VOMS grew over 5% at MTA from 2000 to 2004, as reflected in Table 3.9.



Table 3.9 Annual Passenger Miles per VOMS	
(000s)	

,0000					
-	Baltimore	Cleveland	Denver	Miami	Average
2000	403.4	321.4	450.8	509.8	421.4
2001	414.3	293.1	414.0	518.2	409.9
2002	412.6	315.3	417.4	485.1	407.6
2003	412.1	345.1	383.7	552.2	423.3
2004	424.3	323.6	419.3	447.8	403.8
Source	: National Tra	nsit Database	(NTD) 2000-2	2004	

During the period of 2000-2004, Miami's vehicle employee work hours per VOMS increased by 10.5% from 1,402.0 hours per VOMS in 2000 to 1,548.9 hours per VOMS in 2004. Most of that increase, however, occurred in 2003. Vehicle employee work hours stayed practically unchanged from 2000 to 2002. In 2003, hours per VOMS increased by 10.7% from 1,404.7 in 2002 to 1,554.8 in 2003 and then stayed flat in 2004.

Miami reported the largest increase of the four agencies from 2000 to 2004. Baltimore's 14.0% reduction in 2004 was significant enough to reduce the 2004 level of 1,147.0 below the 2000 level of 1,158.8. Miami's 2004 level of 1,548.9, as shown in Table 3.10, was the highest level of vehicle employee work hours per VOMS reported by any agency during the five-year period.

Table 3.10 Vehicle Employee Work Hours per VOMS

	Baltimore	Cleveland	Denver	Miami	Average
2000	1,158.77	1,416.08	1,336.74	1,401.96	1,328.39
2001	1,187.01	1,429.50	1,358.42	1,425.66	1,350.15
2002	1,215.16	1,060.99	1,385.69	1,404.68	1,266.63
2003	1,333.01	1,079.95	1,200.53	1,554.82	1,292.08
2004	1,147.04	1,469.27	1,360.67	1,548.90	1,381.47
Source	e: National Tra	nsit Database	(NTD) 2000-1	2004	

Miami achieved fewer and fewer annual passenger miles per vehicle employee work hour beginning in 2000. Despite a slight increase of 2.8% in 2003 that increased passenger miles per work hour from 345.4 to 355.1, annual passenger miles per work hour decreased by more than 20%, from 363.7 to 289.1.

Peer agencies appear to have experienced wide fluctuations in passenger miles per work hour; nonetheless, the overall average fell by only 6.9%, and Baltimore was able to log positive growth.

Table 3.11 Annual Passenger Miles per Vehicle	
Employee Work Hour	

	Baltimore	Cleveland	Denver	Miami	Average
2000	348.2	227.0	337.2	363.7	319.0
2001	349.0	205.1	304.8	363.5	305.6
2002	339.6	297.2	301.2	345.4	320.8
2003	309.1	319.5	319.6	355.1	325.9
2004	369.9	220.3	308.1	289.1	296.9
Sourc	e: National T	ransit Databas	e (NTD) 2000)-2004	

Miami's passenger miles per full-time employee experienced positive and negative fluctuations during the period of 2000 to 2004, increasing 2.1% in 2001, decreasing by 6.0% in 2002, and increasing by 3.7% in 2003. The largest decrease of 15.6% was noted in 2004 (from 739.2 to 623.7 thousand miles per FTE). For the entire period, passenger miles per employee decreased by 16.0%, from 742.3 thousand miles per FTE in 2000 to 623.7 thousand miles per FTE in 2004.

A decline in passenger miles per FTE was observed at the peer agencies as well, where the average from 2000 to 2004 fell 8.6%. Baltimore reported the smallest decrease, while Miami reported the largest decrease.

Table 3.12 Annual Passenger Miles per Full-time
Vehicle Maintenance Employee (000s)

	Baltimore	Cleveland	Denver	Miami	Average
2000	649.39	514.10	649.61	742.34	638.86
2001	650.84	465.08	563.46	757.92	609.32
2002	633.27	531.09	568.45	712.54	611.34
2003	616.62	604.15	568.30	739.18	632.06
2004	626.12	482.34	602.76	623.72	583.73
Source	e: National Tra	nsit Database ((NTD) 2000-2	004	



Miami fared well in comparison to peer agencies in improving fleet utilization since 2003.

While the number of passenger miles per VOMS has declined in comparison to previous years, Miami vehicles continue to log more miles per VOMS than the peer agencies. In addition, Miami consistently exceeded peer agency vehicle employee work hours per VOMS and recorded a new high for vehicle employee work hours per VOMS in 2004.

Despite the commitment of record maintenance hours, Miami achieved fewer passenger miles per vehicle employee work hour than Baltimore and Denver, fell below the 2004 average of the four agencies, and showed a 20% decline in performance compared to Miami's performance in 2000.

In addition, Miami's employees provided fewer passenger miles per FTE than their counterparts in Baltimore and 118.6 thousand fewer passenger miles per FTE (decrease of 16.0%) compared to Miami in 2000.

3.3 Management Philosophy

CUTR reviewed current management philosophies that shape decisions related to the ratio of employees to managers, the use of a specialized versus a non-specialized workforce, the degree of oversight and control utilized at various levels of management, relevant types of incentives and promotions, and lines of communication within the organization. While general background information related to many of these data points was reviewed in the

Phase One Final Report, CUTR also obtained information (such as incentives and promotions) during interviews with bus maintenance task force members and through general discourse with the task force. Additional MDT information about each of these points, as well as others found to be relevant during the course of the project is documented in the Phase Two Report. Specifically, communications protocols in practice between the Metrobus Maintenance, Materials Management, and Metrobus Operations divisions were reviewed. CUTR interviewed specific members of the task force and other appropriate MDT management staff to complete this task.

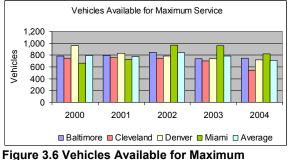
CUTR also investigated the role and functions of the Bus maintenance control Division (BMC). Specifically, while BMC is tasked with collecting and storing bus maintenance data, MDT Metrobus Maintenance Division managers sometimes questioned the usefulness of the available analyses. As such, CUTR examined the bus maintenance record keeping and data analysis functions practiced at MDT, as well as those in practice at peer transit agencies, where applicable.

3.3.1 Organizational Structure

The structure of a transit agency's bus maintenance division can be interpreted as a reflection of its bus maintenance management philosophy. Relevant concerns include historical changes and realignments, lessons learned, and modifications necessitated by agency and/or fleet growth.



A review of vehicles available for maximum service (VAMS) in Figure 3.6 shows the gradual reduction in vehicles available since 2000 at Miami as well as at the peer properties.



Service, 2000 - 2004

It is worth noting that in 2004, while VAMS declined in Miami, VOMS increased by 31.0%. This observation suggests that Miami improved fleet utilization, i.e., the percentage of vehicles operated in maximum service.

Average fleet utilization (relationship between VAMS/VOMS) for the four agencies presented in Table 3.13 fell below the preferred rate of 1.2 in 2004. Denver and Miami did maintain a level slightly higher than 1.2, and both showed improved fleet utilization over time. Nonetheless, the 2004 average of 1.17 for the agencies leaves little margin for substandard equipment performance, as spare ratios would average only 17%.

	Baltimore	Cleveland	Denver	Miami	Average
2000	1.21	1.21	1.51	1.26	1.30
2001	1.26	1.23	1.39	1.34	1.31
2002	1.33	1.38	1.36	1.72	1.45
2003	1.17	1.28	1.25	1.89	1.40
2004	1.18	1.00	1.27	1.24	1.17
Source	e: National Tra	nsit Database	(NTD) 2000-2	004	

Despite reduced fleet levels, most agencies increased inspection and maintenance labor hours. The National Transit Database defines "labor hours for inspection and maintenance" as labor hours charged to inspection and maintenance of revenue vehicles (Section 6.2 of the Uniform System of Accounts (USOA)). Activities in this function (061) include:

- Inspecting revenue vehicle components on a scheduled preventive maintenance basis
- Changing lubrication fluids
- Replacing minor repairable units of specific vehicle components
- Making road calls to service revenue vehicle breakdowns
- Towing and shifting revenue vehicles to maintenance facilities
- Rebuilding and overhauling repairable components
- Performing major repairs on revenue vehicles on a scheduled or unscheduled basis
- Replacing major repairable units of revenue vehicles

Labor hours spent on inspection and maintenance by Miami were consistently lower than the peer average for the entire reporting period. Miami labor hours were almost 20.0% below the average in 2000, declined to 40.0% below the average during 2001-2003, and then climbed to 5.0% below the average in 2004. Total hours are detailed in Table 3.14.



Table 3.14 Labor Hours for Inspection andMaintenance

	Baltimore	Cleveland	Denver	Miami	Average
2000	467,163	501,280	601,549	401,562	492,889
2001	463,002	561,600	812,336	321,190	539,532
2002	495,040	561,600	799,543	316,300	543,121
2003	543,106	561,600	644,549	298,576	511,958
2004	486,830	555,360	592,879	505,264	535,083
Source	e: National Tra	nsit Database	(NTD) 2000-2	2004	

During the period from 2000 to 2003, Miami recorded the smallest number of inspection and maintenance hours among the agencies and, in 2004, logged the second lowest number of inspection and maintenance hours. A lower-than-average number of hours spent on inspection and maintenance could be one of the reasons for a higher-than-average number of failures at Miami. During the period from 2001 to 2003, Denver spent more than twice as many hours for inspection and maintenance than did Miami and had the least number of failures (both major and other failures) among the peer agencies, while Miami had the highest number of failures. The comparison of peer transit agencies in terms of inspection and maintenance labor hours is presented in Figure 3.7.

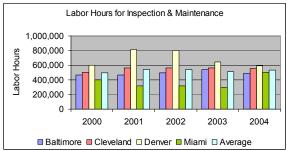


Figure 3.7 Labor Hours for Inspection and Maintenance

When inspection and maintenance labor hours, outlined in Table 3.15, are examined in relationship to VOMS over the five year time period, the number of labor hours spent on inspection and maintenance per vehicle operated in maximum service by Miami was consistently lower than the peer average for the entire reporting period. Miami labor hours per VOMS were 6.1% below the average in 2000, declining to 40.3% below the average during 2001-2003, and then climbing to 15.3% below the average in 2004.

Table 3.15 Inspection and Maintenance LaborHours per VOMS

	Baltimore	Cleveland	Denver	Miami	Average
2000	719.82	809.82	941.39	757.66	807.17
2001	734.92	914.66	1,358.42	587.18	898.80
2002	780.82	1,032.35	1,385.69	560.82	939.92
2003	857.99	1,024.82	1,094.31	590.07	891.80
2004	769.08	1,020.88	1,047.49	762.09	899.89
Source	e: National Tra	nsit Database	(NTD) 2000-2	004	

Graphic presentation of labor hours for inspection and maintenance per VOMS in Figure 3.8 shows Miami at the low end of the scale from 2001 through 2003. Miami's reported labor hours per VOMS in 2002 and 2003 equaled only half of Cleveland and Denver's hours. Reductions in labor hours at those properties, coupled with 29% growth at Miami in 2004, helped normalize hours per VOMS across the four properties in 2004.

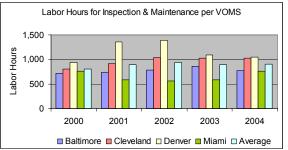


Figure 3.8 Inspection and Maintenance Hours per VOMS

Miami-Dade Transit currently manages four Operations and Inspections (O&I) facilities. Three of these facilities, Central Division, Coral Way Division, and Northeast Division, are similar in



design and have been in operation for several years. The fourth facility, Medley Division, entered service in 2004. All four divisions operate under the oversight of the assistant director of bus services.

Metrobus Maintenance staffing allocations and assigned vehicles are detailed in Table 3.16.

Table 3.16 MDT Bus Maintenance Personnel andAssigned Vehicles

Employee Classification ¹	Central Division	Coral Way Division	Medley ¹ Division	Northeast Division
Bus Technician	47	47	17	46
Bus Technician Trainee	4	5	2	7
Bus Technician Apprentice	10	11	4	10
Bus Hostler	19	23	9	19
Bus General Helper	8	9	4	10
Bus Body Technician	1	12	1	9
Bus Maintenance Clerks	4	4	1	3
Total Employees	93	111	38	104
Total Fleet	238	250	99	238
¹ Metrohus Eleet Management	Plan Revisio	n II. October	2004	

² Medley Division is operated by Penske under contract with MDT

Bus Maintenance staff and vehicles appear to be equally distributed among the facilities with the exception of the Medley Division, which is smaller and responsible for fewer vehicles than the other divisions. Staff allocations mirror vehicle allocations at all of the garages as indicated in Figure 3.9.

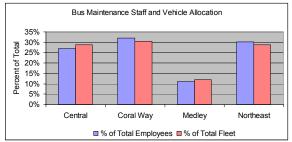


Figure 3.9 Division Staff and Vehicle Allocations as a % of Total

While the operation and management of the three long-established facilities is fully overseen by MDT, the Medley facility is unique in that it is operated

under contract with Penske Trucking. Under the agreement, Miami-Dade Transit provides all Bus Technicians and first line supervisory staff. Penske staff manages the bus maintenance division and oversees maintenance activities. MDT's agreement with Penske Trucking is somewhat unique because only one other transit agency in the U.S. (New Orleans Regional Transit Authority) currently employs Penske to perform bus maintenance functions. Bus maintenance and management techniques traditionally employed by MDT and those utilized by Penske differ slightly and are documented throughout this report.

Preventive maintenance. corrective maintenance, cleaning and storage of vehicles are performed at the four O&I MDT also operates the divisions. support services division, which is composed of the A/C shop, major body shop, major overhaul, and the unit room. Bus components are rebuilt, power plants are removed and replaced, damage from accidents is repaired, and all new buses are inspected prior to release to the O&I divisions from the support services division. Except for central O&I, each facility has its own bodywork and painting shops. The composition of MDT's bus fleet by manufacturer in 2003 and 2005 is illustrated in Figures 3.10 and 3.11.



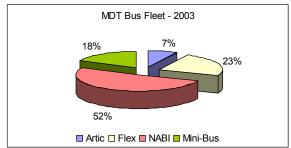


Figure 3.10 MDT Fleet by Bus Type, 2003

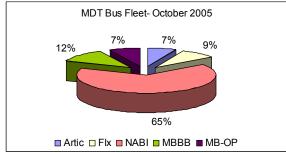


Figure 3.11 MDT Fleet by Bus Type, 2005

The nature of the change of the fleet, which has grown by 9.8% in the time period reviewed, is presented in Table 3.17. It appears that Miami is replacing full-size buses with NABI buses and minibuses with Optare buses.

Table 3.17 MDT Bus Fleet 2003 versus 2005

Year	Artic	Flx	NABI	MB-BB	МВ-Ор	Total
2003	66	209	458	158	0	891
2005	64	84	643	117	70	978
Change	-2	-125	185	-41	70	87
% Change	-3.0%	-59.8%	40.4%	-25.9%	100.0%	9.8%

MDT bus technicians work one of three shifts. The first shift (or day shift) runs from 7 a.m. to 3 p.m. The second, or afternoon, shift spans the hours of 3 p.m. to 11 p.m., and the night shift (third shift) covers the hours of 11 p.m. to 7 a.m. Bus Technicians are granted one 30-minute lunch break and two 10minute breaks during the course of their shift. At Baltimore MTA, bus maintenance was previously structured into four separate. individually managed That structure has been divisions. replaced with one in which the four divisions operate under a central maintenance department that allows for a similar and more unified maintenance Division directors report to structure. the deputy director.

In Cleveland, GCRTA had a reverse experience with bus maintenance management. The agency went away long-standing from а central management format and adopted a district management concept in 1998. This structure involves a system of individual bus maintenance district managers. As such, directors are able to have more direct control over the ongoing processes within their shop. Both advantages and disadvantages are found within this system. While some functions were kept centralized, district shops perform most of the essential daily repairs. Specific responsibilities of the fleet maintenance department include following maintenance standards, fleet management (heavy inventory, repair), facilities management, and technical services, such as warranty administration.

Denver RTD's structure is similar to that of Baltimore MTA. The three bus maintenance divisions, along with technical support, report to the general superintendent of maintenance.

A common best practice is development of a written bus maintenance plan that is regularly followed and referenced. In addition, such plans are modified as

CUTR

necessary when new technologies come into use. MTA and GCRTA reported having no formal, complete written bus maintenance plan. While RTD also had no formal plan in place, officials described the tri-annual review process as a method that functions somewhat similarly to a written plan. RTD also written indicated that preventive maintenance descriptions are utilized, and that the agency is moving toward developing a thorough set of standard procedures operating for bus maintenance. At the time of the site visit, this effort was described to be in its 'infancy stage.' MDT relies on the Bus Operating Manual that contains all written bus maintenance procedures, which are reviewed and updated by Bus maintenance control with assistance from bus maintenance as needed.

3.3.2 Ratio of Employees to Managers

The ratio of employees to managers within a bus maintenance division is another indicator of its management philosophies. Among the more relevant details are the underlying methods used to determine a satisfactory ratio of employees to managers. Changes and/or modifications to the ratio are also a significant factor in the comparison.

At the Central, Coral Way, and Northeast facilities, there are two supervisors assigned to each of the three shifts per day. Relief supervisors are used to ensure that two supervisors are available on every shift at all locations. The number of technicians assigned to each shift at these locations ranges from 12 to 18. However, the actual number of technicians found in a specific shop on any given day may be more or less, depending on a variety of conditions. Factors that contribute to such fluctuations commonly involve varying employee days off, specific shift or day of the week, and employees out sick or on special assignment. There are usually more technicians assigned to the first shift than there are to the second or third shifts. In addition, supervisors at the Central facility reported that the highest number of technicians on the floor usually occurs on Wednesdays.

Employee-supervisor ratios are much different at the Medley facility. Penske Trucking retains only two employees at this location: one district service manager and one supervisor. MDT directly employs the remaining personnel at the Medley facility. There are a minimum of three and a maximum of six technicians on any given shift. supervisors oversee Two the technicians' work. Relief supervisors are not used at the Medley facility.

Among the peer agencies, Cleveland reported a ratio of between 8 to 11 mechanics for every supervisor. This is based on approximately 55 to 60 mechanics at each garage and a management structure that includes four shift supervisors and one equipment manager at each district garage. There is also one crew chief responsible for overseeing the hostlers. At MTA in Baltimore, superintendents head each maintenance division. with seven division shift supervisors on staff at each division location. Two supervisors are assigned to both the morning and afternoon shifts, while one supervisor covers the night shift. Technicians are



assigned according to designated level, with 40 "A" level, 4 "B" level, and 10 "C" level technicians assigned to each division. The supervisory ratio target at Denver RTA is 13 to 15 employees to one supervisor, while, in fact, some shifts actually see a lower figure than this. The key variable in determining the ratio at RTD was reported to be the projected miles per bus. Current union positions include 173 general repair technicians. 15 technical support technicians. 8 technicians in the communications ("Com") shop. 7 technicians that work with fare boxes, and 27 technicians in the unit shop.

A review of the number of full-time vehicle maintenance employees reported in the NTD was conducted. The actual person count reported in the NTD represents the person count of employees at the end of the report year, unlike the calculation of employee work hours. The NTD cautions interpreting relationship between the two the statistics, since the work hours and counts employee are essentially collected for different periods of time.

Based on the NTD from 2000 to 2004, Cleveland and Denver reduced the number of employees over time, while both Baltimore and Miami increased vehicle maintenance positions, by 6.4% and 30.8%, respectively. The numbers of full-time positions at each of the agencies are reflected in Table 3.18.

Table 3.18 Full-time Vehicle MaintenanceEmployees

	Baltimore	Cleveland	Denver	Miami	Average
2000	403	387	443	364	399
2001	401	387	439	374	400
2002	413	323	424	384	386
2003	423	313	398	378	378
2004	429	365	394	476	416
Source	e: National Tra	nsit Database	(NTD) 200	0-2005	

Full-time vehicle maintenance employees in relationship to vehicles operated in maximum service are presented in Table 3.19. When viewed from this perspective, all four agencies show a higher ratio of employees to vehicles in 2004 as compared to 2000, with average growth of 5.3%.

Table 3.19 Full-time Vehicle MaintenanceEmployees per VOMS

	Baltimore	Cleveland	Denver	Miami	Average
2000	0.62	0.63	0.69	0.69	0.66
2001	0.64	0.63	0.73	0.68	0.67
2002	0.65	0.59	0.73	0.68	0.66
2003	0.67	0.57	0.68	0.75	0.67
2004	0.68	0.67	0.70	0.72	0.69
Source	e: National Tra	nsit Database	(NTD) 200	0-2004	

Miami reported the highest ratio of fulltime maintenance employees to VOMS in 2003. The increase in employees was most likely directly related to the ramp-up in service initiated as a result of a successful sales tax initiative known as the People's Transportation Plan.

For the period from 2000 to 2004, Miami's employee work hours increased by 38.2%. Except for one year (2003) when work hours decreased slightly (0.7% decrease), employee work hours have grown steadily each year, with the largest single-year increase of 30.5% recorded in 2004.

"Employee work hours" as defined by the NTD represent the following:



- Total hours worked by transit agency employees during the report year, regardless of starting date
- Work hours are not equal to and are typically less than total hours paid to transit employees
- Work hours are "duty hours," hours during which employees perform work for the transit agency
- Hours related to fringe benefits, such as holiday and sick leave are not considered as work hours

The growth in the number of employee work hours in Table 3.20 is probably attributed to the growth in the number of employees during the period that was discussed previously.

Table 3.20 Employee Work Hours

	Baltimore	Cleveland	Denver	Miami	Average
2000	752,039	876,555	854,180	743,038	806,453
2001	747,819	877,716	812,336	779,834	804,426
2002	770,412	577,177	799,543	792,237	734,842
2003	843,798	591,814	707,114	786,741	732,367
2004	726,075	799,285	770,141	1,026,924	830,606
Source	: National Tra	nsit Database ((NTD) 2000-	-2004	

Miami is the only agency of the four that shows an increase in 2004 vehicle employee work hours in comparison to 2000, as reflected in Figure 3.12.

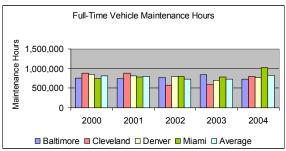


Figure 3.12 Full-time Vehicle Employee Work Hours

3.3.3 Use of Specialized vs. Nonspecialized Workforce

Another indicator of bus kev maintenance program management philosophy is the type of workforce that is utilized and the degree to which it is specialized. Specifically, the workforce may be fully specialized, completely non-specialized. contracted. or а combination of two or more of these scenarios. While the level of variation differs among them, each agency employs a combination-type workforce.

Practices regarding the use of and/or non-specialized specialized technicians are generally similar at each of the four MDT O&I facilities. MDT has only one classification for mechanics, i.e., bus maintenance technician. While the agency has no written policy on specialization. some maintenance technician positions are specialized in the sense that they are "pick positions" that require specialized skills to be accomplished successfully. For example, brake technicians must know how to operate a special lathe machine that simultaneously machines brake drums and brake shoes to fit a specific A pick position for wheel assembly. dealing being with batteries is considered. While "wheelchair equipment repair" and "hotline" functions are not "pick positions," both functions require specialized technical skills.

Supervisors indicated that some technicians are better at small, quick jobs, while others thrive on larger, more involved assignments. Supervisors keep this in mind when distributing work assignments. Their reasoning process also considers a technician's knowledge

of the specific job at hand and whether or not the technician wants to do the job. For instance, supervisors at one of the reported that facilities а specific technician excels at and eniovs wheelchair-related tasks, so a deliberate effort is made to assign such tasks to this individual. Additional factors that influence repair assignments are speed and experience. A veteran technician will likely take one day to complete a brake job, while someone with less experience might require two days. In terms of specialization, by definition, the "hotline" position demands that the attending technician be highly knowledgeable and able to work quickly.

In general, supervisors reported that technicians basically work alone with little work done on a "team" basis. Several suggested that new technicians could benefit from mentoring by seasoned technicians. Skill levels of entry technicians were often found to be less than adequate, and supervisors recommended enhanced screening at the time of hiring to improve the quality of new hires.

Baltimore MTA has three degrees of union-level repairmen, which include 160 at the A-level (40 per division), 16 at the B-level (4 per division), and 40 Clevel (10 per division) and two levels (A and B) of cleaners. The "A" level repairmen are the highest level, followed by "B" and "C." Only "A" level mechanics are allowed to diagnose problems. Union level repairmen and cleaners pick once per year by seniority, which allows them the chance to go to any shop they desire. Qualified employees can only move up to the "A"

level if there is a vacancy. Seniority is the most dominant minimum qualification. These distinctions do not include the major overhaul shops. Because of the preferred hours at this shop (1st shift: 7:30 a.m. to 3:30 p.m., Monday through Friday) employees rarely pick out of this location.

GCRTA intentionally uses vague and overlapping language in its iob descriptions in order to accommodate flexibility in mechanics' assignments. Specialized job categories involve skills brakes. HVAC. related to and The agency intends to electronics. complete a thorough retooling of job classifications in the near future.

RTD in Denver also uses a combination workforce. As such, RTD has only one classification for technicians: general repair mechanic. Specialization occurs at the shop level, with mechanics gaining expertise at the particular location. Examples of specialized shops at RTD include:

- COM shop responsible for electronic-related repairs
- Tech support (retrofits and experimentation
- Fare box repairs of fare collection equipment
- Unit shop maintenance and overhaul of specialized equipment, such as generators and wheelchair lifts

As an example of the degree of specialization at RTD, 90% of unit shop mechanics are certified at the top level. A decade ago, the agency underwent a large hiring process, which brought



many general-skilled technicians into the fold. Over time, the level of personal interest and motivation is directly related to the degree of specialization among individual mechanics. Other general repair fields are non-specialized. About 300 routes at RTD are maintained under contract. The contractor is completely and independently responsible for the entire operation and maintenance of these routes. The contractors are held to specific standards. If such standards are not met, the contractor is charged liquidated damages.

3.3.4 Degree of Oversight & Control

The level of oversight and control in practice at a transit agency, whether it is a formal, written policy or generally understood, is a strong indicator of the bus maintenance program's management philosophy. Reasons behind these choices and historical changes also provide insight into this area.

The MDT Metrobus Maintenance Division has no specific policy that directs the supervisor's degree of oversight and control of assigned staff. Rather, supervisors draw on their own experience and judgment to handle each technician individually. With the overarching goal being "meeting the morning and afternoon peak vehicle requirements," supervisors strive to distribute work assignments and let the technicians do the job in a way that is most comfortable for them. The philosophy at the Medley facility is somewhat more precise; the Penske Trucking encourages technicians to constantly be engaged in activity. At the

other locations, supervisors' are more concerned with the overall progress and outcome of assigned tasks, rather than how the technicians spend their time.

The amount of time that supervisors spend on the shop floor varies by location. Supervisors at one facility report spending a great deal of time with technicians on the floor. Other locations find supervisors more confined to the control room for various reasons. However, all supervisors were available to offer assistance to employees upon demand. Technicians frequently come to the control room for input and advice, and it is the supervisor's role to answer the question or find the information. For example, a supervisor referenced an MDT rulebook in order to address a policy question. While supervisors generally do not inspect or review technicians' work, upon request supervisors do accompany technicians to workstations to offer advice or greater insight into a problem.

None of the peer agencies had a formal policy in place related to employee oversight and control. Baltimore MTA reported that oversight levels are moderate. GCRTA described control as loose mainly due to the fact that first line supervisors at GCRTA are union employees. Management expressed a desire to have tighter control than is currently in practice.

At Denver RTD, employee oversight and control varies by supervisor and by mechanic. At present, there is no formal, written system; however, the agency is in the process of establishing a system. Specifically, they are taking a





progressive approach to correct "less productive" employees by offering them additional training to help increase their personal productivity.

CUTR used a variety of analyses to examine workmanship and employee productivity. The first variable studied was that of revenue vehicle system failures. The 2004 NTD Reporting Manual includes two categories of revenue vehicle system failures. *Major mechanical system failures* are those that limit actual vehicle movement or are safety issues. *Other mechanical failures* include all failures that do not limit vehicle movement or are not safety issues.

Major mechanical system failures for the four agencies are reported in Table 3.21 and show a great deal of variation not only from agency to agency but also within individual agencies from year to year. The same observation can be made for the other mechanical system failures presented in Table 3.22. Since the data reported by Baltimore seem to be really out of line from a variety of the most meaningful perspectives. comparison appears to be presented in Table 3.23, which represents total system failures, a combination of the two categories of failures.

Table 3.21 Major Mechanical	System Failures
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	Baltimore	Cleveland	Denver	Miami	Average
2000	672	3,598	2,462	11,501	4,558
2001	4,058	3,605	708	9,844	4,554
2002	3,792	3,344	1,155	12,885	5,294
2003	4,424	2,012	696	7,413	3,636
2004	3,284	1,688	665	7,694	3,333
Source	e: National Tra	nsit Database	(NTD) 200	0-2004	

Table 3.22 Other Mechanical System Failures

	Baltimore	Cleveland	Denver	Miami	Average
2000	18,250	1,059	2,745	7,368	7,356
2001	0	1,053	445	6,473	1,993
2002	0	795	502	4,252	1,387
2003	0	563	402	4,744	1,427
2004	0	414	516	5,403	1,583
Source	· Notional Tra	nait Databaaa	(NITO) 200	0 2004	

Source: National Transit Database (NTD) 2000-2004

Table 3.23	Revenue	Vehicle	System	Failures
	I C V C II U C	V CITICIC	Oy Stonn	i unui co

	Baltimore	Cleveland	Denver	Miami	Average
2000	18,922	4,657	5,207	18,869	11,914
2001	4,058	4,658	1,153	16,317	6,547
2002	3,792	4,139	1,657	17,137	6,681
2003	4,424	2,575	1,098	12,157	5,064
2004	3,284	2,102	1,181	13,097	4,916
Source	: National Tra	nsit Database	(NTD) 200	0-2004	

Miami's total mechanical failures declined 30.6% from 2000 to 2004. During this period, while total mechanical failures exhibited a clear downward trend, there were relatively large fluctuations from year to year. A 30.0% decrease in 2003 was followed by a 7.7% increase in 2004. Total revenue vehicle system failures are presented graphically in Figure 3.13.



Figure 3.13 Total System Revenue Failures

Miami's total system failures per VOMS exhibited a clear downward trend, decreasing from 35.6 failures per VOMS in 2000 to 19.8 failures in 2004, a 45.5% reduction as shown in Table 3.24. Nonetheless, despite significant reductions in mechanical failures, in terms of failures per VOMS, Miami continues to report nine times more than Denver, five times more than Cleveland,

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almost four times more than Baltimore, and over two times the average for the four properties.

Table 3.24 Revenue Failures per VOMS

		Baltimore	Cleveland	Denver	Miami	Average
	2000	29.16	7.52	8.15	35.60	20.11
	2001	6.44	7.59	1.93	29.83	11.45
	2002	5.98	7.61	2.87	30.38	11.71
	2003	6.99	4.70	1.86	24.03	9.40
	2004	5.19	3.86	2.09	19.75	7.72
Source: National Transit Database (NTD) 2000-2004						

Miami's revenue miles between total mechanical failures clearly improved throughout the reporting period. In fact, MDT's miles between failures improved by 48% in 2003 and 5% in 2004, resulting in an 85% improvement over 2000, as shown in Table 3.25. However, the level of improvement noted at the peer agencies exceeded Miami's level of improvement. In 2004, Baltimore logged three times more revenue miles between failures than Miami, Cleveland logged four times as many, and Denver reported nine times as many.

Table 3.25 Revenue Miles per Failure

	Baltimore C	leveland	Denver	Miami	Average		
2000	976.4	5,051.1	5,284.2	1,283.3	3,148.8		
2001	4,628.3	4,937.7	22,123.2	1,542.9	8,308.0		
2002	5,164.1	4,765.5	14,635.1	1,534.3	6,524.7		
2003	4,350.3	8,292.7	21,078.1	2,262.6	8,995.9		
2004	6,041.4	9,739.2	20,254.1	2,374.6	9,602.3		
Source: National Transit Database (NTD) 2000-2004							

Revenue miles between total failures are presented graphically in Figure 3.14.



Figure 3.14 Revenue Miles per Failure

3.3.5 Incentives and Promotions

Although Phase One of this project dealt extensively with employee benefit and incentive programs, their existence, and the extent to which a transit agency values them, offers significant insight into the management philosophy. A brief mention of the ways in which such programs impact bus maintenance employees is worthwhile within the overall discussion of management philosophy.

None of the O&I facilities currently utilize shop-specific incentives. There was some sentiment among supervisors that there are no incentives, monetary or otherwise, that would encourage technicians to improve their skills.

Common employee incentives and benefits are offered by Baltimore MTA and GCRTA. Benefits at Baltimore MTA with specific relevance to bus maintenance employees include the opportunity for certification training and participation in training at local junior colleges. Baltimore MTA is in the process of developing new employee recognition and rewards programs. GCRTA offers employee rewards each individuals month. and are also recognized "innovation" for their suggestions.

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Union employees at Denver RTD also have common incentives, such as paid holidays off insurance and (including anniversary date and birthday). Denver RTD offers up to \$750 per year in tuition reimbursement to employees who are in degree programs or educational programs associated with the agency. Employees can increase their wages by achieving various certifications; however, they are not mandated to participate in such programs. Retirement can be taken as early as 50 years old, if the employee has attained 20 years of service. RTD attempted to establish an employee incentive program through the union, but the union resisted such efforts. incentives Attendance were also resisted, with the eventual rewards being less than desired by the agency.

3.3.6 Maintenance Division Communications

policies regarding Agency communications between employees and management are another key indicator of its management philosophy. As in other areas, policies may or may not be formalized, or they may be a In some cases, combination of both. special programs encourage to communication may also be in place.

Timely, accurate, and effective communication plays a crucial role in how well Metrobus maintenance meets Throughout their shift. O&I its goals. supervisors are engaged with other groups on a variety of levels. These include communications within the shop, between the shops, with other MDT divisions, and with vendors. Within the supervisors facility. interact with technicians, management, and vendors. Among the most relevant interdivisional communications to this study are those with bus maintenance control, materials management, and bus operations. Other relevant interdivisional contact includes that with information technology (IT), field engineering/systems maintenance (FESM), and safety. These include both labor and management personnel.

Communication methods and frequency vary by shop and are influenced by a variety of factors. For example, the extent of bus operators' interaction with maintenance is partially a function of the proximity of the dispatch area to the O&I shop. As such, a considerable amount of interaction was reported at MDT's smallest facility, which has the closest proximity. One of the shops reported communication between that supervisors and technicians included pre-shift discussion about work agenda, problems, potential solutions and/or fixes. A dry-erase board is mounted in a prominent location and kept current with current relevant messages. and Communication between maintenance personnel and bus operators usually involves problem diagnosis. Several bus operators were observed coming to the control room window at several of the shops to report problems with their assigned bus.

Supervisors at the O&I facility closest to major overhaul reported frequent communication (approximately twice per day) with major overhaul about buses needed and their availability. However, supervisors at another location reported that meetings with supervisors from



other shops are infrequent. In addition, full maintenance staff meetings are uncommon because of the difficulty of getting all three shifts together at one time. There is also significant cost involved in holding multi-shift meetings.

Communication between the body shop and the repair shop at one O&I facility was viewed as important in order to coordinate the best workflow. Specifically, bodywork is completed after mechanical repairs in order to avoid further damage to the bus. Supervisors at this shop reported that use of email to communicate is somewhat difficult because of the time constraints involved with finishing repairs, making pullout, etc. Telephone communications are also becoming increasingly difficult because of several layers of menus involved in reaching the appropriate respondent.

Supervisors at Baltimore MTA host weekly toolbox meetings and bus safety meetings as a primary means to communicate with maintenance employees. GCRTA uses the Together Everyone Achieves More (TEAM) program to promote communication between management and employees. Hosted by the agency general manager (GM), TEAM meetings are held in a town hall format. The GM holds regular meetings at each garage.

Management at Denver RTD reported a positive relationship with bus emplovees. maintenance Good relations are maintained with the union president. In the past, the agency sponsored management labor committee allow meetings for to

discussion of problems; however, the meetings were discontinued because they devolved into little more than complaint sessions rather than serving as a productive forum to address issues.

Communication and collaboration between bus maintenance personnel and bus operators are critical, as is management's active encouragement of such interaction. It is worthwhile to note instances where this effort has had a positive impact on the maintenance program.

Baltimore MTA bus operators complete a pre-trip inspection and report defects to bus maintenance personnel. For the past five years, the MTA safety department facilitates monthly bus safety meetings. Attendees are selected from among bus maintenance and bus operations personnel. The meetings are usually well-attended by dedicated employees.

Collaboration between bus operators and mechanics at GCRTA was reported to be minimal at best. Management representatives from the agency's bus maintenance division indicated that, in general, bus operators were reluctant partners in the bus maintenance process. Collaboration was apparent in the use of defect cards; however, the use was minimal.

Denver RTD reported a fair amount of interaction between bus operators and maintenance staff. The agency has an active safety committee, with bus mechanics and operators among its membership. There is also regular communication between the two areas

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at the manager level; regular bi-weekly meetings are held. Bus operators receive regular notices from bus maintenance personnel regarding important mechanical bus issues and special findings. Although bus operators are not generally involved in troubleshooting, their input may be sought in order to diagnose regular and/or chronic problems with specific buses. Bus maintenance managers adhere to an 'open door' policy, which welcomes input from bus operators at any time.

3.3.7 Problem-solving and Other Innovations

A transit agency's efforts to effectively utilize advanced technologies. especially to solve problems, manage critical functions, and replace parts in timely order, are also indicative of its maintenance bus management philosophy. Each of the peer agencies used advanced technologies to varying degrees. At a minimum, they all use diagnostics. software-based most notably for engine and transmission issues.

MDT is looking forward to implementation of a new computerized maintenance system, which has been under development for several years. MDT management hopes that problemsolving will become more proactive when the new computerized system is integrated throughout bus maintenance.

An important goal that was identified by the Bus Maintenance Implementation Team (BMIT)² was increasing the amount of time shop supervisors spend on the floor with bus technicians. In some ways, this goal represents a fundamental shift in management philosophy, as these practices were found to vary among the facilities. Some shops are closer to attaining this goal than others. Many changes may be necessary at the shop level to make this goal a reality and to make it an effective practice.

At one of the shops, supervisors indicated that they engage in general discussions with technicians prior to the start of the shift. Supervisors at this shop spent a considerable amount of time on the shop floor. The discussion of specific problems usually plays a role in properly assigning work. An example of an innovation established at this shop concerns the issue of batteries. Shop management determined that the current arrangement, i.e., a technician working batteries three days per week, was insufficient to handle the workload. As a result, the shop made the battery job a pick position, which will be a fulltime, 40-hour per week position. Another example of ongoing problemsolving at this shop focuses on the problem of high soot levels found in engine oil samples. For in-house studies, supervisors closely monitor memos that are issued to notify them to keep an eye on specific items or problems. The memos are displayed, items are monitored, tracked, and the memo is eventually returned to the initiating department with the required information.

² The BMIT was formed in February 2005 to implement the recommendations of a 90-day

Operations Review Task Force. The BMIT and 90-day Operations Review Task Force will be discussed in detail later in this report.



Problem-solving and innovations are also at work at another facility. To help reduce road calls, supervisors keep a carbon copy file of repair orders in the control room for the supervisor to use for monitoring chronic issues. In the event that a supervisor is listening to road calls, he can review the file and make decisions to help expedite repairs. Unfortunately, supervisors are usually not able to listen to live road calls due to other responsibilities. In the absence of any type of clerical position, supervisors are responsible for a variety of clerical including answering functions. the phone. While they expressed a desire to spend more time on the floor, in reality, most of their time is actually spent in the control room, and they are unable to give their full attention to the shop floor. Suggested innovations include assigning a clerk to the control room to complete paperwork and answer the phone.

Supervisors are also responsible for receiving two fuel deliveries each day, overseeing delivery of other vital fluids, such as lubricants, and tracking the levels of product on hand and amounts used. It was suggested that transfer of the oversight of the deliveries to materials management, the procurer of commodities. enable the would focus supervisors primary to on functions on the shop floor.

Supervisors at one O&I facility are challenged with what is likely the smallest control room among the three original O&I facilities of MDT. Examples of problem-solving and innovations at this shop include space saving fixes in the control room, such as mounted clipboards on walls. However, the control room maintains specialized tools, equipment, laptops, etc., which still results in congestion in this area. Supervisors at this shop work with vendors to test buses and solve modelspecific issues.

In terms of the use of advanced technology, MTA reported that it has successfully implemented MAXIMO, a new computer maintenance program that is highly functional. Examples of the new system's capabilities include various functions. tracking iob calculating averages and standards, and the use of online forms. As with most new computer systems, MAXIMO, which has been shown to be too generic in some cases, is still evolving and will be customized as necessary. Additional examples technologies of new implemented at MTA include automatic passenger counts and automatic data collection at fueling stations. Such data automatically relayed can be to MAXIMO. MTA is also in the process of acquiring ten hybrid-electric buses.

RTD is also in the process of computerized implementing new а maintenance system, which will be online soon. Among its most desirable functions are daily reporting and reportgeneration. The new system will add considerable value to the road call system, including production of road calls from the previous day and a summary sheet of all road calls. Additional new technologies in use or under development at RTD include automatic passenger counts, fare box updates, on-board cameras, advanced data mobile tracking a form of global



positioning system (GPS), and radio frequency identification (RFID). At present, RFID testing has failed to produce desired results.

While GCRTA did not mention advanced technologies specifically related to bus maintenance, the agency has implemented some systems that may have an indirect effect. For example, automatic vehicle locaters (AVL) and a GPS are in use, and a new communications system was installed. On-board data collection is not in wide use, but some vehicles are equipped with automatic passenger counters. The agency is in the process of implementing Bus Rapid Transit, which will employ articulated buses. (GCRTA had none in its fleet at the time of the review.)

Another effort commonly considered a best practice for bus maintenance programs is actively utilizing information compiled from other agencies, as well as sharing agency information with other agencies. Such practices are especially noteworthy because there is a historical lack of information sharing in the industry. Maintenance management personnel were unsure of any instances of information sharing or use by GCRTA; however, just by participating in this research effort, each peer agency is sharing information. Both MTA and RTD reported seeking out information from other agencies. Specifically, the idea for a brakes-only shop at MTA was generated in this manner. RTD looked for bus maintenance issues related to bus procurement, especially seeking out agencies that had acquired buses immediately prior to and immediately

following its own acquisition. RTD also tries to maintain close ties to former employees who moved to other transit agencies in order to facilitate experience sharing.

In order to maintain the most effective bus maintenance program, transit agencies must have the ability to adapt to necessary changes. MTA officials believe its ability to cope with necessary changes is adequate and that the new computer system slated to come online will offer additional flexibility. GCRTA reported that 87% of its spending is related operations and to that reorganization enhanced their ability to meet new demands. Officials at Denver believe the agency is sufficiently able to adapt as necessary.

Necessary changes may involve development of ideas that require testing. It is worthwhile to document the various methods that may be used to test such innovations. GCRTA and MTA both report the ability to test innovations within shops or use one shop as a testing ground. For example, GCRTA provided one shop with a different item and monitored the results and progress to determine if the change was warranted agency-wide. RTA in Denver referenced its work with the National Renewable Energy Lab (NERL) as an example of the way in which it conducts testing.

Private industry may also provide examples and/or models that may benefit a bus maintenance program. Among the peers, RTD identified the American Trucking Association as a source for best practices. MTA



sometimes looks to other transit agencies for innovative ideas, as with the brake-only maintenance shop. Officials at GCRTA were unaware of any significant examples of such practices.

Transit agencies utilize various strategies to control costs. Such methods may or may not have a significant impact on the agency's bus maintenance program.

RTD has taken a host of measures to control costs. The agency implemented a more efficient computer system that allows for several reporting functions Among these are related to costs. weekly loss reports and monthly budget reports. The system in place for bus maintenance reporting is by division with several different people designated to review the reports. In addition, guarterly budget reports are sent to the agency budget office. RTD bus maintenance also has an ongoing oil analysis program, which is monitored by the quality control department. In recent vears. the agency closed two maintenance facilities that were too costly, based on a program of cost tracking that RTD had initiated.

MTA officials reported that MTA's efforts to control costs included modernizing facilities and implementing new new technologies. such as fare collection equipment and the MAXIMO computer system. MTA also initiated an efficiency study in 2004. Other innovations, such as the idea of a brakes-only maintenance shop, are also meant to help reduce costs. At GCRTA, cost control was among the motivations for the adoption of a district-wide management system. The agency has also controlled costs by placing a freeze on hiring.

3.3.8 Preventive Maintenance Inspection (PMI) Program Guidelines

Each MDT facility follows general guidelines for PMI; however, some shop-specific practices and innovations do exist. The insight and experiences of shop supervisors as well as the amount and level of input they have are highly relevant.

Supervisors expressed a variety of concerns about preventive maintenance inspections related to scheduling and completion. At one facility, the PM list was said to be "not in order" because it "jumped around" leading some buses to go many miles beyond inspection. Necessary repairs found during the PMI are not counted as part of the inspection. Rather, a repair order is generated and the bus requiring the repair order is referred for repair. Some supervisors questioned whether some of the required "repairs" should be included as part of the PMI, such as air dryers. It is possible that failure to complete repairs legitimately tied to the PMI process could lead to inaccuracies in the hours identified for PMIs. The idea of a "PM Crew" was suggested, but it is not considered an efficient way to conduct PMIs.

At one facility, the current PMI is based on a "pass" or "fail" for each item. The inspection is then signed-off at the end. It is anticipated that the revised PMI, which is currently under discussion, will include a space for the technician's



badge number for each line item to help with flow, as one technician starts the inspection another and technician finishes it. This method would also provide a clear indication of who is responsible for each item. Where appropriate, the new PMI would also include directions for completing the work and be specific for each bus type. The revised procedures would also expand responsibility for completion of PMIs from the third shift to all three shifts.

At another garage, a list of buses due for PMIs is computer-generated by bus maintenance control. The BMC production coordinator writes this list on the magnetic/erasable board (Figure 3.14) for the bus maintenance supervisors.

Supervisors are aware that the inspections must be done as soon as possible, especially if it is written in "red," as this is an indication that the deadline for completion is rapidly approaching. Supervisors write the repair order, but the order is not put on the work log until a technician is ready to begin work on the inspection. At one facility, supervisors reiterated that buses must not be placed into service with safety defects; however, vehicles with defects other than safety-defects, while noted, are allowable for service.

MDT targets on-time PMI compliance at 100%, and while MDT has generally shown good compliance with on-time PMIs in the past, MDT fell slightly below the across-the-board 100% compliance reported in 2005 at two divisions, as indicated in Table 3.26. Compliance

rates at Central and Medley fell between 90% and 100%. Northeast and Coral Way achieved 100% PMI compliance throughout the year.

Penske management generates and manages the PMI schedule at the Medley O&I facility.

Table 3.26 Preventive Maintenance Adherence,2005

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Figure 3.15 Sample Magnetic Board

Each peer agency also reiterated the value of employing a strong PMI program, which is also an integral part of the bus maintenance program management philosophy. At RTD for example, the written bus maintenance plan specifically outlines the importance of the PMI program. Cleveland identified PM inspection cycles to be between 90 to 95% in compliance. In Baltimore, improving the PMI process is an integral component of MTA's overall plan to improve the bus maintenance program. Specifically, MTA is working toward a system in which maintenance shops are only responsible for regular maintenance preventive and



maintenatnce-related tasks. Major overhaul work would be completed at another location. MTA anticipates that its new computer management system, MAXIMO, will facilitate the PMI process. Specifically, when MAXIMO generates a repair order for a bus, the system will automatically flag the bus if it is due, or overdue, for a PM inspection. While MTA bus maintenance supervisors try to keep PM backlogs to a minimum, the new system will help by generating a PMI priority sheet each morning.

Although the peer agencies adhere to common maintenance inspection cycles, they have not established specific labor requirements to meet the inspection schedule. In general, safety checks are performed every 2,000 miles, with oil everv 6.000 changed miles and transmission fluid changed every 18,000 miles. GCRTA reported that for new buses, safety checks are completed on a 3,000/6,000-mile cycle, with an oil change at 3,000 miles.

Inspection and maintenance labor hours reported in the NTD were reviewed for the four agencies and are represented in Table 3.27.

Table 3.27 Labor Hours for Inspection andMaintenance

	Baltimore	Cleveland	Denver	Miami	Average
2000	467,163	501,280	601,549	401,562	492,889
2001	463,002	561,600	812,336	321,190	539,532
2002	495,040	561,600	799,543	316,300	543,121
2003	543,106	561,600	644,549	298,576	511,958
2004	486,830	555,360	592,879	505,264	535,083
Source	e: National Tra	nsit Database	(NTD) 2000-2	2004	

Inspection and maintenance labor hours at the four properties have become more similar over time. A reduction in Denver's 2003 (19.4% decrease compared to 2002) labor hours coupled with an increase in Miami's 2004 (69.2% increase compared to 2003) appear to account for the gradual shift to parity in 2004 labor hours as shown in Figure 3.16.

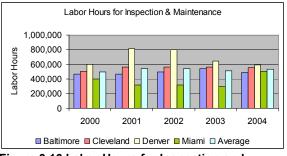


Figure 3.16 Labor Hours for Inspection and Maintenance

However, when inspection and maintenance labor hours are viewed on a per employee basis, Miami falls significantly behind the peer agencies, as indicated in Table 3.28.

Table 3.28 Inspection and Maintenance Hours perEmployee

	Baltimore	Cleveland	Denver	Miami	Average
2000	1,158.64	1,295.30	1,356.67	1,103.19	1,228.45
2001	1,154.62	1,451.16	1,848.74	858.80	1,328.33
2002	1,198.35	1,738.70	1,887.05	823.70	1,411.95
2003	1,283.90	1,794.20	1,620.70	789.90	1,372.18
2004	1,134.80	1,521.53	1,505.92	1,061.48	1,305.93
Source	e: National Tra	nsit Database	(NTD) 2000-	2004	

It should be noted that the NTD did urge caution when comparing labor hours to actual numbers of employees, as hours are accrued throughout the year while the employee count is generated at the end of the year. Variation in these figures could be the result of additional hiring at the end of the year, which would reduce the actual number of hours provided per employee.

Miami reported a 25.6% growth in FTEs (78 additional employees) from 2003 to 2004, as shown in Table 3.29.

Table Empl	e 3.29 oyees	Full-time	Vehicle	Mai	ntenance
-	Baltimore	Cleveland	Denver	Miami	Average
2000	403	387	443	364	399
2001	401	387	439	374	400
2002	413	323	424	384	386
2003	423	313	398	378	378
2004	429	365	394	476	416
Source	National T	ranait Databaar		2004	

Source: National Transit Database (NTD) 2000-2004

At least some portion of the additional FTEs accounted for the 69.2% increase in inspection and maintenance labor hours in 2004; unfortunately, additional conclusions regarding the data are speculative.

The data can be used to compare growth in the two areas. Figure 3.17 compares growth in FTEs with growth in inspection and maintenance labor hours, which are represented in thousands, and includes trend lines for both factors.

Growth in both FTEs and inspection and maintenance labor hours from 2000 through 2004 is similar.

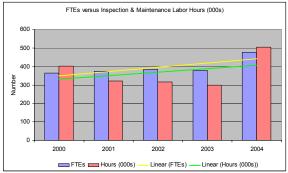


Figure 3.17 FTEs versus Labor Hours

Based on the data, inspection and maintenance labor hours per employee followed a downward trend during the observed time period. Labor hours per employee dropped by 22.2% in 2001 (from 1,103.2 hours in 2000 to 858.8 hours in 2001), and continued falling by

4.1% annually for the next two years. Even the large increase noted in 2004 (34.3% increase from 789.9 in 2003 to 1,061.5 in 2004) could not reverse the overall trend in the observed period. In 2004, labor hours per employee were still 3.8% lower than they were in 2000. Miami's inspection and maintenance hours in 2004 were 20% below the average and almost 30% below hours recorded at Denver and Cleveland.

A year by year comparison is presented in Figure 3.18.

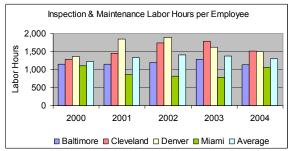


Figure 3.18 Inspection and Maintenance Labor Hours per Employee

3.3.9 Bus Maintenance Control Practices & Functions

MDT bus maintenance control (BMC) provides important support to bus maintenance. BMC personnel are located not only within the shop but also work out of a central office. Researchers met with bus maintenance control staff at each of the bus maintenance facilities as well as with BMC staff at the central division office.

Researchers documented BMC policies and essential job functions and gained insight into the communications between all levels of bus maintenance and BMC personnel. CUTR also examined data and reports that are provided to bus maintenance by the bus



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maintenance control division. The BMC organizational structure is presented in Figure 3.19

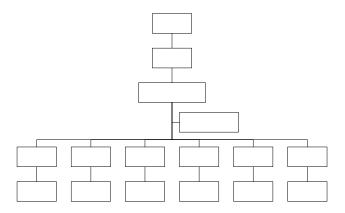


Figure 3.19 Bus Maintenance Control Organization Chart

It is bus maintenance control's responsibility to:

- ensure that information required to conduct the varied aspects of bus maintenance is available;
- verify by inspection of records and activities that operating maintenance actions and products conform to MDT specified requirements and standards; and,
- routinely monitor and report on the performance of bus maintenance functions in the server as of quality PC Central quantity, and timeliness of activities.

Bus maintenance control serves as a primary source A to historia intenance defined data and documentation and cufrently operates under the direction of the division of administration. The chief of bus maintenance control reports directly to the assistant director of business management.

Bus maintenance control was carved out of the bus maintenance organization and designated a division in October 2003. Prior to that time, BMC functioned under the jurisdiction of the division of administration.

In the three traditional O&I facilities. there are four bus maintenance control clerks (BMCC) on staff. Clerks that were the precursor to the current BMC clerks reported to the bus maintenance BMC clerks are currently chiefs. supervised by transit maintenance production coordinators (TMPC). The TMPC positions were re-established in 2003, after the positions had been phased southing that the that the production coordinators were new dispatched to the divisions to supervise the clerks, who were renamed bus maintenance control clerks. Bus Maintenance

Control

There are no administrative clerks assigned to bus maintenance. Administrative Bodffinctions are performed througher by coint effort of the BMC clerks and the bus maintenance supervisors.

Bus Maintenance Contro

In the past, BMMediever(BMCC) weekend coverage with one clerk at each traditional O&I shop. This practice was discontinued Mecause productivity among weekend staff was found to be unacceptable. However, with significant growth among the bus maintenance division's workload. esperial vices on weekends and on an overtime basis. BMC clerks are often faced with an even greater backlog of work on Mondays. As a result, weekend coverage by BMC was scheduled to be reinstated in January 2006, with some modifications. The new position is designed to be a

TMPC Special Projects (2)

BMCC Special Projects (1)



fulltime pick position, which involves a regular 40-hour per week schedule, Tuesday through Saturday. Regular days off for the new position will be Sunday and Monday. BMC management believes that the new approach to weekend coverage will improve productivity.

Overtime is assigned based on emplovee desire and performance rather than on seniority. To ensure that each clerk is skilled in every aspect of the job, duties are rotated at regular intervals, usually every three to four months, with the actual frequency of such rotations left to the discretion of the transit maintenance production coordinator. Payroll duties are an exception to this practice, as clerks with this responsibility are usually maintained in this position for at least a full year.

One of the bus maintenance control division's most vital roles is the management of bus maintenance employee payroll data. There is a large amount of responsibility associated with doing payroll. As such, the shop-level clerk assigned to payroll input must be approved and receive security clearance.

Paperwork is a major issue for bus maintenance clerks. Repair orders are often incomplete or illegible, which becomes especially problematic if the orders are referenced as part of a research effort.

Transit maintenance production coordinators (TMPC) are primarily responsible for scheduling and monitoring PMI adherence, road call monitoring for repeat failures, ad hoc requests from the four divisions, and supervising bus maintenance control clerks (BMCC).

The TMCP position involves a number of daily, monthly, and miscellaneous responsibilities. Central BMC provides checklists of daily and monthly production coordinator responsibilities, which must be completed.

The nature of the production coordinator position allows for frequent contact with maintenance bus supervisors, superintendents, and chiefs. Bus maintenance management staff can request specific information and data analyses from the TMPC; however, requests must be reasonable and must not impede the completion of the daily checklist. In the event that a bus maintenance request would require significant time complete, to the standard protocol is for the bus maintenance shop to submit a formal request to central BMC management. Special project TMPCs, who float from shop to shop as necessary, usually handle such requests.

Requests made to production coordinators by bus maintenance management staff tend to vary by shop. Bus maintenance chiefs have different expectations regarding how data should be presented and formatted. The number of requests and the amount of communication can also vary. However, prefers management BMC to standardize most functions, including report presentation and methods for handling requests. In general, Production coordinators have



experienced few problems with the ad hoc data requests.

Historically, MDT bus maintenance supervisors, chiefs, and superintendents have been reassigned to other bus maintenance facilities as necessary. While there appears to be no set interval for such relocations, TMPCs are required to be adaptable to new and/or different requests made by reassigned bus maintenance management staff.

Bus Maintenance Control management directs general policies for shop-level TMPCs to follow regarding bus PMIs. Policies are in place to set a window of time for completion. BMC indicated that shops rarely miss inspections.

Bus Maintenance Control staff played the lead role in setting up a PMI committee through the Partners in Productivity (PIP) process that created a policy and PMI procedures for surplus buses and developed fleet specific PMI procedures incorporating all OEM recommendations.

Four BMC production coordinators were on the committee, which compared OEM requirements to existing forms. BMC is assisting with updates to the PMI forms. The new forms will be given first to trainers, then to the remainder of the maintenance staff.

A fourth PMI was suggested and then abandoned in favor of a long-term inspection similar to the "F" and "G" inspections in rail. In general, the new PMI program will be fleet specific. Each bus type will have a PMI form tailored to its features. Inspections will also be modified to include everything that the OEM recommends.

BMC recently completed identification of all serialized components for engines, transmissions, and AC compressors and has established a close working relationship with FESM.

In the past, when MDT needed to perform retrofits on buses, only a few people were engaged in the activity with minimal documentation of the process. That resulted in a lack of knowledge of the methods used to complete the BMC has made an effort to retrofit. change the process. For retrofits, FESM now does the "how to," and BMC reports the results. BMC also gets involved in the start up of campaigns, finalizes the procedures, and serves as the custodian of the records. BMC is also involved with procedure manual updates.

BMC tracks and reports the number of open repair orders on a weekly basis. A repair order is considered "open" if all necessary and relevant information has not yet been entered into the system or if the order has not been specifically closed. Although the goal is to have no more than 100 open repair orders per week, the current number is closer to 300. Some of the open repair orders are duplicates, and the division is working to address and resolve the issue. In some cases, computer data output shows open repair orders even though the information has been Another issue involves the entered. process of actually confirming that the been performed work has and completed before the order is closed.



Duplicate orders also confound this area. It is interesting to note that some degree of difference in these issues exists from shop to shop.

The process of entering data from the repair orders is challenging for several reasons. Often times, clerks receive the forms in a less-than-desirable condition. Forms may be dirty or contain illegible handwriting. Modification of this process is an MDT priority. Among proposed improvements requiring are the superintendent's signature or changing repair order form. the Further improvements could include working with the IT division to synchronize repair orders with other reports. Both bus maintenance and bus maintenance control staff favor the consideration of computer access for employees for work-related purposes, specifically, allowing technicians to enter their own repair order data. Computers could be made available to technicians on the shop floor, in the lunchroom, or in a special area within the shop. BMC suggested that accuracy will improve, if technicians are allowed to enter their Additionally. own data. BMC productivity might improve because clerks and production coordinators will not have to spend time searching for clarification regarding unclear source documents.

BMC is also involved in handling repeat failure buses. This process has been modified to meet current conditions. In the past, a list of repeat failures, or "chronic" buses was sent to production coordinators on a regular basis for analysis and investigation. As staff levels fluctuated, the ability to maintain this function declined. As a result, the lead PC, which is a position based out of the central BMC office, floats among the traditional O&I shops in order to troubleshoot and oversee each shoplevel production coordinator.

Bus maintenance control currently posts performance reports on the MDT intranet for use as needed by the divisions. The agency is also in the process of developing unique Internet websites for each division. Ideally, the Bus maintenance division, including chiefs and superintendents, could consult these reports, identify problem areas, and address such problem areas as necessary.

Bus maintenance control is also responsible for oversight of the current fuel management system, which was produced by the EJ Ward Company. The basic system function is as follows:

- Each hostler has a card that is scanned prior to each fueling of the bus
- Meanwhile, the system identifies the bus automatically when it is pulled into the fuel island
- The hostler card turns on the fuel pumps and identifies which hostler filled the bus
- This information becomes a "transaction" that is tracked by the system
- Specific data captured includes:
 - Total fuel dispensed
 - Bus data
 - Hostler data
 - Other control functions



This process is viewed as a fuel accountability issue. BMC staff monitors delivery of fuel, the quantity of fluids dispensed, the quantity of fuel consumed, and the associated mileage. BMC hopes to identify discrepancies through use of this process. A redundant paper system is still in place.

The fuel management system has strong reporting capabilities. The system has specific restrictions that prompt actions to be flagged. For example, if mileage or fuel amounts are less than anticipated, access to fueling may be denied until the problem is addressed. Central MDT administration is particularly interested in fuel statistics. In fact, MDT fleet vehicles are not able to take on fuel at locations that do not have the EJ Ward system in place. An end-of-month report is produced, which examines fuel trends by fleet type and costs related to the actual amount of fuel dispensed. Day-to-day reports are also utilized for fuel consumption analyses and tracking bus consistency.

In an effort to integrate BMC functions into bus maintenance, training has invited BMC to provide a short informal introduction of bus maintenance control at the technician training classes.

BMC actively seeks to document relevant information concerning all aspects related to the bus fleet. Toward that end, an issue arose concerning BMC's role in emergency situations. After several emergency situations concerning bus fires, MDT management initiated a policy that called for the BMC chief to be notified of all bus fires. The BMC chief now contacts the production coordinator at the garage where the firedamaged bus is located to ensure the production coordinator takes the appropriate and required action.

Maintenance control procedures at the Medley facility are somewhat different than those in place at the other divisions. Penske Trucking performs many of the standard BMC functions at the Medley O&I facility, which limits BMC functions at that site and results in the need for only one BMCC at the Medley location.

BMC's interaction with Penske Trucking, is much different than BMC's interaction at the traditional O&I facilities. Rather than a full staff of four clerks and one production coordinator, there is only one BMC clerk on staff at the Medley facility. In addition, data generated by Penske Trucking are formatted differently than MDT's. As such, BMC reports that are issued for the traditional O&I shops appear to be more complete and more reliable than those generated for the Medley facility. Several factors contribute to this discrepancy.

Penske Trucking has its own system, which is based on managing trucks rather than buses. Penske's inspections contain items that are different than those items inspected at traditional MDT O&I facilities; nonetheless, Penske's inspections do meet minimum OEM requirements.

The facility is managed by an MDT project manager rather than by a chief, the manager at the traditional O&I facilities. The MDT project manager is onsite and reviews daily and monthly



reports. The project manager advises BMC of any discrepancies that are found. BMC has completed two performance audits of Penske's procedures.

In order to make data more compatible, BMC is in the process of developing a translation table for codes. This would allow Penske Trucking to reflect MDT codes. Compatibility of data is an extremely relevant issue as line-ups often require the transfer of buses from one shop to another. Problems arise when buses arrive at the new location with Penske Trucking data that MDT is unable to interpret, specifically, in the area of repair codes for a specific bus.

Mileage capture for PMI use is also different at the Medley facility. Penske Trucking uses a different method that must capture data manually for it to be used by MDT. Again, the Penske Truckina system data are not comparable to or compatible with the existing MDT system. Unfortunately, BMC has had to expend a considerable amount of effort to deal with this The Penske-Net system condition. records PMIs a day later than the MDT At end of month, Penske system. Trucking closes out repair orders and PMIs. If not complete, the order goes into next month.

Nonetheless, some positive experiences have been realized by BMC with regard to Penske. Penske tracks, measures, and monitors productivity in a manner deemed most desirable. For example, time stamps are used to account for productivity and allow for a more thorough review of work completed. In addition, PMIs are performed using a separate repair order. When defects are found, the repair order for the inspection is closed and a new repair order for the defects is generated immediately. As a result, defects are fixed in a timely fashion, and buses are not put into service with non-safety defects.

Penske Trucking also handles replacement parts differently. Mechanics personally retrieve parts from the parts storeroom at Penske, which MDT finds to be problematic. BMC could not be sure of the effectiveness of this method. Only one person staffs the parts storeroom at the Medley facility.

BMC expressed additional concerns related to the Penske effort. BMC suggested that modification of the following issues within the contract could improve the quality of service provided by Penske:

- Clarification of Penske's responsibility in data collection and data transfer to MDT, including original data records
- Improved computer security and controlled access
- Employee performance tracking in terms of hours and work
- Error free data records

In discussions with BMC staff at the various facilities, researchers encountered a transit maintenance production coordinator (TMPC) who reported extensive previous experience as a bus mechanic, as well as similar experience at another Florida transit



agency. The TMPC reported a great deal of interaction between the BMC staff and the Bus Maintenance supervisors and indicated that morning interaction is especially important, and face-to-face communication is preferred to emails or other impersonal methods.

Periodically, the TMPC may ask bus maintenance supervisors and/or technicians to collect specific data, such as bus series, engine type, etc. Such efforts are usually intended to develop ideas that will better assist bus supervisors with maintenance their regular responsibilities. Prior examples include changes or updates to codes and data accuracy improvements.

Shop-specific methods were utilized to varying degrees. Such variation may be due to a need for clarification or modified requests by newly assigned bus maintenance management staff. Examples include bus inspections and trend analyses. Although the central BMC office completes most analyses, some reports are generated at the shop level. Specifically, the TMPC generates a list of buses that are nearing a PMI and passes it to the bus maintenance supervisors. The actual scheduling of the inspections and route availability assigned to such buses (such as short trips only) are left to the discretion of the supervisors. The TMPC also compiles a weekly report, which includes the quantity of buses down, and provides it to the bus maintenance chief and supervisors.

The TMPC at another facility reported that the BMC division is moving toward implementing similar work practices at each shop. Such an effort would include many standard procedures now in place, such as a four-clerk hourly staff that works Monday through Friday from 7 a.m. to 3 p.m. Clerks at this facility also shared responsibilities and periodically rotated job functions. One TMPC, with regular hours of 7 a.m. to 4 p.m., supervises the clerks and reports to central BMC.

While weekend coverage is no longer in practice, TMPCs generally agreed that an extra clerk assigned to work on Mondays would be beneficial because staff is always trying to catch up on weekend issues.

3.3.10 On-going Training for Technicians and Supervisors

Training methods and priorities are also indicative of management philosophy, and they have a clear impact on employee productivity. Training methods, selected topics, and specified priorities can vary widely among Activities observed at the agencies. peer agencies are especially relevant to this discussion. Specific details to consider are unique innovations and practices with training (if any), and the attitudes of chiefs and supervisors toward training, including effects on daily operations.

In Miami, the option to seek additional training is generally left to individual supervisors. Some resist learning about the latest technologies, while others attend training sessions whenever possible. One supervisor appeared especially self-motivated to work on buses, learn new techniques, and keep current with new equipment. Extra effort



is regularly made to maintain shift coverage by two supervisors, while allowing for attendance to instructional sessions.

Supervisors at one facility, which had no assigned trainers, described themselves as "out of practice" with "hands on" mechanics of buses. **Supervisors** indicated that many of them have not worked on buses for so long that they really cannot offer good advice on problems. A supervisor, who has been off the shop floor for 12 years, is unfamiliar with the buses in operation today due to significant changes in the fleet. As such, more training for supervisors is needed, especially regarding updates for new buses. Unfortunately, training reduces the number of staff available in the shop. In most cases, supervisors that are unable to answer questions about current equipment refer the questions to their most experienced technicians.

At one facility, supervisors reported that some of the best mechanics are often promoted to supervisory positions, which removes them from "hands on" bus maintenance. They expressed concern about the knowledge gap that was being created as experienced technicians moved away from direct bus Supervisors maintenance. also acknowledged a serious deficiency regarding their knowledge of and expertise with laptop computer operation. Further exacerbating the problem is that those supervisors with seniority high are admittedly not interested in learning new mechanical skills. The shop also experiences the problem of highly trained people taking

or picking jobs that do not fully utilize their skills and expertise. Many technicians use Metrobus maintenance as an entry portal to Metrorail or Metromover maintenance. Although granting Metrobus technicians salary parity with rail technicians was intended to minimize this effect, supervisors report that it continues to be an issue.

Supervisors at all of the divisions acknowledged a need for additional training for technicians and expressed concern about the reduction of the length of the training program for new hires. The shortened training program has resulted in a loss of proficiency on the part of the new technicians when they reach the shop floor.

Supervisors suggested that technicians who are required to enter repair order data directly into computers would benefit from training modules devoted to computer use and diagnostics. Most of the instruction related to wheelchair lift repair is on-the-job. Since manuals and other types of documentation are not always available, a specific course covering repair of the lifts would be beneficial as well.

In response to a resolution from the Miami-Dade County Commission in April 2003, a pilot apprenticeship program to fill vacancies, such as bus maintenance technician, resulting from recruitment difficulties and/or retention was established. The pilot program began in August 2003 with a total of 44 students participating from technical two education centers. A total of 850 hours of training are provided to each participant over a six to eight month



period. Miami-Dade Transit provided a transit bus along with new engines and specialized hardware to each of the two technical education centers in order to enhance the training programs. Successful participants are hired into a six-month on-the-job training program within MDT. Trainees who successfully complete the MDT on-the-job training enter probationary status in the bus maintenance technician classification.

Supervisors reported that, unfortunately, most, if not all, of those enrolled in the apprenticeship program were never actually trained on a transit bus. Supervisors also reported they observed training deficiencies in the area of advanced technologies, especially in the use of laptop computers for bus maintenance diagnostics.

It should be noted, however, that in an alleviate attempt to an existing manpower shortage and minimize the use of overtime in May 2004, MDT assigned a mechanic trainee class, consisting of 21 employees, to the divisions for on-the-job training prior to completion of the technical education center portion of their training, which could account for some of the difficulties noted by supervisory staff. The mechanic trainee class did return to formal classroom training in April 2005 and successfully graduated from the program in September 2005.

Following is a summary of 2004 and 2005 training programs that were identified from MDT's monthly activity report. It appears from the summary that training opportunities increased in the summer of 2005.

Training Initiatives, FY 2004-2005

Vendor Training: Graham-White Air Dryer	October 2003: Most Technicians and several instructors
Vendor Training Ricon Optare Wheel Chair Ramps	October 2003: Coral Way
New Horizons Training	February 2005: Several Supervisors
NABI Air System Training	May 2005 - June 2005: Technicians and Supervisors
Supervisor Certification Training	May 2005: Two Coral Way first year Shop Supervisors
DAR System Training	June 2005: Two training sessions for Supervisors
TSI Training	June 21-24, 2005: Bus Maintenance Staff
Air Systems Components	July 2005: Technicians and Supervisors
Cummins Engine Factory Training	July 2005: Unit Rebuild Shop Supervisor
Homeland Security Training at FDLE	August 2005: Spuerintendents and Transit Shop Supervisors
VAPOR Door System Training	August 2005: Northeast and Support Services Technicians

The bus maintenance training program at MTA, which is managed by the human resources division, is currently under modification. The new computer management system, MAXIMO, will be utilized to track individual employee's training certifications. To coincide with the brake-only repair shop concept, bus maintenance management intends to put all mechanics through brake training school. In addition to brakes, current intraining includes engine house diagnostics and **OEM-sponsored** offers the ASE training. MTA certification program, which allows maintenance employees to ultimately achieve the level of master technician. A pay increase is associated with this achievement. Technicians must recertify at the master level every five years. Like many transit agencies, MTA includes vendor training packages with new bus procurement contracts. MTA has also met with local junior colleges about cooperative training for existing employees.

GCRTA also makes sure that vendorprovided training is included with all new vehicle purchase contracts. In the event that the specific bus is already in the



fleet, the agency requests that training focus on new features and equipment. The aradina system for training functions somewhat like an apprenticeship program. GCRTA also conducts "train the trainer" sessions for in-house training. The agency is aware of the need for training for older mechanics newer technology. on Unfortunately, time and funding issues confound some of these efforts.

RTD has an extensive training program that is tied to employee advancement. Mechanics enter at the bottom of a 6step pay scale. As training and certification are completed, employees move up in pay. Certification is a 2-step process, which includes written and applied components. All training is done during the day shift on agency time. There are nine zones in the training program; certification in six of the nine areas is needed to earn the top wage. Beyond this level, employees can work on re-certifications to earn further pay increases. However, participation in the program is voluntary, and employees are not penalized for unsatisfactory results. This system has been in place since 1980, and both employees and management are generally satisfied with the program. It is interesting to note that the union is also very satisfied with RTD's training efforts.

3.3.11 Engineering

As described earlier, shop-level management engages in a host of interdivisional communication. Much of this interaction revolves around support. While Bus maintenance control provides the most support to Metrobus maintenance, this investigation sought

discover opportunities for other to divisions to provide more support to bus maintenance. One such division was field engineering & systems maintenance (FESM). CUTR examined maintenance supervisors' and chiefs' perspectives on FESM's current role in bus maintenance. FESM recently committed to expanding support to bus maintenance and plans to be more involved in troubleshooting excessive parts failures. FESM agreed to disassemble and analyze a problem component. Opportunities may also exist for FESM to be involved with rebuilds, tests, road tests, supports, etc. In fact, Bus maintenance control discussed FESM's role in the retrofit process. It is FESM that will develop the "retrofit how-to." Bus maintenance supervisors may be able to provide insight into potential changes that can be made to make FESM more effective in bus maintenance through involvement random audits in or writina specifications for PMIs.

Supervisors at the Medley facility reported little involvement with FESM. several opportunities However. for collaboration were identified. Amona the ideas for changes or improvements that FESM could contribute to at this shop were those dealing with lifts. There are no permanent lifts installed at In lieu of such an this location. installation effort, the shop needs a better and safer method for technicians underneath the to aet buses. Supervisors also cited traffic flow within the yard as a hazardous problem that could be addressed by field engineers.



Supervisors at some of the other facilities also reported little involvement with FESM, and all agreed that any additional involvement would be welcomed assistance.

FESM staff are reportedly involved with PIP meetings at one facility. FESM specifications distributes and asks maintenance supervisors for review and input. The shop also receives FESM memos regarding specific problems and related solutions. For example, FESM is involved with developing new specifications for PMIs. Bus maintenance supervisors also reported general aid that FESM provided concerning problem-solving techniques.

Supervisors and chiefs at another shop indicated that they collaborate with FESM as necessary. Bus maintenance staff was generally satisfied with FESM's responsiveness in searching for information, when they do not know the answer. Supervisors also reported that FESM personnel used to perform PMI audits and compare them between bus technicians. Time constraints and job demand have tabled this effort in recent times.

3.3.12 Miscellaneous Issues

Although environmental and waste management practices are usually not at the forefront of a discussion regarding bus maintenance management programs, such considerations are nonetheless a necessary element of best industry practices.

Of the three peer agencies, RTD offered the most detailed information in this area. The agency conducts an annual

first responder refresher course, which deals with potential spills and other related potential emergency situations. RTD recycles engine oil waste and actively follows Environmental Protection Agency (EPA) guidelines for tire disposal. Bus emissions are tested annually, and refrigerant is monitored to diagnose leaks as soon as possible. Environmental considerations with respect to operations have a direct effect on bus maintenance at the Denver agency. RTD uses hybridthe downtown electric buses on pedestrian mall. There are 36 buses employed on this busy, circuitous route. Although environmentally friendly, they are expensive to maintain. The main reason for this is that the usage pattern for these vehicles is particularly harsh, with stops and starts at every block and passenger loads that quickly fluctuate from full to empty. RTD is engaged in other alternative fuel efforts that have potential to impact the bus the maintenance division. In cooperation with the NERL, RTD is testing bio-diesel fuel in buses used in the Boulder area. RTD also has 63 CNG and LNG buses dispersed throughout its fleet, with an option for 250 additional buses. The agency is monitoring lifecycle costs and is paying particular attention to fueling, reliability, and high maintenance issues, which are commonly associated with alternative fuel buses. The unique topography of the area also impacts the function of such vehicles.

While the other peer agencies specifically identified fewer environmental and waste management activities, this does not necessarily mean that similar practices, such as engine oil recycling, are not employed at them. MTA reported that the agency is in the process of acquiring ten hybridelectric buses. Officials at GCRTA said they were in compliance with all environmental laws, but were uncertain what, if any, measures the agency has taken beyond that.

In recent years, there has been considerable growth in the use of spatial data solve transit problems. to Specifically, spatial data tools and techniques, such as GIS, have played an important role. While application of GIS that is specifically related to bus maintenance programs may not be immediately apparent, there is considerable potential for its use. Although MTA and RTD have yet to utilize such methods. GCRTA did collect spatial data to solve a maintenance Specifically, GCRTA had a problem. problem with right-hand mirror accidents and generated a list of "hot" spots to be investigated.

3.4 Employee Productivity

In order to identify influential factors that effect bus maintenance employee productivity, CUTR compiled data about the organization and the workforce. requirements, Manpower customer satisfaction surveys, and bus operators' roles in defect identification are all factors that contribute to productivity. Previously completed bus operator focus groups, which included discussions about their relationship with maintenance, were documented in the Phase One Final Report. CUTR hoped to review customer satisfaction surveys; however, none were deemed relevant to this area.



Several specific productivity issues were brought to light as a result of the Quality Assurance Audit (November 2004) of bus maintenance procedures.

Bus Triage

Ideally, this process sorts buses by the severity of the problem so that easy fixes are expedited and buses are returned to service more quickly. The audit found that prioritizing buses requiring maintenance and optimizing the order of repairs was highly variable and especially dependent on the skill level of individual supervisors. The audit recommended that supervisors performing triage should be readily able not only to diagnose problems but also to assign a technician of appropriate skill level to handle the repair guickly and properly.

This procedure appeared to be in place at one of the facilities. The facility described the use of a "hotline" process that was highly effective in identifying and prioritizing maintenance problems. Supervisors indicated that the hotline played a major role in identifying problems and was critical in returning buses to service.

Bus Defect Cards

The manner in which the defect cards are submitted and processed was found to be variable and less efficient than it should be. The ideal manner in which bus maintenance would respond to defects should be similar to the procedures employed by rental car agencies at the time of customer returns. Supervisors at one of the facilities indicated that the bus operator's defect card is stapled to the repair order. It provides a good description of the problem, especially since the bus operator reviewed the defect card with a maintenance supervisor and discussed the nature of the problem. For all road calls, the repair order with the attached defect card is forwarded to the technician provide to as much information as possible.

Yard Procedures

Direct supervision of hostlers was reported to be minimal. Communication between hostlers and maintenance personnel was also said to be minimal. The process of bus returns, which includes bus triage and bus defect cards as mentioned above, should be such that it begins from the moment the bus drops its fare box and continue until the moment the bus pulls out for service again. The entire process should be reevaluated to ensure that it is operating as efficiently as possible.

PMIs

The November 2004 Quality Assurance Audit found that the PMI checklist used by maintenance personnel did not clearly identify required features and equipment for the active fleet.

A supervisor at one of the facilities agreed that current PMI forms were really outdated and spoke positively about proposed changes to the PMI, specifically the addition of type, series and engine specific information. Bus maintenance control confirmed development of new fleet specific PMI procedures. Several supervisors did note that other changes in the PMI program were needed. In the past, a bus with defects identified during the PMI was not permitted to return to service until defects were corrected. At present, a bus may return to service with defects as long as the defects are not safety defects. Safety defects must be corrected prior to returning a bus to service. A sample of buses with nonsafety defects identified on the magnetic board at one of the O&I Facilities during a site visit is shown in Figure 3.19.

Employee productivity is an issue that has gained attention within the transit industry. Various methods have been identified to monitor the work time of maintenance employees and are being considered for use by many transit agencies.

Time monitoring methods implemented by MDT and peer agencies were examined and found to vary among the agencies.

MDT has incorporated time standards for PMIs, but has yet to establish time standards for repairs. MDT did contract with Florida International University (FIU) to complete a Times Standards Study within Metrobus maintenance. Bus maintenance staff indicated that FIU developed time standards based on assumption that work the was performed under optimal conditions; however, such conditions are rarely the case in practice. Bus technicians have varying levels of skill, which results in differences in the amount of time required to complete diagnostics as well as "repair and replace" efforts. The





status of the time standards project is uncertain.

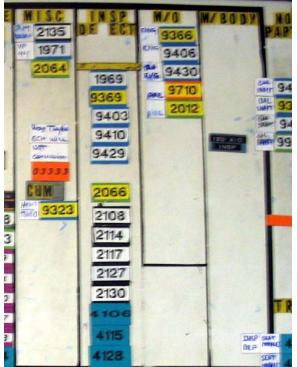


Figure 3.20 "Inspection Defects" displayed on magnetic board at one of the maintenance shops

RTD in Denver has established time standards for selected bus maintenance The agency's maintenance repairs. recording system calculates average times for repairs and documents the average time necessary for items on the repair order. The system informs employees of their performance relevant to the accepted average. The bus maintenance division is actively engaged in an effort to encourage employees to meet time standards and to identify if and where problems may exist.

MTA reported that its new system, MAXIMO, will be capable of monitoring the time mechanics take to complete repairs. A supervisor will generate an electronic work order and assign it to a mechanic. Mechanics will enter data as necessary throughout the repair period. The mechanic will log a final entry when repairs are complete. MTA bus maintenance managers also indicated that, ideally, the concept of the brakeonly repair shop would also lend itself to monitoring the time involved to complete specific repairs.

GCRTA reported very little use of strict time monitoring methods; however, the bus maintenance division utilizes "time restrictions" for work orders involving PMIs, interior cleaning, and brakes. The agency has seen resistance by the union to strict time limit guidelines. Union representatives generally accept only very loose time frames. As such, the few time standards adopted by GCRTA lack precision and tend to be difficult to manage. This is also the case because first line bus maintenance supervisors are also union employees.

In addition to establishing time standards for specific repairs, advanced technologies allow bus maintenance management to track maintenance employee workmanship. While the current extent of such management tactics is difficult to measure, such practices, if used by the peer agencies, are relevant.

At the time of the site visits, none of the peer agencies was actively involved in documenting the workmanship quality of individual bus maintenance technicians. However, MTA reported that its new MAXIMO system will have this capability, should managers decide to utilize the information. GCRTA advised



that the decision to track the quality of employee workmanship is generally left up to supervisors at each shop. The agency is also in the process of upgrading management software, which will significantly facilitate the process of tracking employee workmanship quality.

The extent of training completed by maintenance personnel and maintenance supervisors also has an impact on employee productivity. As such, investigation and documentation of issues related to employee training was warranted. Furthermore, training departments should be aware of all employees in training and should retain copies of all training-related materials.

A transit agency that employs a management-by-objectives approach within its bus maintenance program is said to be following a best practice. Each of the three peer agencies studied here indicated they follow such an approach, which involves developing and utilizing performance measures that are guided by the agency's overall objectives. Such performance measures are incorporated into the agency's decision-making process, with respect to developing planned policies, procedures, rules, and programs. Factors used to gauge performance also offer another key insight into a transit agency's bus maintenance management philosophy. Some of the more important performance indicators and performance measures used by MDT and the peer agencies are briefly described below.

MDT has established a variety of performance measures along with

identified targets that are tracked by individual facility and the agency as a whole. The performance measures are published in a monthly report by Bus maintenance control. Those measures include on-time performance, vehicle availability for peak service, preventive maintenance inspection on-time adherence, miles between mechanical road calls by fleet type, and missed or late runs.

Following is a review of several of those factors.

On-time Performance

Miami considers a bus to be on-time if, the bus leaves the bus stop at the scheduled departure time and/or no more than five minutes after the scheduled departure time. There is no tolerance for the bus leaving the bus stop prior to the scheduled departure time. Miami's target for ontime performance is 75%, as shown in Figure 3.21. During Fiscal Year (FY) 2005, only the Coral Way facility was able to achieve the 75% on-time target, recording 86% on-time performance in 78% April 2005 and on-time performance in May 2005.

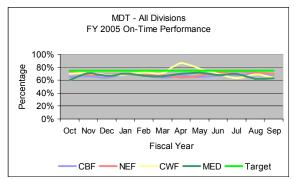


Figure 3.21 FY 2005 On-time Performance

Vehicle Availability for Peak Service



Miami schedules service throughout the day based on passenger demand. The peak vehicle requirement (PVR) is the total number of vehicles needed simultaneously in the peak periods to satisfy passenger demand while maintaining vehicle passenger loads at or below a pre-determined level, based on MDT's established load factor.

There are two peak periods throughout the day, the AM peak and the PM peak. Peak periods, as defined by the FTA, are times when additional services are provided to handle higher passenger During these volumes. times. scheduled headways (amount of time between scheduled buses) are reduced. peak periods end when These headways are returned to normal.

Miami's measure of vehicle availability for peak service is defined as:

Vehicle Availability = Scheduled PVR - Maintenance Misses Scheduled PVR

Vehicle requirements for peak periods used at Miami's four divisions are presented below and vary by day of week and time of day.

		200	5 PVR	2		
	A	M		F	M	
Full-size	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun
CBF	188	113	101	201	126	111
CWF	175	95	82	191	114	106
NEF	190	120	99	199	137	112
MED	41	19	16	33	18	17
Total	594	347	298	624	395	346
Minibus	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun
CBF	37	20	80	39	20	21
CWF	49	29	25	49	36	33
NEF	11	7	6	14	8	9
MED	44	11	12	45	17	15
Total	141	67	123	147	81	78
System	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun
Full-size	594	347	298	624	395	346
Minibus	141	67	123	147	81	78
Total	735	414	421	771	476	424

The peak requirement for full-size buses occurs at the central facility for the weekday afternoon peak period, when 201 buses are required to meet service requirements. Peak requirements for minibuses are at the Coral Way facility to meet weekday morning and afternoon peak service. The weekday afternoon peak period requires the highest total of buses at 771, which includes 624 fullsize buses and 147 minibuses.

Miami has experienced relatively high growth in vehicle requirements in the past several years. Growth in peak vehicle requirements since 2004 is detailed below. The largest increase in vehicle requirements by day of week and time of day is highlighted.



	2005 v	/ersu	ıs 200	4 PVR		
	A	M		F	M	
Full-size	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun
CBF	30	16	17	37	19	19
CWF	27	2	3	30	5	8
NEF	26	1	4	24	4	0
MED	9	-2	-5	-3	-6	-7
Total	92	17	19	88	22	20
Minibus	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun
CBF	7	2	63	4	-7	-1
CWF	1	9	7	2	10	10
NEF	-11	0	0	-9	2	5
MED	-1	-9	-8	-2	-11	-10
Total	-4	2	62	-5	-6	4
System	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun
Full-size	92	17	19	88	22	20
Minibus	-4	2	62	-5	-6	4
Total	88	19	81	83	16	24

The percentage increase in the growth from 2004 to 2005 is reflected in the following chart:

		Grov	wth in PV	/R		
		AM			PM	
System	Mon-Fri	Sat	Sun	Mon-Fri	Sat	Sun
Full-size	18.3%	5.2%	6.8%	16.4%	5.9%	6.1%
Minibus	-2.8%	3.1%	101.6%	-3.3%	-6.9%	5.4%
Total	13.6%	4.8%	23.8%	12.1%	3.5%	6.0%

The target for AM and PM bus availability at each of the divisions is 100%. Bus availability performance for Central, Coral Way, and Northeast from FY 2003 through FY 2005 is illustrated in Figures 3.22 through 3.24.

Some decline in bus availability is noted at all three facilities for FY 2005. The decline in performance does coincide with relatively high growth in the vehicle requirements, which occurred at all of the divisions, as presented previously.

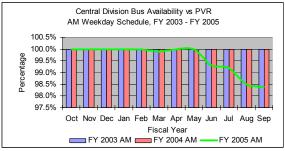


Figure 3.22 Central AM Peak Vehicle Availability

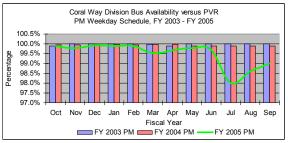


Figure 3.23 Coral Way AM Peak Vehicle Availability

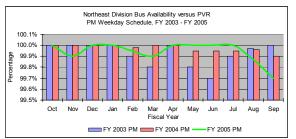


Figure 3.24 Northeast AM Peak Vehicle Availability

The Medley division, which opened in April 2004, also experienced difficulty in achieving bus availability, despite meeting target levels during the early months of operation. Medley AM peak availability for FY 2004-2005 is presented in Figure 3.25.

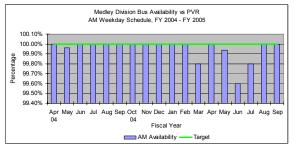


Figure 3.25 Medley AM Peak Vehicle Availability

PMI On-time Adherence

PMI on-time adherence has been defined by MDT as:

On-time PMI = #PMI Performed On-time Total PMI Due

The target for performing PMIs on-time at each of the divisions is 100 percent. PMI on-time performance for Central, Coral Way, and Northeast from FY 2003 through FY 2005 is illustrated in Figures 3.26 through 3.28. Coral Way has achieved the target since FY 2003. Northeast performed at a level close to the target in FY 2005, while Central fell below the target several months during FY 2005.

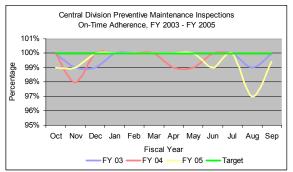


Figure 3.26 Central PMI On-time Performance

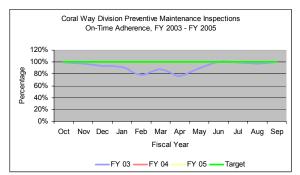


Figure 3.27 Coral Way PMI On-time Performance

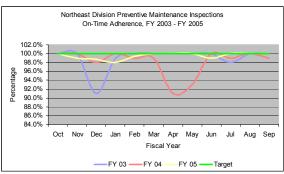


Figure 3.28 Northeast PMI On-time Performance

The Medley division, which opened in April 2004, experienced difficulty in completing PMIs on-time during early months of operation, but improved ontime performance in FY 2005. Medley's PMI on-time performance for FY 2004-2005 is presented in Figure 3.29.

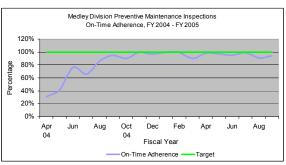


Figure 3.29 Medley PMI On-time Performance



Miles between Mechanical Road Calls A mechanical road call is a mechanical

revenue service interruption of five minutes or more that is based on a symptom code. "Miles between mechanical road calls" (MBMR) are defined as:

> MBMR = Total Miles Total Mechanical Roadcalls

MBMR data for January through March 2003 were revised due to elimination of four symptom codes, which were no longer categorized as "mechanical." Minibuses are included in the MBMR data.

The target for MBMR at Central, Coral Way, and Northeast divisions is 2,800 miles. MBMRs for Central, Coral Way, and Northeast from FY 2004 and FY 2005 are illustrated in Tables 3.30 through 3.33. All three divisions have shown a decline in miles between mechanical road calls in FY 2005.

Central division consistently failed to achieve the targeted MBMR beginning in mid FY 2004 and lasting throughout FY 2005. Coral Way, generally, achieved the target except during most summer months. The Northeast division achieved the target MBMR in only two months in FY 2005.

Table 3.30 Central Miles between MechanicalRoad Calls (including Minibus)

 Oct
 Nov
 Dec
 Jan
 Feb
 Mar
 Apr
 May
 Jun
 Jul
 Aug
 Sep

 FY 2004
 0
 0
 3,256
 3,986
 2,731
 3,156
 2,344
 2,599
 2,456
 2,141
 2,019
 1,823

 FY 2005
 1,554
 1,781
 2,422
 2,322
 2,213
 2,751
 2,398
 2,145
 2,025
 1,687
 1,695

 Target
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Table 3.31 Coral Way Miles between MechanicalRoad Calls (Including Minibus)

 Vot
 Nov
 Dec
 Jan
 Feb
 Mar
 Apr
 Apr
 Jun
 Jun
 Aug
 Sep

 FY 2004
 N/A
 N/A
 4,553
 5,025
 3,701
 3,958
 2,986
 3,632
 2,546
 2,656
 2,165

 FY 2005
 2,148
 3,079
 3,829
 3,707
 3,600
 3,509
 3,274
 2,722
 2,302
 2,905
 2,480

 Target
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Table 3.32 Northeast Miles between MechanicalRoad Calls (including Minibus)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
FY 2004	N/A	N/A	3,124	3,075	2,955	3,279	2,892	2,968	2,513	2,314	2,158	2,389
FY 2005	2,289	2,706	2,865	2,637	2,277	2,823	2,721	2,632	2,475	2,533	2,125	2,373
Target	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800

While the Medley division, which opened in April 2004, failed to meet its target of 7,500 miles between mechanical road calls in FY 2004 and FY 2005, it routinely exceeded the 2,800-mile target of the other divisions. Medley's MBMRs for FY 2004 and FY 2005 are presented in Table 3.33.

Table 3.33 Medley Miles between MechanicalRoad Calls (including Minibus)

 Oct
 Nov
 Dec
 Jan
 Feb
 Mar
 Apr
 May
 Jun
 Jul
 Aug
 Sep

 FY 2004
 N/A
 N/A
 N/A
 N/A
 N/A
 N/A
 S650
 4,335
 3,768
 3,151
 3,512
 4,597

 FY 2005
 3,359
 3,158
 4,310
 4,139
 5,483
 4,846
 3,880
 4,650
 4,714
 4,788
 4,855
 3,140

 Target
 7,500
 7,500
 7,500
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Maintenance-related Late Runs

MDT tracks runs that pull out of the yard late due to operations and maintenance delays. The "late run percentage" due to maintenance is defined as:

Prior to January 2004, Miami excluded minibuses from division-level reports. Minibus pullouts, lates, and misses are now included in division-level reporting.

Maintenance-related late runs for Central, Coral Way, and Northeast from FY 2003 through FY 2005 are illustrated in Figures 3.30 through 3.33. Linear trends for Central and Coral Way are generally upward, while Northeast remains relatively flat.

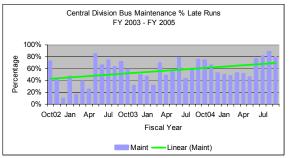


Figure 3.30 Central Maintenance-related Late Runs

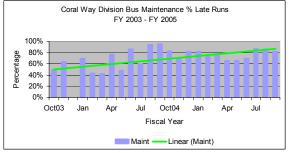


Figure 3.31 Coral Way Maintenance-related Late Runs

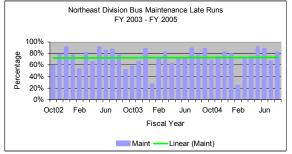


Figure 3.32 Northeast Maintenance-related Late Runs

The Medley division, which opened in April 2004, also shows a slightly upward trend in maintenance-related lates, which are presented for FY 2004 and FY 2005 in Figure 3.32.

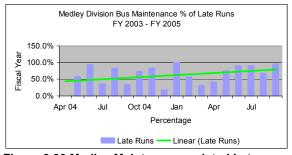


Figure 3.33 Medley Maintenance-related Late Runs

In terms of the use of performance measures at the peer agencies, MTA was in the process of developing work the standards at time of this investigation. Bus maintenance management was most concerned with on-time performance and in 2004 addressed problem and routes implemented new schedules to help correct them.

The new general manager at GCRTA directed that greater focus should be placed on buses. As such, a dramatic improvement was achieved with the miles between road calls indicator. Bus maintenance management staff also reported another important indicator to failures. be repeat which were monitored at the garage level. The agency also relied on standard including: miles between indicators. service interruptions, rider satisfaction, performance. on-time safety, attendance, and revenue. GCRTA incorporated a "Ride Happy or Ride Free" policy regarding customer service.

The board of directors actively sets performance measures at RTD. For example, in 2000, a goal for miles of lost service due to road calls was capped at 13,500. Although it may be costly to the agency, a goal of a 1-2% stock-out rate



was also in place. The agency utilized a tiered reporting system, and each maintenance division reported independently. Standards were measured through weekly loss reports, monthly budgeting reports, and quarterly reports submitted to the budget office. Several individuals reviewed the reports as they made their way up the management chain.

Each of the agencies were found to employ a 3-tiered maintenance program structure, which focused on daily, intermediate, and long-term issues. Specifically, this included daily regular maintenance tasks, preventive maintenance inspections completed at regular intervals, and major overhaul procedures that took place over the long term.

In order to measure agencies' commitment to maintaining the fleet, researchers examined inspection and maintenance labor hours per VOMS.

Miami inspection and maintenance hours per vehicle virtually did not 2000 change from to 2004. Maintenance labor hours per VOMS increased from 757.66 in 2000 to 762.09 in 2004 (an increase of 0.6%). Within the observed period, inspection and maintenance hours per VOMS decreased for two years (from 2000 to 2002), and then increased for the following two years (from 2002 to 2004), reaching the lowest point in 2002 (560.82 hours per VOMS). The linear trend for the four-year period (2000-2004) was flat and reflected minimal change in inspection and maintenance hours per vehicle. A large decrease in

inspection and maintenance hours per VOMS in 2001 (22.5% decrease) appears to have been nullified by a comparably large increase of this parameter in 2004 (an increase of 29.2%).

Despite Miami's 2004 growth in inspection and maintenance hours per VOMS (29.2% versus 2003), Miami provided fewer hours per VOMS than the peer agencies and was 18.1% below the average of the four agencies. Cleveland and Denver, respectively, provided 258.79 and 285.40 more inspection and maintenance labor hours per VOMS than Miami (34.0% and 37.4%, respectively).

Labor hours for inspection and maintenance per VOMS are detailed in Table 3.34.

Table 3.34 Labor Hours for Inspection and Maintenance per VOMS

	Baltimore	Cleveland	Denver	Miami	Average
2000	719.82	809.82	941.39	757.66	807.17
2001	734.92	914.66	1,358.42	587.18	898.80
2002	780.82	1,032.35	1,385.69	560.82	939.92
2003	857.99	1,024.82	1,094.31	590.07	891.80
2004	769.08	1,020.88	1,047.49	762.09	899.89
Sourc	e: National T	ransit Databas	e (NTD) 2000	0-2004	

3.4.1 Organizational Structure

Illustrating the organizational structure of the bus maintenance division at a transit agency can also provide insight into employee productivity. Important details may include modifications, challenges, and implementations, as well as the division's relationship with other divisions within the agency.

Miami-Dade Transit currently manages four O&I facilities. Three of these facilities, Central division, Coral Way Division, and Northeast division, are



similar in design and have been in operation for several years. The fourth facility, Medley division, entered service in 2004. All four divisions operate under the oversight of the assistant director, bus services through the general superintendent, bus maintenance.

Central, Coral Way, and Northeast are each managed by a chief of MDT bus maintenance along with a division superintendent of MDT bus maintenance. Support services management structure mirrors the three divisions with a chief and superintendent of support services.

Bus maintenance staff and vehicles are equally distributed among the divisions with the exception of the Medley which division. is smaller and responsible for fewer vehicles than the other divisions. The Medley division is project managed by а manager pursuant to a Miami-Dade County (MDC)/Penske Trucking contract.

A minimum of two supervisors (except at Medley where there are no relief supervisors provided) are assigned to each shift under the direction of the Superintendent. Technicians fall into a single classification and are union employees affiliated with the Transit Workers Union. Supervisors are members of the Government Association of Florida Supervisors (GSAF). Union picks for all positions, including major overhaul and shops, occur two times each year based on seniority.

The bus maintenance department at MTA includes four divisions. According

to management officials, this structure is a better option for the agency, especially transportation because the and maintenance director established а similar maintenance structure to be followed by all divisions. One superintendent is charged with managing a division. Seven divisional shift supervisors are in place under the superintendent. At least two shift supervisors lead the day and afternoon shifts, with one supervisor assigned to the night shift. Mechanics are union employees and fall into one of three levels: "A" repairmen, "B" repairmen, and "C" repairmen. MTA employs approximately 40 "A" repairmen per (approximately division 160 "A" "B" agency-wide), repairmen 16 repairmen (4 per division), and 40 "C" repairmen (10 per division). Cleaners are grouped into two levels, A and B. Union level repairmen and cleaner positions are picked once per year, according to seniority. Employees have the opportunity to go to any shop. However, one can only move up to an "A" position if there is a vacancy. Among the more important differences among the classes, "B" repairmen are not considered qualified for problem diagnosis. The major overhaul shops are not included in these figures. According to MTA bus maintenance managers, once technicians reach a major overhaul shop, they are less likely to move out because the hours are regular day shift: Monday through Friday, 7:30 a.m. to 3:30 p.m.

In contrast to the system in place in Baltimore, GCRTA moved away from a centrally managed bus maintenance program and adopted a district



management concept in 1998. As such, an individual district director oversees each maintenance facility. While there are pros and cons to both styles of program management, GCRTA favors autonomous district directors, which allows each of them more direct control over the day-to-day repairs within the maintenance facility. However, the agency did retain a centralized fleet maintenance department. which is responsible for inventory, technical services, warranty administration, heavy repairs, and maintenance standards.

Like MTA, Denver RTD also maintains a traditional centralized more maintenance management structure. positions employee Union are distributed among five areas, with most (173) under general repair. Technicians working in specialized areas are distributed as follows: unit shop (27), technical support (15), communications shop (8), and fare box/treasury (7). To determine the necessary number of employees, bus maintenance management specifically considers factors such as the number of miles projected for a bus and wheelchair lift issues.

3.4.2 Repair Orders

Almost all repairs performed bv Metrobus maintenance mechanics are initiated through the use of a written repair order. This section will attempt to document the steps involved in the bus maintenance repair order process. Specific details will include responsibilities of bus maintenance supervisors. bus mechanics. bus operators, bus maintenance control personnel, and relevant others. Shop

specific methods, if any, will also be documented.

General Steps in the Repair Order Process include:

- 1. Bus maintenance supervisor generates repair order
- 2. Supervisor fills out repair order form
- 3. Supervisor assigns job to an available technician who has relevant experience (if possible)
- 4. Supervisor gives copy of repair order to technician assigned to complete the work
- 5. Technician performs the repair and completes the form, detailing the work that was done
- 6. Technician returns the repair order to the bus maintenance supervisor control room
- 7. Bus maintenance supervisor reviews the repair order forms and completes proper codes, information, etc.
- 8. Bus maintenance supervisor submits the completed repair order to bus maintenance control

In general, when a repair order is generated, the reason for the order, the mechanical problem(s) is (are) coded, and the order is dated. The bus operator may have generated the repair order by calling it in, or if it is a road call, the responding service truck is documented. Checklists were developed through the PIP meeting process for use by operators to assist with troubleshooting. The operator may or may not fill out a defect card. Once a supervisor hard copy exists. the attaches the report to the repair order. It is relevant to note that defects found



during a PMI are completed as a repair order, not as part of the PMI.

Penske Trucking handles repair orders at the Medley O&I differently than the way they are handled at the other facilities. The repair order form is computerized using Penske's Service Net software. The supervisor assigns the repair to a technician, then the technician logs into the job. The supervisor can also log into the job. The technician proceeds to work on the bus and logs the status of the repair, including when it is completed.

The traditional O&I facilities generally follow similar procedures to initiate the repair order process and to track the status of repairs. Supervisors initiate the work order and generate a formal repair order and repair order number. This number is imported into the computer system and the task is to a technician. assigned The technician takes the physical form and fills it out, as necessary. Supervisors generally try to match technicians with jobs that utilize their strongest skills.

A large, magnetic board is used to indicate where buses are located and the nature of the service. Each bus assigned to the O&I is represented by a small magnet with the bus identification number. The board is sectioned according to status (in or out of service) and repair type. Some variation exists among the shops. For example, some control rooms have enough wall space to have the board all on one wall; while at other locations, the board may span multiple walls. Shops may also have a unique way of characterizing repairs,

based on the experiences within that location. For example, one facility reported that wheelchair lift issues are As such, the control room common. uses an orange square magnet placed by the bus number on the board to indicate that bus has a wheelchair lift issue. Supervisors report that 80-90% of wheelchair issues are likely caused by bus operator error. Supervisors at that facility stressed the importance of randomly inspecting bus maintenance repairs. They also randomly audit the physical repair order form.

Road calls are a significant generator of repair orders. Repair orders can also be generated inspection results by (commonly referred to as an "inspection defect," in-shop requests, or general bus operator complaints. A supervisor will generate a repair order based on inspection defects, if found. It is not unusual to generate double repair orders for the same bus. This is often the result of a bus going back out on the road after a PMI found a defect, but that defect was not repaired. In some cases, when required repairs are minor, the defects may be corrected on the "hotline," which avoids the need for a formal paper repair order to be generated.

As described earlier, bus operators' involvement in problem diagnosis was found to be relatively minimal among the peer transit agencies. MTA operators attend monthly bus safety meetings and complete pre-trip inspections. Bus maintenance supervisors report that operators at GCRTA rarely use defect cards. RTD also reported minimal



significance of operator input related to bus maintenance personnel productivity.

3.4.3 Written Procedures

Another best industry practice, written work procedures, and their availability for employee use, is believed to have a positive impact on bus maintenance employee performance.

Miami does have a written bus maintenance plan as well as a bus maintenance procedures manual. Both items are updated regularly by bus maintenance control with assistance from support services, bus maintenance, and FESM.

Relevant conditions vary among the agencies. For example, peer technicians at MTA are exposed to written maintenance procedures during the formalized training process. While GCRTA has no comprehensive work procedure document, specialized areas do have written procedures. Specifically, the PMI program has complete written documentation. Written procedures at RTD are included in the bus maintenance plan; however, they focused are mostlv on management functions related to the tasks. RTD is in the process of developing standard operating procedures for selected maintenance tasks.

Standard procedures for troubleshooting and diagnosis, if established, also have the potential to positively impact maintenance employee productivity. Although somewhat limited among the peer group, relevant practices that are most likely to improve technician

productivity are described below. At MTA, bus operators complete a pre-trip inspection prior to every pull-out. In addition, safety checks are automatically every included on MTA bus maintenance work order. Management at GCRTA specifically identified the agency's problem identification and corrective action (PICA) program, which encourages employees to identify problems in any area. Employees fill out the PICA form, which is then reviewed by management. Corrective measures are taken when they are deemed necessary. Bus maintenance management at RTD pointed to its strong communications efforts as the most relevant troubleshooting practices in place at the agency. Attendees are encouraged to discuss problem issues during regular staff meetings, guarterly supervisor-management meetings, or at any time through the "open-door" policy. If necessary, the problem can be referred to the quality control and/or training departments.

3.4.4 Road Calls

Although their numbers fluctuate from day to day, repair orders generated as the direct result of road calls generally make up a significant portion of the daily repairs handled by the bus maintenance This section looks at O&I facilities. common practices involved in handling road calls, including generation of the repair order and completion of the repair. Bus operators, bus maintenance supervisors. and bus maintenance technicians each play a significant role in road calls. General, as well as shopspecific, road call experiences are discussed in this section. The role and operating procedures of the service



trucks is also described. The Central and Coral Way O&I shops dispatch service trucks to points throughout the MDT service area, but there are no service trucks based out of the Northeast or Medley facilities.

Among their many responsibilities, bus maintenance supervisors monitor radio communications, when possible and try to answer potential bus maintenance issues for buses dispatched out of their shop. The intent of this action is to diagnose problems stemming from "primitive road calls," which are road calls that are correctible on the road, thus eliminating the need for the bus to be returned to the shop for repairs. However, a service truck may be dispatched, if necessary. Upon returning from their route, bus operators may also report to the maintenance control room to provide additional details about the problem that led to the road call.

The bus maintenance supervisor's involvement in the general process begins when the road call appears on the computer screen. The "data display" includes: date, time, bus number, symptom codes, and the nature of the problem. The data display also indicates which service truck was dispatched, if any, and contains remarks made by the service truck technician. One of four general status indicators related to Metrobus road calls also appears on the display. These general status indicators include buses that are towed in to the shop, fixed on the street, left in service (LIS), problem to be repaired later, or returned to garage (RTG). The data display allows the supervisor to start the repair order process before the bus returns to the shop. Upon learning the status of the problem bus, the supervisor will also flag that bus number on the magnetic board, according to the appropriate condition.



Bus maintenance supervisors cited bus wheelchair lifts as a significant issue with respect to road calls, especially for those buses equipped with automatic lifts. MDT requires that bus operators must completely cycle wheelchair lifts/ramps during the pre-trip inspection. In addition, testing of the wheelchair ramp/lift is part of the PMI. Nonetheless, if the mechanism fails, MDT agency policy, which dictates that no wheelchair-bound customer should ever have to be left behind, mandates that the bus must be taken out of service. Bus maintenance supervisors reported that in many cases, the problem with wheelchair lifts actually is a lack of lift operation knowledge among bus operators, rather than an actual mechanical failure. Unfortunately, this circumstance is still considered a failure and results in the bus being removed from service. Newer buses tend to have a manual operation backup, which



should ideally result in fewer road calls related to wheelchair lifts. However, according to the supervisors, wheelchair lift-related road calls still occur because a significant number of bus operators have not received adequate training to operate the lift manually.

Peer agencies also described ADA compliance as being especially problematic. Each bus must have all devices in working order or the agency runs the risk of being penalized. ADA equipment tends to present unique challenges to both bus operators and mechanics. As such, some agencies have taken steps to specifically address this area. As the result of a lawsuit. RTD is mandated to cycle and monitor each wheelchair lift at least once per To assure compliance with this dav. order, the radio is connected to the mechanism and automatically notifies dispatch when the function is complete. RTD also added Braille signs (including bus numbers) to each bus. GCRTA reported that its fleet is 100% wheelchair compatible, and this process was made easier because of the agency's conscious effort to maintain a homogeneous bus fleet. MTA found that its NeoPlan buses did not meet kneeling requirements. As such, the agency engaged a vendor to develop a plan to retrofit and repair these vehicles.

Several other factors impact the quantity and frequency of Metrobus road calls. Poor road conditions, which cause undo wear on buses, play a role in creating additional road calls. Soot build-up on engines, which causes excessive heat in the engine compartment, is also an often-overlooked factor in road call numbers.

Two service trucks are generally dispatched out of each shop where service trucks are assigned. They cover the morning peak period; one shift is 6 a.m. to 2 p.m., while the other is 7 a.m. to 3 p.m. The position of service truck driver, also referred to as a road call technician, is a pick position. There has been debate about whether or not to assign each service truck to a specific area. This would involve determining a "base" location for each service truck to which the driver would return at the end of each call. While this concept may offer some benefits, the general feeling among bus maintenance supervisors is that it would ultimately prove to be Each service truck is inefficient. responsible for a large geographic area. As such, requiring the driver to return to a specific point after each road call could result in a considerable amount of additional and repetitive travel. For example, a long-distance road call that is followed by another long-distance call in the same area would cause a significant amount of time and resources wasted on travel.

Advanced technologies the have potential to facilitate the repair order Computerized Equipment process. Management Systems (EMS) offer several beneficial features. However, the rate that available technologies improve generally outpaces a transit agency's ability to keep current with the most modern capabilities. In addition, technology training also tends to be an especially issue, among veteran personnel. This section briefly



describes current computer capabilities in use at the bus maintenance shop level. Concerns and suggested improvements are also noted.

At the Medley O&I facility, Penske Trucking makes extensive use of its proprietary software, Service Net. This system provides technicians with general login credentials and allows for repair order data to be entered directly by the attending technician(s). The details of this process are described elsewhere in this report.

The traditional MDT O&I shops utilize an EMS system, which is how road calls and repair orders are referenced by supervisors as described above. In fact, supervisors' greatest daily use of the system is to monitor road calls. Once in the system, a repair order can be called up through the EMS by clicking on the bus number. Additional bus-specific information contained in the record vehicle includes incident history, mileage, and a graphic historical, colorcoded display of maintenance problems for that bus. Unfortunately, there is no check within the system to prevent multiple repair orders from being opened on the same bus. This is a source of confusion and inefficiency and is especially confounding for Bus maintenance control efforts.

Peer agencies reported minimal difficulty with road calls. Baltimore allows vehicles with "minor road calls" to remain in service, while "major road calls" must be removed from the road.

Cleveland reported that miles between road calls greatly improved with the

arrival of a new general manager, who was focused on bus performance.

CUTR calculated annual vehicle revenue miles per total system failure to examine vehicle performance at the four All agencies displayed agencies. considerable improvement in performance from 2000 to 2004, with average revenue mileage growth per failure of over 200%. Miami increased the number of miles between failures from 1,283 to 2,375 miles, an 85% improvement. While Miami's increase is significant, it fell well below the 283.3% and 518.7% growth in miles between failures that occurred at Denver and Baltimore, respectively. Annual vehicle revenue miles per total system failure are presented in Table 3.35.

Table 3.35 Annual Vehicle Revenue Miles perTotal System Failure

	Baltimore	Cleveland	Denver	Miami	Average
2000	976	5,051	5,284	1,283	3,149
2001	4,628	4,938	22,123	1,543	8,308
2002	5,164	4,765	14,635	1,534	6,525
2003	4,350	8,293	21,078	2,263	8,996
2004	6,041	9,739	20,254	2,375	9,602
Sourc	e: National T	ransit Databas	se (NTD) 200	0-2004	

3.4.5 Laptop Computer Issue

The introduction of portable personal computers, or laptops, into the transit bus maintenance shop environment has been highly beneficial for diagnosing mechanical problems and analyzing performance data. As buses become more technologically complex, the use of laptops by maintenance personnel is essential. In fact, they have become most important among the tools available to bus technicians. Nonetheless, several factors impact their utilization and effectiveness. The following section details conditions and



experiences associated with bus maintenance laptop computers.

First, it should be noted that laptop computers are not used at the Medley division. Two standard personal computers are located on the shop floor of this facility. Technicians utilize these devices for diagnostics and to enter data into repair orders. Supervisors here report about a 60% proficiency rate among technicians.

The traditional MDT O&I shops extensively utilize laptop computers for diagnostics and "black box" data analysis. Supervisors report that most bus repairs involve some degree of laptop computer use. Many of the software programs contain drop-down menus that allow technicians to pinpoint Entire maintenance their analysis. manuals can be installed on the laptops, allowing for quick access and precise detail about procedures in question. Some shops also have an instructor on site to handle problems and questions.

Although bus maintenance shops have used the devices for a considerable period of time, the use of portable computer technology in the field is still considered to be in its initial phases. As such, issues that arise surrounding their use, maintenance, and availability tend to be complex and have limited established practices and solutions. However, bus maintenance supervisors generally agree that the benefits of using laptops for bus maintenance procedures outweigh the problems.

Compatibility tends to be an issue with laptop computers. In some cases,

newer buses require connections that older computers cannot support. Newer computers also may not be able to deal with older vehicles. Data connection ports often vary from bus to bus, each requiring a unique cord or plug. This becomes highly problematic, as keeping track of many different small pieces of computer equipment is difficult in the hectic environment of bus maintenance shops. Storage is also an issue, as sufficient room is required for the computer, its component parts, and during periods of battery recharging.

Proficiency among mechanics may vary widely. Some staff appear to be far more comfortable with the laptops than others. New technology is often found to be somewhat intimidating to veteran staff and supervisors. Training presents a problem because the shops usually can ill-afford to remove technicians from the shop floor. The laptops themselves are also in short supply compared to the volume of repairs requiring their use.

Laptop durability and maintenance are also challenges. Cost considerations have led to the purchase of personaltype machines, rather than the hardened. shock-resistant types commonly employed law by enforcement agencies. Such machines, which are typically equipped with extra long charge batteries, are better suited for a maintenance shop environment. Maintaining the latest software is an ongoing task that presents challenges. Because of their extensive use, the shops have a difficult time sending laptops out for updates and repairs.

3.4.6 Tool Issues

Issues related to technicians' tools have the potential to impact bus maintenance employee productivity. Specific concerns in this area include minimum tool requirements, storage, and common practices. General details, as well as shop-specific conditions, are noted in this section. Supervisor insight is also especially relevant in this area.

MDT observes а minimum tool requirement, which mandates that bus maintenance technicians purchase their standard tools. Maintenance own apprentices are issued starter tools, but must meet a minimum tool requirement over time. Although MDT provides bus maintenance employees with a tool allowance, supervisors readily admit that the amount is only enough to cover replacement costs for broken, lost, or stolen tools. While MDT does reimburse technicians for damaged tools, the process is lengthy. Pavroll deduction of tool costs is also available to maintenance employees.

MDT management has established Metrorail performance as a standard within the agency. Toward that end, MDT has tasked Metrobus to become more like Metrorail. In terms of tools, Metrobus maintenance supervisors provide bus suggested that MDT technicians with all necessary tools, which is the practice for Metrorail maintenance technicians. MDT does purchase specialized tools that are necessary for some buses. In some cases, maintenance shops may have different specialty tools that are sometimes borrowed between shops as needs arise. Common tools are usually

available on the shop floor as necessary, but they may be of lesser quality than private equipment.

Security and organization are also toolrelated concerns. MDT management believes Metrobus maintenance should emulate their Metrorail counterparts in this area as well. Specifically, the dedicated use of tool cribs, which are locked areas used to store tools belonging to off-duty technicians, is highly regarded as beneficial to the bus maintenance shops. The current status of tool cribs varies by shop. Plans are under development to establish a tool crib at the Coral Way facility. Specifically, a portion of an unused alignment bay is to be converted to the tool crib. Limited available space may impede progress at other facilities. For example, the Northeast facility had a separate tool area for each of the three maintenance shifts; however, the shop had to find room for an air conditioning area and for tire storage. As a result, two tool cribs were converted, leaving all shifts to jockey for the limited remaining Another tool policy that has area. suffered because of space limitations is that of removing unused toolboxes from the shop floor at the end of each shift. Although the policy had been strictly adhered to in the past, the lack of space forced an easing of this rule. However, the emphasis on implementing Metrorail tool practices will likely result in a return to stricter enforcement of this policy.

3.4.7 Mechanic Classification Issue

One of the most difficult issues facing the MDT Metrobus maintenance division, especially in terms of employee productivity, is that of classifying





maintenance employees. In fact, prior research projects have focused entirely on this complex issue. Researchers determined that Metrobus maintenance management personnel, who must deal with this issue on a daily basis, could provide a unique perspective.

In an effort by MDT management to stem the attrition rates of bus mechanics from the Metrobus maintenance division to the Metrorail division, MDT eliminated specific bus maintenance employee classifications and reclassified all maintenance mechanics under one general job title, i.e., bus maintenance technician. Specifically, the proposal called for the positions of bus mechanic 1 and bus mechanic 2 to be combined into one position referred to as bus technician. All mechanics were technicians, reclassified which as ultimately led to some less than gualified mechanics attaining the position of technician. Metrobus maintenance supervisors strongly asserted that classifying all bus maintenance employees as technicians has led to problems. Some staff indicated that this was, in fact, the "biggest problem" facing the Metrobus maintenance division. Ultimately, the reclassification effort has resulted in creating only a small group of workers who are now considered 'highly Some supervisors viewed a skilled.' recent group of new technicians as functioning more as trainees than technicians.

Additional factors related to this issue include minimally qualified or wholly unqualified applicants being accepted into the training program. In some cases, technicians may indeed complete

training classes and pass final exams, but are still found to be "less than competent" with respect to actually repairing a bus. The reclassification also resulted in unqualified veteran promotions. employees receiving Additional unintended consequences have included reduced motivation to learn or advance among long-term technicians. Union issues are also a factor. The ability to attract truly qualified applicants is diminished because senior employees unversed in current technical training are entitled to remain in the most desirable shifts as a result of seniority.

Supervisors voiced a common concern regarding the automatic attainment of "technician" status upon entry into Metrobus maintenance, which is further exacerbated by the absence of a coordinated and ongoing training program.

Despite the difficulties MDT identified with the new single classification of bus maintenance technician, a single classification for mechanics was common practice at the peer agencies.

A significant difference in the structure of the peer agencies was in the nature technicians' the advancement. of Baltimore and Denver have developed tenure and certification requirements for advancement to higher level positions compensation. with additional Cleveland requires proficiency for assignment to specialized shops.



3.4.8 Customer Satisfaction Surveys

At the inception of this project, researchers considered what effects, if any. customer satisfaction surveys and/or complaints might have with respect to bus maintenance employee Shop supervisors were productivity. generally unaware of any specific impacts from such items. In fact, transit agencies rarely administered extensive customer surveys. However. did observe researchers that bus personnel maintenance were immediately responsive to customer service issues raised by upper level agency management. Specifically, in cases where unacceptable conditions were observed by management, shop managers were contacted immediately, informed of the conditions, and directed to pursue corrective measures as soon as possible. Such occurrences are rarely documented; rather, each task is accepted as а part of daily responsibilities and duties.

While necessary, such a practice of immediate responsiveness has the potential to impact bus maintenance employee productivity. Supervisors must assign the response quickly, often directing the technician to put the ongoing task on hold. In some cases, the responding action may involve the technician traveling to an off-site location.

Although customer satisfaction surveys may potentially be an indicator of employee productivity, none of the peer transit agencies had information from them that directly related to the bus maintenance program. The only source of relevant survey information was found to be employee surveys. Specifically, GCRTA surveyed employees regarding benefits. Several years earlier, RTD surveyed employees regarding supervisors. RTD also surveys employees upon the completion of training classes. No results were made available to CUTR.

3.4.9 Current Manpower Data

Researchers intended to document current applications of manpower data at the maintenance shop-level. Also deemed relevant at the shop-level were analyses of employee productivity conducted at the shop-level.

Responses to this issue were minimal among the MDT bus maintenance facilities. Supervisors at only one facility identified attempts to use manpower employee productivity data for Specifically, purposes. bus maintenance management staff applied such information to improve morale among new employees. Supervisors made an effort to select technicians for tasks on which an individual was specifically interested in working.

3.4.10 Employee Attendance Issues

Attendance issues have the potential to impact employee productivity in the bus maintenance program. Within the transit industry, such matters are often complicated by labor agreements. Although each peer agency has a specific attendance policy in place, the effects of employee attendance issues considerably among varied them. Denver reported little impact, while MTA reported that they did have an issue, but took a proactive approach to dealing with employee attendance. Specifically,

managers contact the employee after a week absence and encourage the person to return to work. Communications and encouragement continue on a weekly basis. Contact attempts are documented, and a weekly report of absent employees is generated and reviewed. MTA reported that this approach has been somewhat effective in getting employees back to work and avoiding a long dispute process.

GCRTA also reported a very specific attendance policy with a long list of At one point or another, each rules. agency has experienced issues with a small number of employees who system manipulate the to their advantage. This group usually pushes the limits of rules related to workers' compensation and/or the Family Medical Act (FMLA). Regarding Leave employee turnover, each of the peers reported no significant issues except for retirements.

MDT tracks absenteeism by employee classification and assigned location. Absenteeism data are published in the monthly performance report.

MDT defines absenteeism as:

Absenteeism = Total Hours Lost Total Scheduled Hours

A summary of Bus Maintenance (all divisions) absenteeism from 2003 through 2005 fiscal year to date (FYD³) is presented in Figure 3.34.

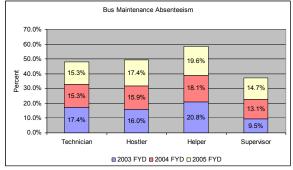


Figure 3.34 Bus Maintenance Absenteeism, 2003 – 2005 FYD

For bus maintenance as a whole, over the past three years, absenteeism for all four classifications ranges from 14.6% Bus technicians and bus to 19.6%. helpers improved attendance as absenteeism rates for those two classifications declined. On the other hand, bus hostlers showed an increase in absenteeism after a small decline in 2004. Bus supervisors recorded the largest increase in absenteeism, which appears to have begun in 2004.

Facility specific data provide a detailed look at absenteeism for each classification at specific locations. At the central bus facility, as presented in Table 3.36. absenteeism increased in only one classification. i.e., bus supervisors, where it appears that absenteeism has grown over time.

Table 3.36 Central Bus Facility Absenteeism FYD¹

Position	2003	2004	2005	04vs03	05vs04
Technician	17.2%	17.0%	14.8%	-0.2%	-2.2%
Hostler	23.2%	22.1%	21.1%	-1.1%	-1.0%
Helper	34.9%	27.7%	27.1%	-7.2%	-0.6%
Supervisor	10.4%	12.3%	16.5%	1.9%	4.2%
¹ FYD = Ave	rage of M	lonthly A	verages		

At the Coral Way facility, three of four classifications experienced a rise in absenteeism, as illustrated in Table 3.37.

³ FYD is defined as the Average of Monthly Averages



Table 3.37 Coral Way Facility Absenteeism F

Position	2003	2004	2005	04vs03	05vs04	
Technician	18.9%	15.6%	13.0%	-3.3%	-2.6%	
Hostler	12.9%	14.8%	15.3%	1.9%	0.5%	
Helper	16.2%	12.3%	19.5%	-3.9%	7.2%	
Supervisor	2.8%	10.3%	10.7%	7.5%	0.4%	
¹ FYD = Average of Monthly Averages						

At the Northeast facility, absenteeism increased in all four position classifications. Absenteeism for the Northeast facility is outlined in Table 3.38.

Table 3.38 Northeast Facility Absenteeism FYD¹

Position	2003	2004	2005	04vs03	05vs04	
Technician	19.2%	16.0%	16.2%	-3.2%	0.2%	
Hostler	12.5%	12.4%	15.1%	-0.1%	2.7%	
Helper	12.7%	16.0%	19.1%	3.3%	3.1%	
Supervisor	11.8%	17.6%	19.8%	5.8%	2.2%	
¹ FYD = Average of Monthly Averages						

Caution must be used in interpreting the absenteeism data from the Medley facility, as the facility did not open until April 2004. The 2004 FYD data reflect only six months of actual data for comparison purposes. Nonetheless, absenteeism appears to have increased in all classifications at a relatively rapid rate, as shown in Table 3.39.

 Table 3.39 Medley² Facility Absenteeism FYD¹

Position	2003	2004	2005	04vs03	05vs04	
Technician		8.4%	17.3%		8.9%	
Hostler		9.2%	23.3%		14.1%	
Helper		18.6%	27.3%		8.7%	
Supervisor		7.9%	11.7%		3.8%	
¹ FYD = Average of Monthly Averages						

² Medley Facility opened April 2004

Absenteeism for bus technicians and bus hostlers grew at support services after a year of improved attendance in all four classifications. Absenteeism for support services is presented in Table 3.40.

Table 3.40 Support Services Absenteeism FYD ¹
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Position	2003	2004	2005	04vs03	05vs04
Technician				-1.9%	
Hostler	21.8%	14.8%	17.6%	-7.0%	2.8%
Helper	17.9%	17.8%	12.2%	-0.1%	-5.6%
Supervisor	17.7%	9.9%	8.0%	-7.8%	-1.9%
¹ FYD = Average of Monthly Averages					

Facility-specific absenteeism shows rates in excess of 20% for bus helpers and bus hostlers at Central and most recently at Medley, with rates approaching 20% for supervisors at Modest improvements in Northeast. attendance were noted for bus technicians at Central and Coral Way, and a high level of improvement was noted for supervisors and bus helpers assigned to support services.

3.4.11 Metrobus Retrofits

The practice of installing upgraded parts, devices, or equipment onto existing vehicles in the fleet is known as retrofitting. With such a large and diverse fleet, the MDT Metrobus maintenance division deals with a variety of retrofits on a continuous basis. As such, procedures and scheduling related to retrofits significantly contribute to employee productivity. The following section documents important practices in this area, as well as bus maintenance supervisor insights and concerns.

The Metrobus maintenance division is responsible for oversight of bus retrofits as they become necessary. Retrofits are commonly associated with vehicle warranties. They can be predetermined and specified at the time of purchase, or they can be a corrective measure deemed necessary after purchase and covered in general terms within the warranty. Vendors may also request



that retrofits be completed on selected vehicles.

In most cases, the procedure begins when a vendor notifies the agency, generally the field engineering & systems maintenance division, that a warranty retrofit is due. Such determinations are frequently based on mileage. At the shop level, bus maintenance supervisors receive a "warranty memo" that describes the work to be done and the buses involved. The supervisor files a repair order and schedules the work through the EMS. Often times the vendor will come to MDT and complete retrofits on the property. This practice is welcomed, as it affords bus maintenance considerable savings and frees bus technicians to work on other repairs.

In some cases, failed vehicle systems lead to retrofits. Fixes in such cases may have been developed in-house. Not all traditional O&I facilities handle retrofits. The Coral Way location does not have available space necessary to do this type of work. The support services shop is routinely engaged in Specific shops may be retrofitting. tasked with completing all retrofits for the fleet, regardless of dispatch location, as was the case with the recent air conditioning retrofit project that was complete entirely at Central O&I.

Some supervisors reported that retrofits commonly lack extensive procedural documentation. As such, in the event that a knowledgeable employee leaves the agency, specific retrofit details stand a good chance of being lost. This is a growing concern at MDT as there are many veterans approaching retirement among the Metrobus maintenance staff.

CUTR reviewed campaigns and retrofits documented in MDT's monthly activities report throughout 2004 and 2005. The rather extensive list of activities along with the status of the work is presented The campaigns and retrofits below. span all facilities and many focused on improving performance by reducing road MDT appeared to be actively calls. involved in completing a significant portion of the work. In cases where the work is completed by a vendor, the logistics involved in facilitating the work also fall on the bus maintenance staff.

Campaigns, FY 2004-2005	Status
CAMPAIGN: NABI Cradle Campaign	December 2004: Completed
CAMPAIGN: NABI C-Frame Campaign	March 2005: Completed
CAMPAIGN: NABI Roof Campaign	April 2005: Restarted
REPLACEMENT: Ikarus Sutrak A/C Compressor	May 2005: Support Services completing
	retrofit of final bus
UPGRADE: 9300 ISC Engine Buses Muffler	March 2004: Completed a total of 58 buses
Upgrade	
RETROFIT: Optare 30-ft LFN Buses	April 2005: Retrofit completed
CAMPAIGN: Filtration Solutions Filter	May 2004: Campaign completed
CAMPAIGN: Replace Turbo unit proactively	December 2004: Completed
CAMPAIGN: IO Controls Seat Alarm	April 2005: Completed
RETROFIT: Driver's Doorpost on NABI Buses	March 2005: Completed
INSTALLATION: Bike Rack Installation	February 2005: Installation and
	maintenance ongoing at all 3 O&I Divisions
PROBLEM: Visibility issue new NABI buses	January 2004: Mirror relocated to resolve concern
CAMPAIGN: NABI Bumper Support Campaign	December 2004: Completed
CAMPAIGN: NABI Hymer Bulkhead Reinforcement	November 2004: Ongoing
CAMPAIGN: NABI Settee Campaign	October 2004: Completed
RETROFIT: Ikarus Artic Sunshade Retrofit	August 2005: Ongoing at Support Services
PROBLEM: Riveted Brake Shoes	June 2005: Completed; July 2005: re- inspected fleet
CAMPAIGN: Bumper & Tail Light Campaign	May 2005: CWF Body Shop rebuilding bumpers/tail lamp assemblies in-house
PROBLEM: Wheelchair Equipment Inspections	July 2005: Completed
PROBLEM: Steering Box Pressure Adjustment	July 2005: Proceeding with adjustment
CAMPAIGN: Bluebirds	September 2005: Completed
INSPECTION: Wiring Defects in Blue Bird Buses	September 2005: Inspected Medley Blue Bird Buses

3.5 Equipment Performance

Most transit agencies have engaged in at least minimal efforts to improve performance. equipment Miami's maintenance supervisors reported that the primary focus of bus maintenance is meeting service demands. Bus maintenance frequently relies on data collected and analyzed by bus maintenance control to identify problem



areas. Bus maintenance works closely with FESM to implement recommended changes and relies on vendors to complete fixes for most components, which generally have 500,000 mile warranties.

Miami has established target equipment performance levels in a variety of areas. Bus performance is monitored and performance reports are issued on a monthly basis.

Such efforts among the peer agencies, including overall program performance improvements as well as individual maintenance employee improvements, are discussed below.

Overall performance improvement actions undertaken by MTA included development work standards. of revisions to training courses, and OEMsponsored training to be included with all bus purchase contracts. MTA also addressed unsatisfactory conditions at shops. the maintenance such as inadequate conditioning, air poor ventilation, and completion of necessary renovations.

GCRTA has developed "in-house" guidelines, and the agency indicated that its move to a decentralized management system has had a positive effect on equipment performance. However, such effects have not been Other efforts to studied in detail. improve equipment performance include setting a goal of maintaining a mostly homogeneous bus fleet and servicing all new BRT articulated buses at only selected maintenance facilities. Rather than constantly switching responsibilities

among mechanics, bus maintenance supervisors make a conscious effort to assign specific tasks to employees who skilled are most in that area. Additionally, supervisors prefer to assign tasks to mechanics who are most interested in that specific job. The bus mechanic grading system, which functions somewhat like an apprentice program, is also believed to have helped improve maintenance performance. Lastly, bus maintenance management at GCRTA indicated that the renewed focus on bus maintenance by the agency's new general manager has had a positive effect on overall performance.

General efforts at Denver RTD to improve bus equipment performance include its focus on mechanic training and certification programs. Specifically, "average time maintenance the recording system" has served as a guide to areas in need of attention. Additional needs are also determined by charting processes and identifying problem fields. RTD charts bus mileage to project anticipated repairs. With goals set by the head of bus maintenance. each maintenance division tracks its own performance and submits results on a regular basis.

3.5.1 Bus Equipment Performance Data

The intent of this section is to describe shop-specific data collection efforts. Researchers hoped to learn how data are processed, managed, and utilized by the shop. If available, historical information based on supervisor experiences was also included.

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Shop-specific data collection efforts conducted by the traditional Metrobus Maintenance Division O&I shops are In most cases, infrequent. Bus Maintenance Control Division personnel are enlisted to perform special data collections, when necessary. BMC efforts are described in detail elsewhere in this report. While data gathering efforts were reported to be sporadic and infrequent. some bus equipment performance data were collected on an informal basis minimally and documented. Often such efforts were engaged to quickly determine specific problems and decide on the most reasonable remedial actions. For example, supervisors at the one facility determined that turbo chargers were experiencing problems due to soot build up in the engine oil. A switch to extended life oil filters was determined to be the best remedy. While no hard data were collected, supervisors felt the result of this action had a positive impact.

In some cases, no remedy can be readily implemented, but supervisors better understanding gain а of conditions and vehicles. Additional examples of informal performance data collection efforts include an investigation of bus idle time. This is an area that can be looked into more formally at the shop level because shops handle buses differently. At one of the facilities, buses are parked and turned off, while ready buses at another facility are nested and throughout left idlina the dav. Supervisors concluded that the ambient air temperature affects bus performance, but no data have been collected in this area.

The frequency at which a transit agency purchases new buses clearly impacts the overall equipment performance picture at a transit agency. While federal guidelines call for a 12-year replacement schedule, an agency can go above and beyond this mandate. The types of buses that are purchased are also relevant, as are agency goals associated with replacement.

The age distribution of the active vehicle inventory for MDT and the peer agencies as reported in the National Transit Database for years 2002 through 2004 is outlined in Table 3.41.

Table 3.41 Age Distribution of Active Vehicles

	Baltimore	Cleveland	Denver	Miami	Average
2002	9.7	7.0	3.2	6.6	6.6
2003	7.8	4.8	3.7	5.3	5.4
2004	8.9	5.5	4.6	4.6	5.9
Source	e: National Tra	nsit Database	(NTD) 200	2-2004	

The average age of Miami's fleet has been equal to or less than the average of the four properties over the past three years.



Each of the peers follows the federal replacement standard, but some have a more active and contemplative approach. While Baltimore reported



nothing more than adherence to the guidelines, Cleveland actively monitors bus replacement cycles and sets a goal of annually replacing one-twelfth of its bus fleet (approximately 8.3%). Denver also reported following the FTA guidelines; however, RTD acquired 700 new buses over the course of 1999-2000. The agency looked exclusively at heavy-duty buses (those designed for a 12-year, 500,000 mile service life) and specifically turned away from other "medium duty" buses. The agency purchasing practices based on "age" are apparent in the data outlined in Table 3.41.

While local geographic and climactic conditions at the peer agencies were dissimilar to those in MDT, it was also worthwhile to note whether or not geographic and climatic conditions were a concern to the bus maintenance programs among the peers. All three indicated seasonal climate issues were challenging, but indicated that extended winter seasons and inclement weather posed no insurmountable problems. Denver is confronted with a unique terrain, a challenge that is not a factor in Baltimore, Cleveland, or Miami.

3.5.2 Vendor-specific Responsibilities

The following section describes several common vendor tasks and their regular interactions with bus maintenance mechanics and managers. Supervisors were also asked for their insight regarding the amount of vendor involvement in the shop.

Vendors manage a variety of responsibilities within the bus maintenance shops related to vehicles,

parts, and equipment. Ideally, vendor personnel offer a level of expertise and familiarity with their products that is of assistance to bus maintenance personnel. As such, they have the potential to make a significant positive impact on the performance of their equipment.

As described earlier, vendors are actively engaged in vehicle retrofitting and warranty repairs. Specific vendors who serve MDT, such as Detroit Diesel, Allison, Rockwell, and Cummings, service provide on-call for their components. including engines, transmissions, suspensions, drive trains, and air conditioning units. Bus tires are through leased the Goodyear Corporation, which maintains a 24-hour, 5-day per week service facility within each of MDT's O&I shops to handle all tire issues.

In addition to regular on-site service and service calls, vendors may call on the shop as part of a regular sales route. In some instances, vendors may work with bus maintenance personnel on special data collection efforts. They may also provide new or improved parts for testing or tracking purposes. Nonmechanical vendors are also active within the shop. For example, MDT contracts with Goodwill for bus cleaners and IPS Bloodborne Pathogen Cleanup Services to clean up biohazards on buses, when necessary.

As indicated throughout this document, methods in practice at the traditional MDT O&I facilities differ substantially from those employed by Penske Trucking at the Medley facility. Within



this specific concern, Penske actually serves as a vendor to MDT in providing bus maintenance for the Medley fleet. Penske also has direct responsibility for facilities maintenance concerns, fuel deliveries, as well as oversight of and interaction with the same vendors that do business with the other divisions.

3.5.3 Bus Out-of-Service

A very basic, yet immediate indicator of performance is the current service status of the piece of equipment, i.e., a bus. The following section provides additional insight into the methods used by bus maintenance facilities to indicate and manage out-of-service buses. Where applicable, shop-specific methods are described and supervisors' comments are noted.

Bus maintenance supervisors make extensive use of the magnetic boards in the control room to indicate factors related to the operational status of the buses within the fleet. With the overarching concern of having the appropriate number of buses in service, location status is a key factor. The magnetic bus number is placed in the corresponding location on the board according to broad and specific categorizations. First, the bus is either parked on site or at offsite locations. These may include the MDT Support Services, another O&I shop, or a vendor The magnetic board service facility. (Figure 3.35) is also used to indicate the reason for bus is out-of-service. Common reasons are represented by a specific magnetic symbol or color, while special conditions, such as hold for brake test, are generally written in with erasable marker.



Figure 3.35 "Out of Service" Buses posted on Magnetic Board at one of the Maintenance Shops

Warranty work, which is performed 24 hours per day, is a frequent cause for buses to be taken out of service. Compounding the issue is the practice by some vendors of removing the bus to an offsite location for warranty service. Bus maintenance supervisors generally indicated their preference for vendors to send technicians to the shop rather than sending the bus offsite or being reimbursed for repairs completed by bus maintenance personnel. MDT However, some vendors, such as NABI, are reluctant to send their own technicians on site to complete repairs.

3.5.4 Bus Down-for-Parts

MDT Inventory Practices

In a previous study, CUTR examined inventory and procurement practices within MDT's Materials Management Division, focusing on whether the inventory was of proper size. The results of the study indicated that in late 1985/early 1986, three bus operating and inspection (O&I) divisions along with the major overhaul garage were fully operational and responsible for maintaining a total fleet of 552 buses. Reported inventory assets totaled \$12.3 million. The Central warehouse accounted for 35% of the total inventory,



while bus and rail accounted for 31% and 34%, respectively. Since the Central warehouse, often referred to as the Central bus warehouse, stocked primarily bus parts, almost two-thirds of the inventory was bus parts.

In 2004, the 1986 inventory of \$12.3 million had grown to \$23.2 million, an increase of 88.5%. The 2004 inventory included parts and materials for the entire fleet of 136 Metrorail vehicles, and materials for the 29 parts Metromover vehicle fleet, and parts and materials for a new area, referred to as the Radio Shop. An overview of Inventory growth by division adjusted for inflation since 1986 is presented in Table 3.42.

When adjusted for inflation, the 1986 inventory grows from \$12.3 million to \$19.3 million, an increase of 19.9%. The Central warehouse inventory shows a 17.3% decrease; the rail inventory, which includes Metrorail, Metromover, and the radio shop, shows a 127.2% and, the bus inventory, increase; exclusive of the Central warehouse decreases by 55.3%. When the Central warehouse is combined with the bus division, inventory value decreases by 35.1%. In terms of the value of the dollar, inventory growth occurred only in the area of rail. All bus divisions and the Central warehouse reflected a decline in value.

A major contributor to inventory growth was an increase in the vehicle fleet. In June 2004, MDT vehicles available for maximum service totaled 990, with MDT providing all maintenance needs for 891 of those 990 vehicles. At the time of the study, MDT contracted with Penske Truck Leasing for maintenance of 99 buses. Allocation of vehicles by division is detailed in Table 3.43.

Table 3.42 2004 Inventory Growth Inventory Growth in Adjusted Dollars

Inventory Growth in Adjusted Dollars								
	1986	2004 ^b						
Division	in 2004 \$ ^ª	Actual \$	+/- %					
Metrorail	\$6,549,024	\$9,790,420	49.5%					
Metromover		\$3,797,405						
Radio Shop		\$1,291,982						
Rail Subtotal	\$6,549,024	\$14,879,807	127.2%					
Central Warehouse	\$6,820,626	\$5,640,970	-17.3%					
Central O&I	\$1,060,359	\$516,358	-51.3%					
Coral Way O&I	\$830,648	\$727,306	-12.4%					
Northeast O&I	\$792,116	\$631,216	-20.3%					
Central Support	\$3,291,747	\$794,395	-75.9%					
Bus Subtotal	\$5,974,870	\$2,669,275	-55.3%					
Bus Subtotal + Central Warehouse	\$12,795,496	\$8,310,245	-35.1%					
Total	\$19,344,520	\$23,190,052	19.9%					

^a All figures have been adjusted using the CPI inflation factor, which uses the average Consumer Price Index for a given calendar year. Data represent changes in prices of all goods and services purchased for consumption by urban households.

^b as of June 30, 2004

Table 3.43 Allocation of Vehicles by Div	vision
Allocation of Vahiolog by Division	

	1986			2004 Fle	et		+/- %
Division	Fleet	Rail	40' Bus	30' Bus	Artic Bus	Total	Increase
Metrorail	81	136					
Metromover		29					
Rail Subtotal	81	165					103.7%
Central O&I	226		156	41	41	238	5.3%
Coral Way O&I	161		168	57	25	250	55.3%
Northeast O&I	165		210	28	0	238	44.2%
Bus Subtotal	552		534	126	66	726	31.5%
Total MDT Maintained	633	165	534	126	66	891	40.8%
Purchased Maintenance (Bus)			43	56	0	99	
Total	633	165	577	182	66	990	56.4%

MDT's rail fleet more than doubled and the bus fleet, maintained by MDT, grew by 41%. The growth in the fleet was accompanied by a decline in the inventory value expressed in 2004 dollars. Even discounting the decline in buying power, inventory per rail vehicle

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increased in excess of 75%, while inventory for buses decreased at all garages by almost 50% and declined by 22% when the entire Central warehouse inventory is charged to the bus division, as shown in Table 3.44.

Table 3.44 Inventory by Vehicle, 1986 versus 200	4
Inventory by Vakiala 1086 versus 2004	

			Inventory	2004°		Inventory	
Division	1986	Vehicles	per Vehicle	Actual \$	Vehicles	per Vehicle	+/- %
Metrorail	\$4,164,214	81	\$51,410	\$9,790,420	136	\$71,988	40.0%
Metromover				\$3,797,405	29	\$130,945	100.0%
Radio Shop				\$1,291,982			
Rail Subtotal	\$4,164,214	81	\$51,410	\$14,879,807	165	\$90,181	75.4%
Central Warehouse	\$4,336,913			\$5,640,970			
Central O&I	\$674,232	226	\$2,983	\$516,358	238	\$2,170	-27.3%
Coral Way O&I	\$528,170	161	\$3,281	\$727,306	250	\$2,909	-11.3%
Northeast O&I	\$503,669	165	\$3,053	\$631,216	238	\$2,652	-13.1%
Central Support	\$2,093,066			\$794,395			
Bus Subtotal	\$3,799,137	552	\$6,882	\$2,669,275	726	\$3,677	-46.6%
Bus Subtotal+ Central Warehouse	\$8,136,050	552	\$14,739	\$8,310,245	726	\$11,447	-22.3%
Total as of June 30, 2004	\$12,300,264	633	\$19,432	\$23,190,052	891	\$26,027	33.9%

The materials management division operates on a fixed budget for inventory needs. Given that the nature of the vehicles served by the inventory is guite diverse, materials management must prioritize the expenditure of funds. Rail vehicles constitute lona-term а investment. The 136 rail vehicles in service today are almost 20 years old or one-half of their useful life. A major rail rehabilitation project currently is underway to modernize those vehicles over the next five to six years.

In the interim, the fleet must be maintained despite the fact that many parts are difficult to obtain and, in some cases, obsolete. The rail vehicles are unique in that the only other agency that operates those same vehicles is Baltimore MTA. MDT and Baltimore MTA used a joint procurement to acquire the vehicles in the early 1980s. Lead time for acquiring rail parts can run into months and frequently the manufacture of new parts is required. Tooling costs associated with re-

manufacture are often extremely high, and it is not unusual for the agency to be required to purchase an established number of parts regardless of the quantity needed. As a result of these limitations, the very expensive rail inventory tends to grow as the vehicles age. As the current vehicles are inventorv rehabilitated. the will experience significant growth. Recent estimates put that figure at around \$17 million. As the rehabilitation proceeds, the "old" inventory will be disposed of, and the inventory levels will decline until the cycle of aging starts over.

Mover vehicles have a shorter life span than rail vehicles; nonetheless, they also mid-life overhaul require а at approximately 15 years. MDT's current Phase One vehicles have reached that stage; however, the agency has determined that replacement rather than rehabilitation of those vehicles is the preferable cost-effective alternative. Until replaced, the Phase One vehicles will continue to require a significant inventory, and the aging of the Phase Two vehicles will further compromise inventory reduction efforts. After replacement, a new inventory, at significant cost, will be required to maintain the new Phase One mover fleet. The current inventory cost per rail almost \$72,000, vehicle is while inventory costs per mover vehicle are approaching \$131,000. Both costs are expected to increase in the near term.

Buses, on the other hand, are much more consumable than rail or mover vehicles. The 12-year life cycle of a bus precludes the need for a midlife overhaul. While buses are tailored to



specific agencies, unlike the rail vehicles, major components are common to many transit agencies, so bus parts are easier to obtain. Less lead time is required to acquire the parts, and there is less of a problem with However, obsolescence. because buses turn over more quickly, inventory is impacted by the need to maintain parts for a variety of types of buses that are in varying stages in their life cycles. MDT's June 2004 bus fleet consisted of 1992-1994 Flxibles, 1997 NABIs, 1999-2003 NABI low-floor buses, 1994-1995 Ikarus articulated buses, 2001-2002 Blue Bird buses, and 2003 Optares. The average age of the bus fleet was in the range of 5 to 6 years. The inventory cost per bus was about \$3,700 at the garages (including Central support) and \$11,500 including the entire Central warehouse inventory. Since 1986, the inventory per bus has declined 22 to 47%.

A factor that can be used to assist in the evaluation of the inventory, which was identified in the study's literature review is turnover rate of stock. The rate of stock turnover is a barometer of stock sitting on the shelf versus actual use. Based on the discussion of the differences in MDT's rail and bus vehicles, one could anticipate that turnover rates for rail and mover would be lower than those rates recorded for bus. MDT's turnover rate fell from 7.3 in 1978 to 1.2 in 1985. Two of the peer agencies visited reported target turnover rates of 3. Baltimore MTA indicated that they had at some point achieved a turnover rate of 2.7, while Cleveland RTA reported that they were only able to achieve a turnover rate of 3, if they

included consumables (consumables have the highest turnover rate, and in the case of Cleveland RTA, they are all contracted-out). While MDT does report turnover in their monthly report, they report turnover by division rather than by the agency as a whole.

From October 2003 through June 2004, Central O&I consistently reported the highest turnover rates and exceeded a turnover rate of 6 during four of the months presented. Northeast O&I never reported a rate less than 4. Coral Way O&I and Central support both showed improvement in turnover rates during the last four months of the reporting period. The Central warehouse generally stayed within a turnover rate of 2 to 3. Metrorail and Metromover failed to achieve a turnover rate of 1. while the radio shop's turnover rates were sporadic, ranging between .26 and 1.70.

An average of the monthly rates for October 2003 through June 2004 indicates the lowest average turnover rate of 2.47 was recorded in January 2004, and the highest turnover rate of 3.19 was reported in March 2004. The turnover rate was improving and more than doubled the rate reported in 1986.

The inventory analysis found that since 1986:

- Inventory allocations for Central warehouse and the bus divisions fell to 24% and 12%, respectively.
- In terms of the value of the dollar, inventory growth occurred only in the area of rail. All bus divisions and the



Central warehouse reflected a decline in value.

- The current inventory cost per bus was about \$3,700 at the garages (including Central support) and \$11,500 including the entire Central warehouse inventory. Since 1986, the inventory per bus declined 22-47%.
- Central O&I consistently reported the highest turnover rates and exceeded a turnover rate of 6 during four of the months presented. Northeast O&I never reported a rate less than 4. Coral Way O&I and Central support both showed improvement in turnover rates during the last four months of the reporting period. The Central warehouse generally stayed within a turnover rate of 2 to 3.

A warehouse & stores goal at the time of the study was to maintain a $2\frac{1}{2}$ % vehicle down for parts ratio through September 30, 2004 with the objective of maximizing storage capacity.

Expressing the performance measure as a percentage of the fleet masked the actual number of buses unavailable for service due to lack of parts. Projections for buses down for parts were incorporated into the draft Metrobus Fleet Management Plan, October 2004, and are detailed in Table 3.45 along with the percentage of the fleet they represent. In all cases, the numbers were well below the $2\frac{1}{2}\%$ rate.

Table 3.45 Maintenance Projected Bus Down for Parts

Maintenance Projected Buses Down for Parts

	FY 04		FYC)5	FY 06	
	Down for Parts	% of Fleet	Down for Parts	% of Fleet	Down for Parts	% of Fleet
Full-size Bus	5	0.776%	6	0.838%	6	0.777%
Mini-bus	2	1.099%	2	0.735%	3	0.904%
Total	7	0.847%	8	0.810%	9	0.815%

The above calculation is based on the number of vehicles that are projected to be unavailable each day due to lack of parts for repair, which is similar to the methodology used to calculate the $2\frac{1}{2}$ % rate used by materials management.

Researchers reviewed daily totals of buses down for parts by O&I division. A summary of that information follows in Table 3.46.

Table 3.46 Vehicle Down for Parts Ratio

Buses D	Buses Down for Parts								
Month	# Days in Month	Central O&I Buses Down for Parts	Northeast O&I Buses Down for Parts	Coral Way O&I Buses Down for Parts	Total Buses Down during Month	Average # Buses Down per Day	Total Fleet	% of Fleet Down for Parts	Daily Maximum # Buses Down for Parts
Sep 02	30	189	49	113	351	12	580	2.0%	25
Oct 02	31	198	57	170	425	14	580	2.4%	21
Jan 03	31	132	71	135	338	11	580	1.9%	14
Feb 03	28	112	96	188	396	14	580	2.4%	18
Mar 03	31	122	110	173	405	13	627	2.1%	18
Apr 03	30	58	121	65	244	8	627	1.3%	16
May 03	31	87	61	103	251	8	627	1.3%	13
Jul 03	31	105	118	98	321	10	632	1.6%	16
Sep 03	30	111	91	102	304	10	632	1.6%	21
Oct 03	31	95	98	72	265	9	632	1.4%	16
Mar 04	31	191	167	176	534	17	637	2.7%	29
Apr 04	30	118	131	119	368	12	717	1.7%	22
Jun 04	30	105	126	158	389	13	717	1.8%	30
Jul 04	31	77	99	125	301	10	717	1.4%	16
Source: I	Materials N	lanagement i	Monthly Repo	rts, FY 2002-	2004				

Despite achieving rates well below $2\frac{1}{2}\%$, in every case the actual number of buses down for parts was 2 or 3 times the maintenance projected number of buses down for parts. The average number of buses down per day is different than the maximum number of buses down per day and has an impact on vehicle availability.



Researchers recommended a series of actions to improve performance in this area that included:

- Increased cooperation between materials management and bus maintenance
- Explore the details surrounding unavailable parts and develop a listing of the five most common unavailable parts that are keeping buses out of service at each of the three divisions
- Track and report the number of buses not available for service each day, which is a better measure of inventory performance than the average number of buses down throughout the month
- Classify the common unavailable parts as "critical" parts within each division
- Intensify efforts with vendors to accomplish timely delivery of the critical parts
- As progress is made in making critical parts available, the cycle should continue with the next five most common parts identified and added to the list

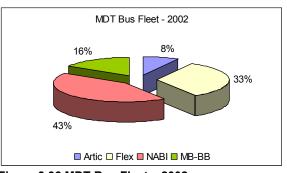
Researchers also recommended that in order to further the goal of maximizing storage capacity, MDT conduct a detailed review of the current inventory. The inventory analysis showed a significant increase in the allocation for rail with a corresponding decrease for bus. Given the issue with buses down for parts and the inventory trends observed, it is possible that inventory composition was weighted too heavily towards rail.

MDT Parts Usage, 2002/2003

Researchers analyzed bus parts usage for 2002 and 2003. Data used represented monthly inventory dollar values for buses by type and model year, garaged in different locations.

For the purpose of the analysis, MDT's fleet was categorized into four vehicle types: articulated buses, Flxible buses NABI buses and minibuses (referred to as Artic, Flex, NABI and Minibus respectively, followed by the two-digit number indicating the year of the model). Since the complete data set for Minibuses was not always available, the analysis concentrated on the first three types of buses.

In 2003, the average age of the Artic buses was 8.6 years; the average Flex bus was 11.3 years old, the average NABI bus was 2.5 years old, and the average Minibus was 1.6 years old, with the average age for the overall fleet about 7.2 years. From 2002 to 2003, MDT increased the total number of buses and changed fleet composition, placing more emphasis on the newer NABI buses. MDT's fleet composition in 2002 and 2003 is presented in Figures 3.36 and 3.37, respectively.





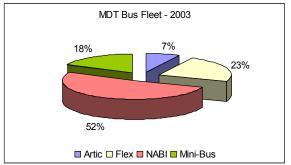


Figure 3.37 MDT Bus Fleet - 2003

The share of NABI buses increased from 43% in 2002 to 52% in 2003, and the share of Minibuses increased from 16% in 2002 to 18% in 2003. At the same time, the portion of Flex buses decreased from 33% to 23%, and Artic buses fell from 8% to 7%. This change in the fleet composition towards the newer buses allowed MDT to improve the average age of the fleet by almost a year (from 8.1 years in 2002 to 7.2 years in 2003).

The shift towards more NABI buses and minibuses was also reflected in the dollar amount of bus inventory used. comparison of the inventory The breakdown between 2002 and 2003 is presented in Figure 3.38. The annual amount of inventory used for NABI buses and minibuses increased from 2002 to 2003 following the increase in the number of NABI and minibuses over the same period of time. The decrease in the amount of inventory used for Flex buses followed the decrease in the number of Flex buses from 2002 to 2003. The dollar amount of inventory used for the Artic buses increased even though the share of this type of buses decreased. This is an indication that from 2002 to 2003, Artic buses became more expensive to maintain, requiring more inventory, which is not unusual for older vehicles.

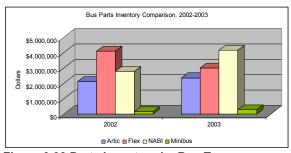


Figure 3.38 Parts Inventory by Bus Type

MDT's fleet was garaged and maintained at the Central O&I division, Coral Way O&I division, and Northeast O&I division. All three divisions performed required maintenance and repair procedures; however, they did differ by the number of buses and the bus types they had. Both variables affected the average age of the total fleet in each garage and changed from year to year. The average age of the fleet by garage for 2002 and 2003 is presented in Table 3.47.

Table 3.47 Average Fleet Age by Garage

	2002	2003
Central Bus Facility	4.3	4.7
Coral Way Facility	4.5	4.2
Northeast Facility	4.5	4.7

It could be seen that among the three garages only Coral Way slightly improved the average age of its fleet from 4.5 years in 2002 to 4.2 years in 2003. Both Central and Northeast saw increases in the average age of their fleets in 2003.

In 2003, garages differed not only in the average age of their fleets, but also in the composition of the fleet and in the inventory efficiency of the buses. One

way of looking at the inventory efficiency is to compare the percentage of buses of each type in the garage with the respective percentage of total inventory required to maintain that type of bus. The composition of bus fleet and the inventory breakdown by garage are presented in Table 3.48.

Table 3.48 % of Total Fleet and Inventory byGarage and Fleet Type

Garage	Bus Types	Share of number of buses (%)	Share of parts value (%)
	Artic	19%	48%
Central	Flex	12%	10%
	NABI	69%	42%
Coral Way	Artic	12%	32%
	Flex	12%	12%
	NABI	71%	56%
	Minibus	5%	0%
Northeast	Flex	30%	46%
	NABI	70%	54%

The data indicate that the most inventory efficient buses in the Central garage are the NABI buses. NABI buses constituted 69% of the total Central fleet but required only 42% of total inventory (measured in monetary terms) to maintain them. By contrast, Artic buses represented 19% of the number of buses in the garage, but required 48% of total garage's inventory to maintain them.

As in the case with the Central garage, the most inventory efficient buses in Coral Way garage were NABI buses. They constituted 71% of the total number of buses in the garage and require 56% of the total inventory value. Artic buses (as in Central garage) were the most inventory inefficient, requiring 32% of the inventory value while constituting only 12% of the total number of buses in the garage.



As with the previous two garages, NABI buses were the most inventory-efficient in the Northeast garage as well. Flex buses, on the contrary, were inventory inefficient; however, this inefficiency was not as pronounced as the Artic buses inefficiency at the Central and Coral Way garages.

Another way of looking at the inventory efficiency of buses is to compare the average inventory used per each bus type across the garages. Average inventory used per bus shows how much inventory was required to maintain each bus type. Table 3.49 shows average inventory for the three major garages.

Table 3.49 Average Inventory Dollars Used per	
Bus	

Bus Types	Central	Coral Way	Northeast
Artic	\$36,753	\$34,022	
Flex	\$12,515	\$11,910	\$17,365
NABI	\$8,849	\$9,709	\$8,847
Minibus		\$602	

Among the three major bus types (Artic, Flex and NABI), Artic buses required the largest amount of inventory per bus and NABI buses used the smallest amount of inventory per bus, regardless of the garage. One possible explanation could be that Artic buses were much older than NABI buses and, thus, required more maintenance. The average age of Artic buses in all the garages was 8.6 years, while the average age of NABI buses was 2.5 years. However, Artic buses were not the oldest ones in MDT's fleet. The average age of Flex buses, for example, was 11.3 years, but they required, on average, three times less inventory per bus than the newer Artic buses.



At all three garages, NABI buses constituted the largest share in terms of the number of buses. At the Coral Way and Northeast garages, NABI buses also used the largest share of inventory; while at the Central garage the largest amount of inventory was used by Artic buses.

A detailed inventory comparison that accounts not only for bus type but also for model year is presented in Table 3.50.

Table 3.50 Detailed Inventory Comparison by FleetType

••	Central Bus Facility		Co	Coral Way Facility			Northeast Facility		
Bus Type	Number of Buses	Inventory (\$)	Inventory per Bus	Number of Buses	Inventory (\$)	Inventory per Bus	Number of Buses	Inventory (\$)	Inventory per Bus
Artic 94	15	539,662	35,977	25	850,553	34,022	-	0	-
Artic 95	26	967,216	37,201	-	0	-	-	0	-
Flex 90	4	44,973	11,243	3	32,399	10,800	4	38,914	9,729
Flex 92	-	0	-	-	0	-	5	74,152	14,830
Flex 93	22	280,419	12,746	23	277,269	12,055	28	455,584	16,271
Flex 94	-	0	-	-	0	-	30	594,802	19,827
NABI 97	18	300,372	16,687	16	290,718	18,170	16	226,771	14,173
NABI 98	6	89,617	14,936	7	115,046	16,435	6	110,615	18,436
NABI 99	31	403,387	13,012	31	488,052	15,744	31	455,437	14,692
NABI 00	33	378,895	11,482	31	397,476	12,822	32	395,119	12,347
NABI 02	37	162,901	4,403	36	159,745	4,437	37	166,519	4,501
NABI 03	26	1,069	41	29	5,283	182	32	7,943	248
Minibus 03	-	0	-	10	6,018	602	-	0	-

The most inventory intensive buses were clearly the Artic buses. Among all buses, they required the largest amount of inventory per bus. It was discussed previously (Table 3.46) that NABI buses, overall, required the least amount of inventory per bus. This, however, might be misleading, since the average age of the NABI fleet was much younger than the average age of other types of buses. The comparison between individual buses. accounting for their age. revealed that the NABI buses were even less inventory efficient than the much older Flex buses. For example, Flex 90 garaged at Central required bus \$11,243 worth of inventory a year per bus while the NABI 00 bus garaged at the same location required \$11,482 worth of inventory per bus. Similar results were seen in all other garages,

indicating that the relatively new NABI 00 buses required more inventory per bus than Flex 90 buses, which were ten years older.

Inventory efficiency of the garages was influenced by the types of buses assigned to each garage. Since the three major garages had different fleet compositions, it was of interest to examine how they stood against each other in terms of overall inventory efficiency. One way of looking at the overall inventory efficiency was to compare the share of buses assigned to the garage with the share of inventory used. Figure 3.39 compares share of inventory used to the share of buses at each garage.

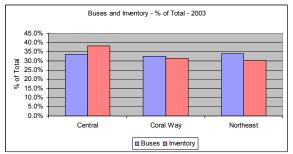


Figure 3.39 Inventory and Fleet % of Total by Garage

Among the three garages, only Central had a percentage of inventory used that exceeded the percentage of buses (i.e. Central had 33.5% of the total number of buses and used 38.1% of the total amount of inventory).

Table 3.51 presents the comparison of inventory used per bus between the garages for the most common buses.

Table 3.51	Invent	tory	Used	d per Bus	, 2003	
	-					

	Central	Coral Way	Northeast
Buses	2003	2003	2003
Artic 94	\$35,977	\$34,022	\$0
Flex 90	\$11,243	\$10,800	\$9,729
Flex 93	\$12,746	\$12,055	\$16,271
NABI 97	\$16,687	\$18,170	\$14,173
NABI 98	\$14,936	\$16,435	\$18,436
NABI 99	\$13,012	\$15,744	\$14,692
NABI 00	\$11,482	\$12,822	\$12,347
NABI 02	\$4,403	\$4,437	\$4,501
NABI 03	\$41	\$182	\$248

Not counting the Artic 94 bus, which was a typical outlier, the highest inventory used per bus was reported by NABI 97 and NABI 98 buses in all three garages. With the exception of the NABI 03 bus, there was no significant variation in the inventory used per bus at different garages.

In the detailed review of bus inventory used in 2002 and 2003, researchers found the following:

- Artic buses were the most inventory inefficient, requiring a higher amount of inventory per bus than other types of buses, regardless of the garage
- NABI buses, while being more inventory efficient when new, lost that efficiency with age faster than Flex buses
- Flex buses, regardless of age, remained the most inventory efficient buses
- No consistent inventory inefficiencies were found at any of the garages.

3.5.5 Shop Space Adequacy & Capability

The size, layout, and in-shop capabilities can impact the performance of a transit bus fleet. Specifically, best industry practices dictate that the most

effective bus maintenance facilities are those that incorporate adequate space for repairs and storage, as well as for modern tools and equipment. In addition, facilities that were originally designed to house and service transit buses are generally considered ideal. The following section documents observations made at bus maintenance facilities. Bus maintenance management personnel also provided insight into this area, including recent implementations and deficient areas.

MDT's traditional O&I facilities were constructed in the early 1980's to maintain a fleet that included over 1,000 buses, based on a transit service plan proposed for Metro-Dade in the late 1970's.

The three O&I facilities are generally similar in size and accommodations, but vary in layout and design. Shop control room sizes were especially variable. The Coral Way control room was far smaller than those at Northeast and Central. Supervisors have had to be creative in their use of space.

For the most part, each shop utilizes all of its available space, but the efficiency of the use of space is dependent upon the attitudes and priorities of bus maintenance management personnel at the shop. For example, some shops appeared far more cluttered than others. In some cases, managers relayed specific plans for updating underutilized areas of the shop. As mentioned earlier, tool cribs have also been infringed upon by space shortages.







Maintenance Shop Control Room

Maintenance shop managers reported a variety of other space and equipment adequacy concerns. For example, employee severelv parking is constrained at the several of the One shop has a limited facilities. capacity to store and service vehicle batteries. A common issue that was raised related to the maintenance of lifts and other heavy equipment within the shop. Supervisors voiced concern that preventive maintenance on such equipment was deficient and identified several examples of non-functioning lifts. Only two of one facility's six-post lifts, which are required to service articulated buses, were operational at the time of this research effort. Other shops also reported various numbers of lifts to be out of service. Supervisors reported that in the past, each shop housed two-person facilities а maintenance crew that was responsible for equipment such as lifts. Such crews have since been eliminated from the shops resulting in a lack of preventive maintenance performed on heavy equipment with repairs completed only after equipment has failed.



Maintenance Shop Area

The Medley O&I facility is small and is the only location where bus operators and bus maintenance personnel share the same building. As a result, space is inadequate to accommodate meeting rooms or training rooms. The facility also lacks adequate space for a mechanics' tool crib. The building was originally designed to service trucks. As a result, bus maintenance personnel must be cautious about the types of repairs conducted at the shop. Specifically, the shop is limited in its lifting capabilities. There are no floor lifts installed at this facility, and the pit is accommodate too shallow to undercarriage bus service. The shop relies on portable lifts when mechanics need to get under a bus. Additionally. cranes. other overhead lifting or capabilities. available. are not Maintenance service must be scheduled based on equipment availability. On occasion, the shop has been forced to remove buses from service because no lift was available.

Facilities among the peer agencies varied widely. Both Baltimore and Cleveland have older facilities located in crowded urban areas, which offer little



room for expansion. In fact, MTA's central facility includes several buildings that were used to service trolley cars during the early part of the 20th century. GCRTA is in the process of modernizing some of its facilities, and a new facility maintenance is under construction. In contrast, bus maintenance facilities in Denver, a region which has experienced tremendous growth over the past few decades, tended to be newer and specifically designed for the tasks at hand. The oldest shop among the RTD facilities was built in 1977. Shops are updated regularly, and there is considerable space for expansion, if necessary.



4. MDT Bus Maintenance Division – Support Services

4.1 Overview

In addition to the three traditional O&I facilities and the Medley (Penske) O&I shop, the MDT bus maintenance division operates an auxiliary repair shop known as support services. This shop is responsible for major repairs that usually require a bus to be unavailable for service for a long period of time. The support services shop is the only MDT bus maintenance facility that is not operated 24 hours per day, 7 days per week. Regular working hours at this location are 7 a.m. to 4 p.m., Monday though Friday.

The support services management team is not required to meet a daily schedule for peak period bus service because buses are not dispatched from this location. However, the support services shop often receives requests to complete tasks with short turn around times so that buses can be returned to scheduled service. The shop is also responsive to daily bus needs that arise at the O&I facilities.

While each O&I shop generally has the ability to complete all necessary maintenance work on buses, these shops are not really designed for longterm repairs. The support services facility is designed to house buses that will be out of service for longer periods of time. The shop has more equipment and manpower and greater capacity.

The three departments that exist within support services are:

- Major Overhaul
- Unit Room
- Body Shop

While two of the O&I facilities have body shops, capacity is limited. The Central O&I shop does not house a body repair shop. As such, the support services shop handles a great deal of body shop work for the fleet, especially for buses dispatched out of the Central facility.

The management structure in place at the MDT bus maintenance division's support services shop is similar in some ways to the traditional O&I bus maintenance facilities. Because of their proximity, the support services shop superintendent is able to cover the corresponding position at the Central O&I shop, when necessary. In fact, at the time of the site visit, the Central superintendent position was vacant.

A unique aspect about the support services shop is the latitude that it has to decide which repairs and adjustments are effective and which are not. Major overhaul has significant influence in implementing testing and changes, and the shop can dictate the priority of bus repairs.

The support services division provides service to buses from all O&I shops. As a general rule, a bus that comes into the support services shop is not returned to its assigned O&I shop until it is street ready. A bus is designated street ready once all mechanical problems are completely fixed. Exceptions may be made in cases of body damage. In some instances, body-damaged buses from O&I facilities that have body repair

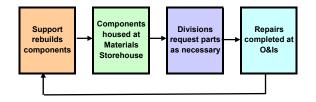


shops may be returned to that location for body repair. Such decisions are usually based on whether or not the body damage severely affects the roadworthiness of the bus. If the body damage is considered to be an environmentally unsafe condition. support services will complete the However, support services repair. completes all body repair work necessary for buses from the Central O&I location because that shop has no body repair facilities.

Parking space availability is an issue at support services facility. the Specifically, lacks the shop approximately 30 parking spaces. Support services will not accept a bus from an O&I facility until the shop is ready to start the work. When space becomes available, support services notifies the appropriate shop that it is ready to accept the bus and begin work. There are some notable exceptions to this general practice. For example, if a bus is involved in a major accident and cannot be driven safely, it is brought directly to the support services shop. Non-roadworthy buses are towed, while buses that have major mechanical malfunctions are usually delivered via flatbed truck.

In general, bus maintenance overhauls are completed according to manufacturers' schedules and according to information compiled and tracked by bus maintenance control production coordinators. Life cycle replacements generally follow a 45-day or 120-day time period. Support services makes a continual effort to coordinate the workload within the shop and tries to strike a balance between meeting regular requirements and repairing long term damaged vehicles.

The unit room is a prime example of best efforts to coordinate workflow. It was specifically set up with the most favorable days and shifts in order to attract the most experienced staff. The unit room is, in effect, a factory for rebuilding parts. Once rebuilt, the materials management division stores the components and distributes them to bus maintenance O&I facilities as necessary. Finally, the refurbished part is installed on a bus.



Engines are also overhauled, but not as part of the unit room. MDT bus maintenance only completes engine overhauls on Cummings diesel engines. The agency is not allowed to overhaul Detroit Diesel engines, as the vendor is required to complete such work.

In most cases, it appears to be cheaper to buy new components rather than to rebuild them. In addition, new components include a limited warranty and offer up to a ten-year life expectancy. Rebuilt parts offer a limited life expectancy of approximately two years. Their use may also have a negative impact on life cycle, which is considered most important. As such,



some believe that money paid to people doing component rebuilds would be better spent on the O&I divisions. Those technicians seeking a position in the unit room require certification.

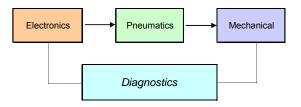
Other considerations have focused on possible changes to the unit room. To reduce costs. MDT considered eliminating the unit room; however, this action was opposed bv labor representatives. As an alternative, management explored eliminating the unit room from "pick position" status. This move would allow supervisors to re-staff the area with those best qualified for the position. Prospective unit room staff could be selected and trained based on their mechanical knowledge of components. This change in status could enable the use of an apprenticeship program in this area. Under the present structure, apprentices are unable to get "hands on" experience within the unit room.

If successful, MDT could transfer other specialized areas from pick positions to assigned areas. Obstacles to this type of move include a lack of trained and qualified personnel available from vocational schools in addition to lack of labor support.

Within support services, the chief focuses on establishing priorities. (superintendents) afford Managers supervisors discretion in determining their role and function. Supervisors are responsible for oversight of technicians and assignment of work. Some problems have arisen with long-time supervisors who are resistive to change, particularly in the use of computers and

advanced technology. The skills of the current workforce need to be developed to ensure a sufficient pool of knowledgeable supervisors as the agency approaches mass retirements of 25 to 30 year employees.

In order to reach a more complete understanding of overall bus mechanisms and functions, employees and supervisors are best served by developing a foundation of knowledge and skills related to each of the systems that are at work. For example, electronic, pneumatic, and mechanical systems tend to "build on" each other. A strong understanding of each area results in a much more effectively skilled technician.



Experience shows that generalization among employee skills is less effective than promoting employees to specialize in fields they enjoy. One of the supervisor's many responsibilities is to expose technicians to all areas so that they can decide where they want to go and in which field they want to specialize.

Unfortunately, within the current structure, position picks are based on seniority. As such, the best qualified person for a job may not be able to get job because of less tenure with the Support services managers agency. favored structure that allows а employees to pick а shop with



assignments within the shop determined by management based on individual qualifications, experience, and desire to do the job.

In general, MDT makes every attempt to follow OEM recommendations for parts replacement. The agency tries to anticipate necessary replacements and to order accordingly. The availability of replacement parts commonly varies from one extreme to another. There may be an abundance of a specific part, while another is in short supply. The availability of a specific part may also vary during the course of the year. Running out of parts that are manufactured overseas or in other faraway locations is usually problematic because delivery times tend to be extended. In most cases, vendors do not warehouse parts. As a result, there can be a long waiting period for delivery. This may also lead to MDT buying more of an item or buying a more complex item than is necessary. Although MDT has made some effort to collaborate on the purchase of replacement parts with other transit agencies in similar need, vielded minimal this practice has positive results.

The major overhaul division within support services reported routine parts shortages due to a variety of reasons. Uncommon replacement parts for older buses are sometimes unavailable because the parts have not been ordered during the life of the bus. Acquisition of this type of part often requires a longer waiting period for delivery of the part and subsequent delay in the repair of the vehicle. Variable cross-compatibility of parts between buses is another cause of parts shortages. Future needs for a new fleet are often easier to anticipate, especially for experienced supervisors. For example, a potential problem for NABI Series 50 engines lies ahead because this engine has not yet been rebuilt. When such work becomes necessary, the time required may be more extensive anticipated.

In some cases, major overhaul relays specific problems to the MDT field engineering division (FESM). FESM works with the then vendor or manufacturer to address the problem and identify a solution. There have issues vendor been regarding workmanship quality in the past.

The movement of a bus to support service begins when an O&I shop supervisor calls support services regarding the transfer. The supervisor completes a transfer form, which must accompany the bus. Unless it is an emergency situation, support services will not accept a bus unless it is prepared to start work on it. Once onsite, the "no board" shows the buses have been received. A daily report, prepared by the bus maintenance control production coordinator, indicates the status of each bus. This report support services supervisors helps expedite the repair process, so buses can be returned to the originating O&I as soon as possible. Support services is able to service about six buses at a time.

The division does not calculate an average turn-around time for the time a bus spends at the support services



division because of the diverse and varied nature of activities required to return buses to service. Supervisors touched on the issue of cannibalization of buses for parts. This is a difficult issue for the support services shop because it is bound to replace all necessary parts before returning the bus to the O&I shop.

MDT is in the process of adding at least 70 new buses in the near term. This translates into approximately three new buses per day that are delivered to support services. The shop performs a "post-delivery inspection" on each new vehicle before it is assigned to an O&I shop location.

Supervisors have become accustomed to inspecting vendors' work closely. Many vendors have experienced high turnover rates, leading to the potential of inadequately trained technicians working for them. Vendors commonly test components in addition to facilitating repairs.

4.2 Major Overhaul

Approximately 15 technicians work in the major overhaul area. They are responsible for major repairs and cradle rebuilds. They also maintain the Team Metro Bus, which is a bus that was modified to be an office on wheels. In general, major repairs completed by the support services major overhaul division are unscheduled. When problems found at the O&I shops are diagnosed as major, they are referred to major overhaul. In some cases, the problem is re-diagnosed upon arrival, but more often than not, the major repair is then scheduled. Some of the major repairs

regularly completed at the support services facility include: engine removal replacement, burned and buses. transmissions, differentials, and cradle assemblies. The "cradle" refers to a combination of parts that make up the "engine power pack," which is anything that powers the bus. The maior overhaul division maintains a supply of cradles so that they are readily available when needed. In the event a bus cradle is replaced, a "C" inspection is always completed as part of the repair order.

Supervisors and technicians use computers to record hours and track data items on a spreadsheet. Support services utilizes two-man repair crews that work on jobs. While the majority of jobs require two technicians, a supervisor can pull one of the crew members to assist another crew.

Technicians identify the problem or problems. This information is then relayed to the supervisor. In some cases, problems that are common or obvious may not go to a supervisor for input. Rather, the technician completes the repair and informs the supervisor of the work that was done. After work has been completed, the supervisor inspects the work. A bus may be road-tested, which involves driving the bus about 100 miles, after major repairs.

4.3 BMC Production Coordinator Role within Support Services

The bus maintenance control Division staff at the support services facility consists of one transit maintenance production coordinator and two bus maintenance control clerks. BMCC are



responsible for data entry of repair orders and inspections as well as payroll for all departments within support services.

The TMPC at support services is responsible for a variety of duties to support the shop, some of which are different than those at the traditional O&I shops. Collecting, monitoring, and analyzing bus data are frequent tasks completed by the TMPC, who tracks bus miles per gallon and reads hub mileage to identify erratic reports. Special projects, such as establishing data collection procedures for campaigns or other efforts may also be part of the TMPC's duties. At the time of this research effort. the production coordinator was working with the superintendent to reintroduce select past reporting efforts. Included are the unit room production report and the engine reliability report.

The unit room production report indicates what is on hand in that division. One of the reasons for using this report is to project anticipated needs for a three-month period along with the availability of parts by part number by month. The hours required to refurbish each part are also documented so that in-house production costs can be compared to vendor bids to identify the least costly option for part procurement.

The engine reliability report documents 12 years of engine repair orders. There are 12 reporting categories for an engine. Similar reports are created for air conditioning units, transmissions, and other major parts. The TMPC participates in the process of tracking serialized engine components. The goal associated with special projects such as these is to identify specific areas where the support services shop can improve.

The bus procurement process generates very detailed records. The TMPC at support services plays a role in the acceptance process for new buses. The major components are documented, and a PM schedule is generated. These data are entered into the CAD/AVL system.

The unit room was established in part as a result of vendor reliability issues. MDT decided to implement a section responsible for rebuilds, which could be monitored in-house to ensure quality.

The support services TMPC recommended a detailed review and revision of MDT's repairs codes. The original list was established outside of a specific methodology, and throughout the years, the list has become unwieldy and incongruous with revisions providing only short-term benefits.



5. Comprehensive 90-day Review & Bus Maintenance Implementation Team

MDT management had previously expressed concern regarding the completion rate of necessary bus repairs, especially those associated with preventive maintenance inspections. Although these concerns were among the original reasons for initiation of this project, the findings contained in the Quality Assurance/Quality Control Audit Report AFR-QAA 0204 (AFR-QAA0204) relating to the bus maintenance division in late 2004 exacerbated the issue. The audit found that PMI checklists were improperly completed and recommended that MDT only not coordinate an inspection training program but also establish a Quality Control Program to verify the PMI inspection processes. As a direct result of the audit findings, MDT immediately initiated Comprehensive а 90-dav Review on December 9, 2004.

5.1 Comprehensive 90-day Review

MDT established ten committees to address not only areas identified in the audit report but also areas of concern identified by MDT management. Following is a list of the ten committees and a summary of activities and recommendations that were developed within the committee structure:

Staffing & Recruitment Committee

The Project Team consisted of human resources (HR), training, bus maintenance, the transit workers union

(TWU), civil rights & labor Management, and budget staff.

Short-range goals included revisiting prerequisites for new recruits and forecasting manpower needs to enable allocation of the training time necessary to establish proficiency prior to assignment. Launching a career ladder program internally prior to advertising open recruitment was established as a mid-range goal.

As a long-range goal, the committee suggested re-evaluating the curriculum of partnering agencies to require completion of a CDL license, safety instruction, and EPA certification prior to graduation.

Technical & Continued Training Committee

The project team included HR, training, quality control (QC), bus maintenance, and TWU representatives.

Short-range goals included taping classes presented by vendors for future use in training classes, development of "Preventable Accident а Training" module, creation of a re-entry curriculum for employees with long-term absences, and implementation of a three month on-the-job training (OJT) program with rotation to other divisions for new hires and instructors.

The committee suggested that training time for new bus familiarization be established as a mid-range goal, and recommended that, as a long-range goal, a budget be established for continuing education and training.



Supervisory Roles & Responsibilities Committee

The project team included: HR, Training, bus maintenance, budget, information technology services (ITS), office of support services (OSS), QC, TWU, civil rights & labor management, and budget staff.

Short-range goals identified by the committee included an update of job essentials and job specs for supervisors, coordination of service bulletin research efforts with bus maintenance control and materials management, and examining the feasibility of converting paper forms to electronic forms.

Mid-range goals included defining the supervisor's role: function versus support, re-examining the provision of clerical support, having the supervisors attend county certification classes, and providing a computer training program for all supervisors.

As long-range goals, the committee recommended that all supervisors receive Enterprise Asset Management System (EAMS) training, kiosks be installed on the shop floor for supervisors, and allocation of clerical staff for 7x24 operations.

Parts Procurement Committee

The project team was comprised of: bus maintenance, bus maintenance control, ITS, OSS, quality assurance/quality control (QAQC), materials management, budget, and TWU representatives.

As short-range goals, the committee suggested that current parts practices,

including delivery, quality, process, and min/max, be reviewed, that all unit room rebuilt components be tracked for reliability, quality, and cost-efficiency, and that vendors be required to provide specific delivery dates.

Specific mid-range goals included restoring the parts runner, adjusting the budget to account for Saturday stock room service, requiring addendums or revisions to OEM and vendors manuals to address inaccuracies, and pursuing after-market sources.

In the mid-range, the committee directed that a discussion of the RFP versus bidding process should occur. The committee concurred that a maintenance representative should be assigned to the technical committee for vehicle specifications, MDT barcoded parts should be required, performance measures should be added to the parts contracts, and the parts budget should be increased.

Overhaul & In-house Warranty Work Committee

The project team included: HR, training, bus maintenance, bus maintenance control (BMC), ITS, OSS, QAQC, materials management, and TWU representatives.

the short-run, the committee In recommended that vendor certification necessarv along with tools and equipment to perform in-house warranty work be obtained. As a mid-range goal the committee suggested that existing procedures for rebuilding and testing all major components should be updated and re-distributed.

Facilities & Equipment Committee

The project team consisted of bus maintenance, bus operations, ITS, field engineering & systems maintenance (FESM), OSS, and TWU representatives.

Short-range goals included inspection of all hydraulic lifts, review of CUTR's manpower analysis, forwarding lift inspection findings to bus maintenance, and including bus maintenance input in facilities' annual capital plan. The committee also recommended that, long-range, facilities dedicate resources to maintain bus facilities.

Towing & Flat Bed Services Committee

The project team included: bus maintenance, bus operations, BMC, OSS, materials management, budget, and TWU representatives.

The committee recommended that vendor performance for vehicle recovery be monitored.

Mid-range, the committee suggested that MDT act as a secondary or third party vendor in providing towing services; and, long-range, a new tow truck should be dedicated to in-house towing projects.

Service Lane & Hostler Roles Committee

The project team included: bus maintenance, bus operations, BMC, OSS, ITS, and TWU representatives.

Short-range, the committee favored confirming implementation of the

nesting/lot concept and recruiting staff to assume yard responsibilities.

A service lane supervisor scope of responsibilities should be developed in the mid-range, and, long-range the service lane supervisor should receive proper equipment. A cross-training curriculum needs to be developed for operators and traffic controllers.

Bus Traffic Control Committee

The project team consisted of bus operations, ITS, OSS, and BMC staff.

The committee recommended that the role of the transit operations supervisor be re-evaluated, contact numbers for lost and found items for customers be provided, a list of fuel allowances by bus type be developed by bus maintenance, a pocket chart for each bus be established, and the radio system at each console be upgraded.

Quality Control Committee

The project team included: bus maintenance, bus operations, BMC, OSS, and QAQC representatives.

In the short-range, a working definition of "quality control" needs to be developed, written responses must be provided to safety inspections reports and audits in a timely fashion, and a copy of the maintenance quality control program recently implemented for AM inspections should be made available.

In the mid-range PM inspections should begin with next purchase of equipment, and, long-range, current process mapping for bus maintenance should be reviewed.





5.2 Bus Maintenance Implementation Team (BMIT)

In late February 2005 upon completion of the 90-day review, MDT's deputy director, operations established the bus maintenance implementation team (BMIT), which was tasked with taking immediate action on the draft recommendations of the 90-dav operations review task force. The target timeframe was 30 days. The assistant director rail services served as the chair of the BMIT.

The structure and operating methods of the task force and review plan were patterned after successful initiatives undertaken by MDT's rail division. An executive summary of major actions undertaken by the BMIT was issued in April 2005. Included were the following activities:

Preventive Maintenance Program

- Subcommittee continuing work on revisions to entire program
- PM recommendations from all OEMs were researched and evaluated for applicability to current fleet
- PM inspection forms reformatted to be fleet specific
- Requirement to ensure proper torque on all lug nuts was added
- PM "S Inspection" was developed for surplus equipment

Parts Accessibility & Availability

- Created space in Metrorail and Metromover parts rooms to stock bus parts for rapid deployment to service truck technicians
- Compiled and evaluated a list of most frequently used parts for PM inspections and general repairs

 Adjusted minimum/maximum inventory levels to ensure parts availability

Recruitment & Training

• Prioritized knowledge resources throughout organization

Fleet Reliability

- Re-established cross-functional team to study and resolve root causes of vehicle equipment failures
- Implemented quality control checks
- Upgraded laptops with vehicle software; assigned laptops to shop floor, including three laptops reassigned from Metrorail maintenance managers
- Road call partners in productivity (PIP) team meets bi-weekly to analyze repeat failures
- Quality control (QC) program was implemented, which mandates random checks of repairs and PMs documented on new QC form
- Conducted fleet-wide inspection of wheel lugs to check for broken lugs and ensure proper torque

Procedures

- Metrobus procedures control board (PCB) was activated to review and revise all Metrobus procedures and to identify new procedures: 15 procedures identified for revision; 6 procedures completed; and 9 areas of concern submitted for consideration
- Reviewed and revised maintenance repair codes



Quality Assurance

- Committee referred 12 rebuilt components to quality assurance for QA audits
- Initiated monthly reporting on average costs per unit: rebuilt versus vendor

General Working Conditions & Environment

- Toolbox safety meetings implemented on all shifts
- Upgrade of garages' appearance underway

5.3 Quality Assurance/Quality Control Initiative

An implementation Plan was also developed to address the Quality Assurance/Quality Control Audit Report. The initiative is summarized below:

Quality Assurance Audit 0204-02 – Bus Maintenance Responsibility

- Coordinate necessary training for bus technician on bus-specific features/equipment to ensure proper inspections and/or tests are performed
- Ensure adequate training is provided for the proper completion of the PMI form, including the identification of defects for required repairs
- Document formal training
- Establish a quality control program to verify PMI processes are completed and data integrity is assured for maintenance and repairs

Quality Assurance Audit 0204-03 – Bus Maintenance Responsibility

• Submit all tools and equipment for evaluation of calibration intervals for

compliance with calibration program requirements.

- Include personal tools in the evaluation
- Coordinate results with bus maintenance control (BMC) and field engineering & systems maintenance (FESM) to establish calibrated tool requirements by bus type and application/operation and implement within the calibration procedure
- Establish internal tool room controls to enforce storage methods for safeguarding tools, including checkout procedures

Quality Assurance Audit 0204-05 – Bus Maintenance Responsibility

- Establish fault isolation/problem diagnostics procedures within the bus maintenance technician training program to supplement the formal classroom training to ensure integrity is achieved and maintained
- Document and include additional training records of bus maintenance technicians by coordinating requirements with the human resources training division

Quality Assurance Audit 0204-06 – Bus Maintenance Responsibility

- Review and revise bus maintenance activities to incorporate the Hot Line Process for all shifts for compliance with approved procedures
- Ensure records of inspections include required forms for documenting results
- Coordinate with bus maintenance control to ensure the Hot Line process meets the requirements of bus maintenance, the form is included with the procedure and is



formalized/controlled, and the planning of miscellaneous stock items shall be identified for support to the process

• Evaluate the requirements for establishing a separate Hot Line procedure and coordinate implementation with bus operations

Quality Assurance Audit 0204-07 – Bus Maintenance Responsibility

- Establish quality control monitoring and verifications of the work orders to ensure recorded defects from PMIs are repaired and verified prior to acceptance into the Equipment Management System (EMS) to prevent inaccuracies in overall performance reporting
- Evaluate the process of deferred PMI defects and develop guidelines and procedures for ensuring required tracking and reporting for timely repairs
- Coordinate with bus maintenance control on monitoring overall performance of unscheduled repairs from PMIs

The final report of the bus implementation team was not available for inclusion in this report.



6. Miami-Dade Transit as a Top-20 Transit Agency

MDT is one of the largest transit agencies in the nation, ranking ninth in 2004 in terms of annual passenger miles. In addition to comparing MDT to several of its most similar peers, it is of interest to see how Miami performs as one of the 20 largest transit agencies in the country. The statistics used for the following comparison represent data for the 20 largest transit agencies, including MDT, obtained from the National Transit Database for years 2000 through 2004. Agency selections were based on the twenty agencies operating the maximum number of vehicles in service during 2004. The agencies identified in 2004 were used throughout the 2000-2004 reporting period to examine growth and performance trends.

Specific performance levels are reported for Miami-Dade Transit along with the maximum, minimum, average, and median of all 20 agencies. Individual agencies, other than MDT, are not identified within the report in terms of individual performance levels.

Following are the agencies included in the review:

- Alameda-Contra Costa Transit District (AC Transit) Oakland, California
- Chicago Transit Authority (CTA) Chicago, Illinois
- Dallas Area Rapid Transit (DART) Dallas, Texas
- Denver Regional Transportation
 District (RTD) Denver, Colorado

- King County Department of Transportation, Metro Transit Division (King County Metro) Seattle, Washington
- Los Angeles County Metropolitan Transportation Authority (LACMTA) Los Angeles, California
- Maryland Transit Administration (MTA) Baltimore, Maryland
- Massachusetts Bay Transportation Authority (MBTA) Boston, Massachusetts
- Metro Transit (Metro Transit) Minneapolis, Minnesota
- Metropolitan Atlanta Rapid Transit Authority (MARTA) Atlanta, Georgia
- Metropolitan Transit Authority of Harris County, Texas (Metro) Houston, Texas
- Miami-Dade Transit (MDT) Miami, Florida
- MTA New York City Transit (NYCT) Brooklyn, New York
- New Jersey Transit Corporation (NJ TRANSIT) Newark, New Jersey
- Pace Suburban Bus Division (PACE) Arlington, Illinois
- Port Authority of Allegheny County (Port Authority) Pittsburgh, Pennsylvania
- Southeastern Pennsylvania Transportation Authority (SEPTA) Philadelphia, Pennsylvania
- The Greater Cleveland Regional Transit Authority (GCRTA) Cleveland, Ohio
- Tri-County Metropolitan Transportation District of Oregon (TriMet) Portland, Oregon
- Washington Metropolitan Area Transit Authority (WMATA) Washington, DC



6.1 Agency Comparative Data

Throughout the period of 2000-2004, MDT's number VOMS of was significantly below the average for the 20 largest agencies (38.8% to 52.4% below the average), depending on the year (Table 6.1). The average for the top-20 agencies might have been skewed by the presence of a few extremely large transit agencies in the sample. The evidence for that can be seen in the large maximum values for the entire sample, and in the fact that the average for the group of agencies exceeds the median value for all the vears in the observed period. Nonetheless, MDT's VOMS is below even the median number of VOMS for the group. For the entire period, the number of VOMS at MDT is 11.4% to 34.5% below the median value. From 2000 to 2003. MDT's VOMS consistently remained at least 30.0% below median and at least 47.0% below average number of VOMS for the group.

Table 6.1 Vehicles Operated in Maximum Service

	Maximum	Minimum	Average	Median	MDT				
2000	3,840	441	1,038	777	530				
2001	3,887	447	1,050	786	547				
2002	3,915	452	1,067	807	564				
2003	3,893	440	1,063	772	506				
2004	3,849	467	1,083	748	663				
Source: National Transit Database (NTD) 2000-2004									

For the period of 2000-2004, the number of major mechanical failures at MDT decreased 33.1% (Table 6.2). However, the average number of failures at the 20 largest agencies decreased even more over the same time period (a decrease of 48.1%). As a result, the gap between the number of major mechanical failures at MDT and the average number of failures at the top-20 agencies widened over the observed period. While in 2000, the

number of major mechanical failures at MDT exceeded the average by only 0.2%, in 2004, MDT recorded 29.2% more failures than an average top-20 agency.

For the entire period, MDT remained above the median value for the top-20 agencies in terms of the number of major mechanical failures. The largest deviation from the median was observed in 2002. During this year, MDT recorded the largest number of failures (12,885 failures). In 2002, the number of failures at MDT exceeded the average by 86.7% and was 3 times higher than the median value for the 20 largest transit agencies.

Table 6.2 Major Mechanical Failures

	Maximum	Minimum	Average	Median	MDT		
2000	58,854	672	11,475	6,270	11,501		
2001	26,566	708	7,631	4,562	9,844		
2002	19,856	735	6,902	4,159	12,885		
2003	16,974	696	6,542	5,040	7,413		
2004	16,458	594	5,954	4,144	7,694		
Source	· National Trar	nsit Database	(NTD) 2000-2	2004			

Source: National Transit Database (NTD) 2000-2004

Since MDT ranked rather low among the top-20 agencies in terms of VOMS and had a higher-than-average number of major mechanical failures during the period of 2000-2004, it is reasonable to expect a greater-than-average number of mechanical failures per vehicle at MDT. Over the period of 2000-2004, the number of major failures per vehicle operated in maximum service at MDT significantly exceeded both the average and the median number of major failures per VOMS at the largest 20 transit agencies (Figure 6.1). During the observed period, MDT's major failures per VOMS were 2.2 to 3.3 times higher than the average and 2.3 to 4.9 times higher than the median number of major failures per VOMS at the top-20 transit



agencies. In addition, in 2002 (the year when MDT's major failures per VOMS were 3.3 times higher than the average and 4.9 times higher than the median value), MDT recorded the greatest number of major mechanical failures per VOMS (22.85 failures per vehicle).

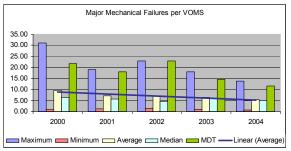


Figure 6.1 Major Mechanical Failures per VOMS

Compared to the top-20 transit agencies, MDT had more than the average number of other mechanical failures in all the years of the observed period except 2002 (Table 6.3). From 2000 to 2004, the number of other mechanical failures at MDT decreased by 26.7%, while the average number of failures at the 20 largest agencies dropped by 64.3%. As a result, the number of MDT's other mechanical failures, as compared to the top-20 agencies, went from 9.4% above the average in 2000 to 2.3 times higher than average (i.e., 130% above average) in 2004. In 2002, however, MDT's other mechanical failures stood at 4.6% below the average of the largest 20 transit agencies. During the observed period, the number of other mechanical failures at MDT consistently exceeded the median number of failures at the top-20 14.5% agencies by to 226.3%. depending on the year. In 2004, for example, the number of failures at MDT was 3.3 times higher than the median

number of failures at the 20 largest agencies.

Table 6.3	Other	Mechanical	Failures

	Maximum	Minimum	Average	Median	MDT				
2000	19,050	1	6,732	6,436	7,368				
2001	17,779	0	4,370	2,324	6,473				
2002	2,815	0	4,457	2,322	4,252				
2003	23,334	0	3,430	2,328	4,744				
2004	7,699	0	2,403	1,656	5,403				
Source	Source: National Transit Database (NTD) 2000-2004								

Since MDT had a higher-than-average number of other mechanical failures, and a lower-than-average number of vehicles. MDT ranked consistently above average in terms of other mechanical failures per VOMS (Figure 6.2). During the period of 2000-2004, the number of other failures per VOMS at MDT exceeded the average failures per VOMS at the top-20 agencies by 50.8% to 204.1%. The deviation from the median failures per VOMS was even higher. During the observed period. MDT's number of other failures per vehicle operated in maximum service was 2.6 to 4.7 times higher than the median number of failures per VOMS observed at the 20 largest transit agencies. From 2000 to 2004, the gap between MDT and the top-20 transit agencies widened. For example, the number of failures per VOMS recorded by MDT in 2000 was 89.1% higher than the top-20 average and 2.6 times higher than the top-20 median value. In 2004, failures per vehicle at MDT were 3.0 times higher than average and 4.4 times higher than median failures per VOMS at the 20 largest agencies.

For the entire period, MDT had more system revenue failures than the average or median number of failures at the largest 20 transit agencies (Table 6.4). Total system revenue failures at



MDT decreased by 30.5% from 2000 to 2004. During the same time, the average number of total failures at the 20 largest transit agencies decreased by 54.1%.

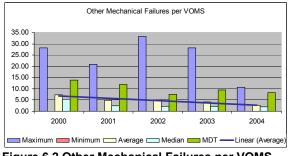


Figure 6.2 Other Mechanical Failures per VOMS

As a result, the gap between MDT and the average of the top-20 transit agencies increased during the observed period. In 2000, the number of total system revenue failures at MDT was 3.6% higher than the average and 12.5% higher than the median of the top-20 transit agencies. In 2004, the number of MDT total system revenue failures exceeded the average by 56.7% and the median by 64.7%.

Table 6.4	Total	System	Revenue	Failures

	Maximum	Minimum	Average	Median	MDT				
2000	65,193	1,480	18,207	16,779	18,869				
2001	35,279	1,153	12,002	8,930	16,317				
2002	38,691	1,657	11,359	8,219	17,137				
2003	35,179	1,098	9,972	7,591	12,157				
2004	21,249	1,164	8,357	7,954	13,097				
Source	Source: National Transit Database (NTD) 2000-2004								

The number of total system revenue failures per vehicle at MDT was significantly higher than both the average and median of the top-20 agencies from 2000 through 2004 (Figure 6.3). During the observed period, MDT's number of total system revenue failures per VOMS decreased by 44.5% (from 35.6 in 2000 to 19.8 in 2004), while the average of the 20

largest agencies decreased by 52.6% (from 17 in 2000 to 8.1 in 2004), widening the gap between MDT and the top-20 agencies. In 2000, MDT exceeded the top-20 average in terms of total system revenue failures per VOMS 2.1 times and exceeded the top-20 median 2.5 times. In 2004, MDT recorded 2.5 times more total system revenue failures per VOMS than the average of the 20 largest transit agencies and 2.6 times more total system revenue failures per VOMS than the median of the top-20 agencies. In addition, MDT's number of total system revenue failures per vehicle exceeded the top-20 median by more than three times from 2001 to 2003, reaching almost four times in 2002 (30.4 total system revenue failures per VOMS at MDT versus the median of 7.7 total system revenue failures per VOMS).

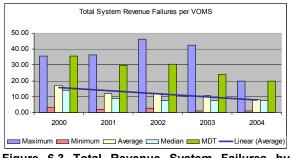


Figure 6.3 Total Revenue System Failures by VOMS

During the period of 2000-2004, MDT consistently spent significantly fewer labor hours for inspection and maintenance compared to the average and median hours spent by the largest 20 transit agencies (Table 6.5). Over the period, the number of inspection and maintenance labor hours at MDT increased by 30.8%; however, this growth occurred in the last year of the period (2004). From 2000 to 2003 the

number of inspection and maintenance labor hours at MDT fell steadily, ending 25.6% lower in 2003 than in 2000. For the same period, both the average and median number of inspection and maintenance labor hours at the 20 largest agencies fell as well, but they fell by less than MDT. As a result, from 2000 to 2003, MDT's number of maintenance hours fell from 62.4% below average to 70.1% below average and from 49.5% below median to 57.9% below median as compared to the top-20 transit agencies. In 2004, however, MDT recorded labor hours used for inspection and maintenance 46.9% lower than the average at the top-20 agencies and 18.6% below the median number of hours at the top-20 agencies. This was a significant improvement compared to the year before (2003) as well as for the entire period of 2000-2004. However, MDT still lags behind

the largest 20 agencies in terms of the number of labor hours spent on inspection and maintenance.

Table 6.5 Inspection and Maintenance LaborHours

	Maximum	Minimum	Average	Median	MDT			
2000	4,876,065	213,033	1,068,092	795,786	401,562			
2001	4,936,123	220,368	1,066,997	794,194	321,190			
2002	4,772,104	238,542	1,036,452	809,000	316,300			
2003	4,819,934	227,905	1,027,041	708,893	298,576			
2004	4,793,898	279,221	986,145	644,913	525,264			
Source: National Transit Database (NTD) 2000-2004								

Although MDT had a less-than-average aggregate number of inspection and maintenance labor hours, it operated a less-than-average number of vehicles. Regardless of this fact, however, MDT ranked lower than both the average and top-20 transit the median of the agencies terms of inspection in maintenance labor hours per VOMS throughout 2000-2004 (Figure 6.4).

Compared to the 20 largest agencies, MDT improved marginally over the observed period. With 757.7 inspection and maintenance labor hours per VOMS in 2000, MDT was 23.5% below the average and 22.8% below the median of the top-20 transit agencies. In 2004, MDT recorded 762.1 inspection and maintenance labor hours per VOMS, which was 13.9% below the average and 21.7% below the median compared to the 20 largest transit agencies.

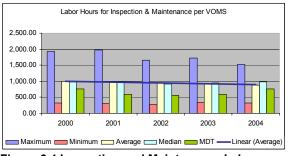


Figure 6.4 Inspection and Maintenance Labor Hours per VOMS

During the observed period, the number of full-time vehicle maintenance hours at MDT increased by 38.2%, while the average of the 20 largest transit agencies decreased by 1.4% (Table 6.6). As a result, the gap between MDT and the top-20 transit agencies, in terms of the number of full-time vehicle maintenance hours. decreased. but maintenance hours at MDT still remained below the average of largest 20 agencies. In 2000. MDT recorded full-time 51.3% fewer vehicle maintenance hours than the average number of hours at the top-20 agencies and 27.3% fewer hours than the median number of maintenance hours at the largest 20 agencies. In 2004, MDT stood 31.7% below the average and only 1.0% below the median in terms of



full-time vehicle maintenance hours as compared to the top-20 transit agencies.

Table 6.6 Full-time Vehicle Maintenance Hours

	Maximum	Minimum	Average	Median	MDT				
2000	6,472,178	428,833	1,524,199	981,909	743,038				
2001	7,547,480	418,627	1,551,852	975,553	779,834				
2002	7,584,839	436,705	1,542,335	1,000,607	729,237				
2003	7,888,850	450,134	1,550,395	964,720	786,741				
2004	7,324,807	447,472	1,502,528	1,036,855	1,026,924				
Source	Source: National Transit Database (NTD) 2000-2004								

From 2000 to 2004, the number of fulltime vehicle maintenance hours per VOMS at MDT grew by 10.5%, while both the average and the median number of full-time vehicle maintenance hours per vehicle at the top-20 transit agencies decreased slightly (Figure 6.5). As a result, the number of full-time vehicle maintenance hours per VOMS at MDT went from 0.6% above average in 2000 to 19.2% above average in 2004 compared to the 20 largest transit agencies. Full-time vehicle maintenance hours per VOMS at MDT were 1.3% lower than the median at the top-20 agencies in 2000, but increased to 14.7% above the median by 2004.

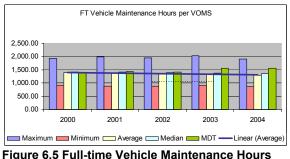


Figure 6.5 Full-time Vehicle Maintenance Hou per VOMS

From 2000 to 2004, the number of fulltime vehicle maintenance employees at MDT grew by 30.8%, but still remained significantly lower than the average at the top-20 transit agencies (Table 6.7). In 2000, MDT had 364 full-time vehicle maintenance employees, which was 51.8% lower than the average and 20.8% lower than the median of the largest 20 transit agencies. In 2004, MDT had 476 full-time vehicle maintenance employees and was 35.0% below the average and only 1.9% less than the median of the top-20 transit agencies.

Table 6.7 Full-time Vehicle MaintenanceEmployees

		Maximum	Minimum	Average	Median	MDT	
	2000	2,830	223	755	460	364	
	2001	3,515	239	778	466	374	
	2002	3,189	254	763	482	384	
	2003	3,030	257	749	471	378	
	2004	2,929	246	732	485	476	
Source: National Transit Database (NTD) 2000-2004							

From 2000 to 2004, the number of fulltime vehicle maintenance employees per VOMS at MDT increased by a modest 4.3% from 0.69 in 2000 to 0.72 in 2004 (Figure 6.6). For the first three years of the period (2000-2002), MDT lagged behind the average of the top-20 transit agencies in terms of full-time maintenance employees per VOMS. The number of maintenance employees per VOMS surpassed the average in 2003 and actually exceeded the average of the top-20 agencies by 9.1% in 2004. With 0.72 full-time vehicle maintenance employees per VOMS in 2004, MDT was 7.5% above the median of the 20 largest transit agencies. Both the average and the median values of the top-20 agencies decreased over the observed period.



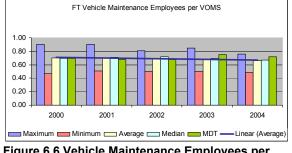


Figure 6.6 Vehicle Maintenance Employees per VOMS

During the period of 2000-2004, MDT ranked consistently higher than the average and the median in terms of full-time vehicle maintenance hours per employee as compared to the 20 largest transit agencies (Figure 6.7). In every year of the observed period, MDT exceeded the top-20 average by 2.7%-10.0% and exceeded the top-20 median by 5.7% to 10.1%. The number of full-time vehicle maintenance hours per employee increased 5.7% at MDT from 2000 to 2004, while the average of the 20 largest agencies decreased by 1.4% during the same time.

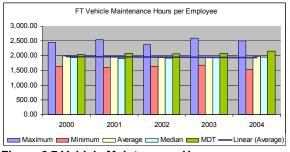


Figure 6.7 Vehicle Maintenance Hours per Employee

Over the period of 2000-2004, the number of inspection and maintenance labor hours per employee at MDT decreased by 3.8%, while the average number of inspection and maintenance labor hours per employee at the 20 largest transit agencies decreased by

5.0% (Table 6.8). For the entire period, MDT remained below both the average and the median of the 20 largest transit agencies in terms of inspection and maintenance labor hours per employee. 2000. MDT reported 1,103.2 In inspection and maintenance labor hours per employee, which was 21.6% below the average and 20.6% below the median of the top-20 transit agencies. 2004. MDT recorded 1.061.5 In inspection and maintenance labor hours per employee, which was 20.5% below the average and 26.5% below the median of the largest 20 transit agencies. MDT inspection and maintenance labor hours per employee as a percentage of the average (as well as the median) declined from 2000 to 2003, reaching the lowest point in 2003 (41.8% below the average and 40.2% below the median). In 2004, however, MDT inspection and maintenance labor hours per employee jumped 34.4% (compared 2003). to causing significant improvement in terms of how MDT compared to the average and the median of the 20 largest transit agencies.

Table 6.8 Inspection and Maintenance LaborHours per Employee

	Maximum	Minimum	Average	Median	MDT	
2000	2,439.09	528.47	1,406.59	1,389.13	1,103.19	
2001	2,552.57	525.12	1,370.99	1,344.28	858.80	
2002	2,085.39	540.67	1,354.81	1,320.50	823.70	
2003	2,040.10	624.40	1,357.80	1,322.00	789.90	
2004	2,085.14	604.42	1,335.95	1,443.97	1,061.48	
Source: National Transit Database (NTD) 2000-2004						

Throughout the observed period (2000-2004), MDT ranked much lower in terms of inspection and maintenance labor hours as a percentage of vehicle maintenance hours compared to the average and the median of the 20 largest transit agencies (Table 6.9). The

gap between MDT and the top-20 agencies in terms of inspection and maintenance labor hours as а percentage of vehicle maintenance hours decreased until 2003, but showed some improvement in 2004. The smallest gap between MDT and the top-20 agencies was observed in 2000. of 54.0% MDT's vehicle when maintenance hours were inspection and maintenance labor hours compared to the 69.9% average and 71.5% median of the top transit agencies.

Table 6.9 Inspection and Maintenance LaborHours as a Percentage of Vehicle MaintenanceHours

	Maximum	Minimum	Average	Median	MDT	
2000	100.0%	29.8%	69.9%	71.5%	54.0%	
2001	100.2%	30.3%	69.7%	67.2%	41.2%	
2002	100.0%	30.6%	70.3%	73.4%	39.9%	
2003	100.0%	31.6%	69.9%	67.6%	38.0%	
2004	100.0%	30.8%	68.0%	70.7%	49.2%	
Source: National Transit Database (NTD) 2000-2004						

In 2000, MDT was 22,7% below the average and 24.5% below the median of the top-20 agencies in terms of inspection and maintenance labor hours expressed as a percentage of vehicle maintenance hours (Figure 6.8). Bv 2003, MDT dropped in this parameter to 45.6% below the average and 43.8% below the median (the largest gap during the period of 2000-2004) compared to the largest 20 transit agencies.

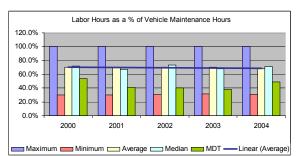


Figure 6.8 Inspection and Maintenance Labor Hours as a Percentage of Vehicle Maintenance Hours

From 2000 to 2004, the number of vehicles available for maximum service (VAMS) at MDT increased by 23.0% (Table 6.10). At the same time, the average number of VAMS at the largest 20 agencies increased by a modest 2.5%, and the median number of VAMS grew only by 1.8%. Despite faster-thanaverage growth, MDT remained consistently below the average of the top-20 transit agencies in terms of VAMS. The largest gap between MDT and the top-20 transit agencies was observed in 2000, when the number of VAMS at MDT was 46.2% lower than the average and 29.3% lower than the median number of VAMS at the top-20 agencies. The smallest gap between MDT and the top-20 transit agencies was observed in 2002, when MDT was 24.2% below the top-20 average and only 0.6% below the top-20 median in terms of VAMS. In 2003. MDT exceeded the median number of VAMS at the largest 20 transit agencies by 0.9%.

In the analysis of VAMS at the top-20 agencies, the average is greater than the median, suggesting the presence of a few extremely large transit agencies among the top-20 group. Those agencies with an extremely large



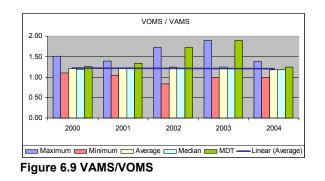
number of VAMS (e.g., New York) skew the average upward. Thus, it might be more appropriate to compare MDT to the median number of VAMS rather than the average number of VAMS at the largest 20 transit agencies.

Table 6.10 Vehicles Available for MaximumService

	Maximum	Minimum	Average	Median	MDT	
2000	4,489	565	1,239	942	666	
2001	4,457	526	1,248	934	732	
2002	4,486	572	1,279	975	969	
2003	4,539	548	1,286	948	957	
2004	4,509	544	1,270	959	819	
Source: National Transit Database (NTD) 2000-2004						

From 2000 to 2004, MDT consistently reported a VAMS/VOMS ratio that exceeded both the average and the median of the 20 largest transit agencies (Figure 6.9). The VAMS/VOMS ratio shows how the available fleet is being utilized by the transit agency. A large VAMS/VOMS ratio would indicate that a large portion of the fleet is not being used in maximum service.

MDT's VAMS/VOMS ratio increased by 50.0% from 2000 to 2003, reaching 1.89, which was 52.4% higher than the average and 57.5% higher than the median VAMS/VOMS ratio of the 20 largest transit agencies. In 2004. however, MDT's VAMS/VOMS ratio dropped 34.4% (from 1.89 in 2003 to 1.24 in 2004), which was 1.6% below the 2000 level (1.24 in 2004 compared to 1.26 in 2000). Despite such a sharp decrease in 2004, the VAMS/VOMS ratio at MDT still remained 5.1% higher than both the average and the median VAMS/VOMS ratio at the top-20 transit agencies. For the entire period of 2000-2004, the average and the median VAMS/VOMS ratio at the 20 largest agencies decreased by 2.5% and 0.8%, respectively.



Scheduled revenue miles at MDT increased by 29.3% over the period from 2000 to 2004, while both the average and the median at the 20 largest transit agencies increased by a maximum of 4.5% during the same time period (Table 6.11). Despite the growth scheduled revenue miles. MDT in remained below the average of the top-20 agencies throughout 2000-2004, but did exceed the median in every year beginning in 2002. In 2000, MDT had 25,052.5 thousand scheduled revenue miles, which was 30.8% lower than the average and 7.7% lower than the median number of revenue miles at the 20 largest transit agencies. With 32,393.6 thousand scheduled revenue miles in 2004, MDT was 14.3% below the average but 14.4% above the median of the 20 largest transit agencies. It is important to note that the average number of revenue miles at the top-20 transit agencies is greater than the median number. Furthermore, the average is closer to the minimum number of miles than the maximum, which might indicate the presence of a few extremely large observations among the top-20 group that skew the average number of scheduled revenue miles for the entire group. Therefore, it might be



more appropriate to compare MDT to the median rather than to the average of the 20 largest transit agencies.

Table 6.11 Annual Scheduled Vehicle RevenueMiles (000s)

	Maximum	Minimum	Average	Median	MDT	
2000	99,236.3	17,002.9	36,181.9	27,156.1	25,052.5	
2001	100,929.1	17,754.2	36,528.1	26,723.5	26,206.7	
2002	102,217.9	18,116.1	37,478.4	27,091.3	27,422.5	
2003	102,338.8	18,070.4	37,636.0	27,086.7	30,295.7	
2004	101,582.6	18,013.2	37,818.3	28,318.8	32,393.6	
Source: National Transit Database (NTD) 2000-2004						

MDT's scheduled revenue miles per VOMS grew by 3.4% from 2000 to 2004, staving consistently above the average and the median of the 20 largest transit agencies throughout the period (Figure 6.10). In 2000, MDT had 47.3 thousand scheduled revenue miles per VOMS, which was 29.6% higher than the average and 31.7% higher than the median number of revenue miles per VOMS at the top-20 transit agencies. Except for 2003, MDT's revenue miles per VOMS stayed approximately at the same level compared to the top-20 agencies, i.e., 29%-33% above the average and the median. In 2003. however, due to a large spike (23.1%) in revenue miles per VOMS, MDT jumped to 58.9% above the average and 59.6% above the median of the top-20 transit agencies in terms of scheduled revenue miles per VOMS. The following year (2004), revenue miles per VOMS at MDT fell by 18.4%.

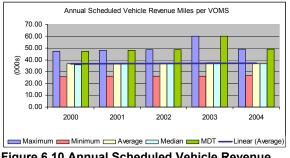


Figure 6.10 Annual Scheduled Vehicle Revenue Miles per VOMS (000s)

From 2000 to 2004, MDT's total number of vehicle miles grew 29.3%, compared to average growth of 4.0% and median growth of 6.0% for the 20 largest transit agencies (Table 6.12) Despite a largerthan-average growth, MDT remained significantly below average in terms of vehicle miles as compared to the group. In 2000, MDT was 34.6% below the average and 15.7% below the median number of vehicle miles at the top-20 transit agencies. As a result of continual growth in vehicle miles during the observed period, the gap between MDT and the 20 largest transit agencies decreased. In 2004, for example, MDT stood 18.7% below the average and 2.8% above the median number of vehicle miles at the top-20 transit agencies.

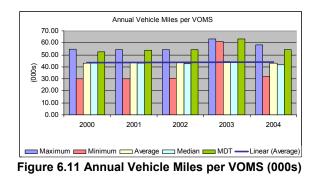
Table 6.12 Annual Vehicle Miles (000s)

	Maximum	Minimum	Average	Median	MDT			
2000	115,202.7	21,281.4	42,624.4	33,056.8	27,871.1			
2001	117,543.5	21,774.8	43,112.7	32,346.5	29,365.8			
2002	119,061.7	22,133.4	44,107.2	31,749.0	30,559.2			
2003	121,225.9	22,026.7	44,397.5	31,522.7	32,075.9			
2004	121,838.7	21,849.1	44,325.5	35,043.2	36,037.7			
Source: National Transit Database (NTD) 2000-2004								

The average vehicle miles per VOMS at the 20 largest transit agencies changed minimally from 2000 to 2004, while the median decreased by 3.4% (Figure 6.11). Meanwhile, the number of vehicle miles per VOMS at MDT

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increased by 3.4% during the same time. MDT stayed consistently above the average and the median of the top-20 agencies in terms of vehicle miles per VOMS. In 2000, MDT recorded 52.6 thousand vehicle miles per VOMS, 21.7% higher than the average and 22.4% higher than the median number of miles per vehicle at the 20 largest transit agencies. With 54.4 thousand vehicle miles per VOMS in 2004, MDT was 25.7% above the average and 30.9% above the median number of vehicle miles per VOMS at the top-20 transit agencies. The largest gap between MDT and the top-20 transit agencies was observed in 2003, when MDT exceeded the top-20 average by 42.6% and the top-20 median by 44.1% in terms of vehicle miles per VOMS.



Throughout the period of 2000-2004, MDT remained 17.8%-33.0% below the average of the top-20 transit agencies in terms of actual vehicle revenue miles, but exceeded the top-20 median in 2003 by 3.1% and 2004. and 9.9%, respectively (Table 6.13). At the same time, during the observed period, MDT's actual revenue miles grew faster than the average and the median number of revenue miles at the 20 largest transit agencies. From 2000 to 2004, actual revenue miles grew by 28.4% compared to the average growth of 4.7% and the median growth of 3.4% at the top-20 transit agencies. Due to faster-thanaverage and faster-than-median growth, the gap between MDT and the largest 20 transit agencies narrowed during the period of 2000-2004. In 2000, MDT was 33% below the average and 11.6% below the median of the top-20 transit agencies in terms of actual vehicle revenue miles. By 2004, MDT stood 17.8% below the average and 9.9% above the median in terms of actual revenue miles as compared to the 20 largest transit agencies.

Table 6.13 Annual Actual Vehicle Miles (000s)

	Maximum	Minimum	Average	Median	ŃDТ	
2000	98,907.4	16,991.2	36,133.0	27,380.5	24,214.8	
2001	101,025.7	17,754.2	36,479.8	26,384.9	25,175.8	
2002	102,134.7	18,116.1	37,354.0	26,556.0	26,294.1	
2003	103,509.1	18,056.8	37,493.8	26,674.0	27,506.3	
2004	103,665.1	17,994.8	37,829.4	28,300.0	31,100.5	
Source: National Transit Database (NTD) 2000-2004						

During the period of 2000-2004, actual revenue miles per VOMS at MDT exceeded the average of the 20 largest transit agencies by 25.3%-27.9% and exceeded the median of the top-20 agencies by 24.7%-29.2% (Figure 6.12). In 2003, however, actual revenue miles per VOMS at MDT increased 16.6% (from 46.5 to 54.4 thousand miles per VOMS), 45.5% above the average and 45.3% above the median of the 20 largest transit agencies that year. For the entire period of 2000-2004, actual revenue miles per VOMS at MDT grew 2.7%. During the same period, the average and the median of the top 20 transit agencies increased by 0.7% and 2.2%, respectively.

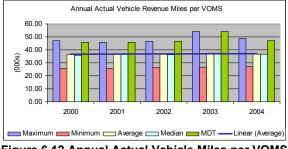


Figure 6.12 Annual Actual Vehicle Miles per VOMS (000s)

Over the observed period, MDT's percentage of vehicle miles that were revenue-earning miles stayed practically unchanged, decreasing by 0.7% from 2000 to 2004 (Table 6.14). During the period, MDT stayed 1.0%-3.0% above the average and the median of the top-20 transit agencies in terms of the percentage of vehicle miles that were earning revenue. This indicates that MDT was doing slightly better than the largest 20 transit agencies in using total vehicle miles for revenue-earning.

Table 6.14 Vehicle Revenue Miles as a Percentageof Vehicle Miles

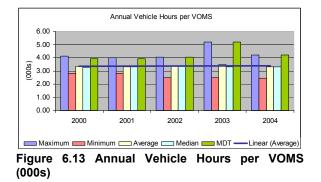
	Maximum	Minimum	Average	Median	MDT	
2000	98.6%	77.8%	84.5%	85.5%	86.9%	
2001	98.6%	77.4%	84.2%	85.1%	85.7%	
2002	98.5%	77.5%	84.4%	85.4%	86.0%	
2003	98.4%	76.9%	84.2%	84.7%	85.8%	
2004	98.6%	76.7%	85.1%	85.0%	86.3%	
Source: National Transit Database (NTD) 2000-2004						

Over the observed period of time, MDT fell significantly below the average of the 20 largest transit agencies in terms of vehicle hours, 41.4%-24.0% below average, (Table 6.15). However, MDT's vehicle hours grew 34.8% from 2000 to 2004, which was faster than the growth of the average and the median of the 20 largest transit agencies during the same time (3.8% and 1.2%, respectively). Since the average number of vehicle hours can be skewed due to the presence of extreme observations in the group of the 20 largest agencies, it is more appropriate to compare MDT to the top-20 median number of vehicle hours. While MDT was 15.0% below the median of the 20 largest transit agencies in terms of vehicle hours in 2000, it exceeded the median number of vehicle hours in 2003 by 3.8% and by 13.1% in 2004.

Table 6.15 Annual Vehicle Hours (000s)

	Maximum	Minimum	Average	Median	MDT	
2000	14,585.7	1,410.6	3,534.4	2,437.8	2,071.0	
2001	14,774.1	1,456.5	3,572.3	2,441.2	2,158.2	
2002	15,217.8	1,451.8	3,667.9	2,478.8	2,287.0	
2003	15,302.7	1,445.6	3,704.2	2,519.8	2,615.6	
2004	15,286.3	1,443.5	3,670.1	2,466.8	2,790.7	
Source: National Transit Database (NTD) 2000-2004						

During the period of 2000-2004, the number of vehicle hours per VOMS at MDT grew by 7.7%, while the average and the median number of vehicle hours per VOMS at the 20 largest transit agencies remained practically unchanged (Figure 6.13). Throughout the observed period, MDT exceeded both the average and the median of the top-20 agencies in terms of vehicle hours per VOMS. Except for 2003, MDT's number of vehicle hours per VOMS was 17.4%-26.8% higher than the average and 18.2%-28.0% higher than the median number of hours per VOMS. In 2003, however, vehicle hours per VOMS at MDT jumped 27.7% (from 4.1 to 5.2 thousand hours per VOMS) causing MDT to exceed the average of the 20 largest agencies by 49.9% and to exceed the top-20 median by 56.2% in terms of vehicle hours per VOMS that This spike was followed by an vear. 18.6% decrease in vehicle hours per VOMS at MDT in 2004.



As was the case with total vehicle hours, vehicle revenue hours at MDT stayed below the average of the observed period (Table 6.16). This is true despite the fact that vehicle revenue hours at MDT grew faster than revenue hours at the top-20 transit agencies. From 2000 to 2004, revenue hours at MDT increased by 32.8%, while the average number of revenue hours at the top-20 transit agencies grew only 3.1%, and the median number of revenue hours decreased 2.4% during the same time. Since the average can be skewed by the presence of extreme observations in the group of the top-20 agencies, it might be more appropriate to compare MDT to the median rather than to the average of the 20 largest transit agencies. While MDT was 12.9% below the median of the 20 largest agencies in terms of vehicle revenue hours in 2000, MDT exceeded the top-20 median in 2003 and 2004 by 6.9% and 11.7%, respectively.

	Maximum	Minimum	Average	Median	MDT	
2000	12,641.5	1,246.7	3,162.5	2,190.3	1,908.8	
2001	12,780.6	1,266.2	3,192.7	2,184.8	1,968.7	
2002	13,151.1	1,250.4	3,284.2	2,222.6	2,091.3	
2003	13,172.6	1,272.2	3,311.5	2,186.4	2,336.2	
2004	13,105.3	1,274.6	3,262.1	2,137.0	2,535.8	
Source: National Transit Database (NTD) 2000-2004						

From 2000 to 2004, revenue hours per VOMS grew 6.1%, while both the

average and the median of the 20 largest transit agencies decreased by 1.0% and 0.3%, respectively (Figure 6.14). Throughout the observed period, MDT stayed consistently 20.4%-29.1% above the average and 23.7%-31.7% above the median of the top-20 transit agencies in terms of vehicle revenue hours per VOMS. Due to a large spike in revenue hours per VOMS in 2003 (from 3.7 to 4.6 thousand revenue hours per VOMS), MDT exceeded the top-20 average by 49.5% and the top-20 median by 55.0% that year.

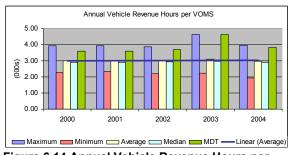


Figure 6.14 Annual Vehicle Revenue Hours per VOMS (000s)

Except for 2003, the percentage of vehicle hours that were revenue-earning hours stayed above 90.0% at MDT during the period of 2000-2004 (Table In all years of the observed 6.17). period, except for 2003, MDT was slightly better than the 20 largest transit agencies in terms of using vehicle hours for revenue-earning activities. In 2000, 92.2% of vehicle hours earned revenue for MDT compared to the top-20 average of 89.3% and the top-20 median of 89.5% (MDT was 3.2% above the average and 3.0% above the median of the 20 largest transit agencies that year). In 2004, MDT used 90.9% of vehicle hours for revenueearning activities compared to the average of 88.9% and the median of 89.7% at the 20 largest transit agencies. Only in 2003 did MDT fall slightly below the average and the median of the top-20 transit agencies in terms of the percentage of vehicle hours that were revenue hours. In that year, 89.3% of MDT's vehicle hours were revenueearning, which was 0.1% below the average and 0.4% below the median of the largest transit agencies.

Table 6.17 Vehicle Revenue Hours as aPercentage of Vehicle Hours

	Maximum	Minimum	Average	Median	MDT	
2000	98.3%	77.3%	89.3%	89.5%	92.2%	
2001	98.3%	78.0%	89.2%	90.2%	91.2%	
2002	98.7%	88.2%	89.5%	90.0%	91.4%	
2003	98.6%	82.8%	89.4%	89.7%	89.3%	
2004	98.5%	79.5%	88.9%	89.7%	90.9%	
Source: National Transit Database (NTD) 2000-2004						

The number of unlinked passenger trips at MDT grew 14.2% from 2000 to 2004 (from 65,821.0 thousand trips to 75,137.4 thousand trips), while the average number of unlinked trips at the 20 largest transit agencies grew 1.3%, and the top-20 median number of unlinked trips decreased 5.3% (Table 6.18).

Throughout the period of 2000-2004, MDT remained 48.1%-58.2% below the average of the 20 largest transit agencies in terms of unlinked passenger trips. MDT also remained 8.9%-15.9% below the median of the top-20 agencies, except during 2004. In 2004, the number of unlinked passenger trips at MDT was for the first time 1.3% higher than the median number of unlinked trips at the 20 largest agencies.



Table 6.18 Annual Unlinked Passenger Trips (000s)

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-	Maximum	Minimum	Average	Median	MDT		
2000	821,994.5	32,732.0	142,856.7	78,298.3	65,821.0		
2001	926,017.7	31,080.7	147,875.1	77,327.4	65,413.7		
2002	976,567.7	29,183.4	151,674.1	73,963.1	63,369.4		
2003	911,622.7	28,017.1	146,656.6	70,825.5	64,546.6		
2004	893,390.1	28,450.1	144,774.0	74,165.5	75,137.4		
Source: National Transit Database (NTD) 2000-2004							

The number of unlinked passenger trips per VOMS at MDT decreased 8.7% during the period of 2000-2004, while the average and the median number of trips per VOMS at the 20 largest transit agencies decreased 4.3% and 0.9%, respectively (Figure 6.15). Except for 2002, MDT exceeded both the average (by 0.4%-10.1%) and the median (by 3.3%-15.4%) of the top-20 transit agencies in terms of the number of unlinked passenger trips per VOMS. In 2002, however, the number of unlinked trips per VOMS at MDT fell 4.3% below the average, but stayed 3.3% above the median of the 20 largest transit agencies. In 2003, a 13.5% spike in the number of unlinked trips per VOMS was observed at MDT (unlinked trips per VOMS increased from 112.4 thousand trips per VOMS in 2002 to 127.6 thousand trips per VOMS in 2003). As a of result this increase. unlinked passenger trips per VOMS at MDT reached a high point of 10.1% above the average and 15.4% above the median of the top-20 transit agencies that year.

From 2000 to 2004, the number of unlinked passenger trips per full-time vehicle maintenance employee at MDT decreased by 12.7% from 180.8 to 157.9 thousand trips per employee (Table 6.19).

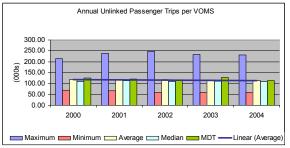


Figure 6.15 Annual Unlinked Passenger Trips per VOMS (000s)

At the same time, the average number of unlinked passenger trips per full-time vehicle maintenance employee at the 20 largest transit agencies increased by 1.2% and the median decreased by 3.2%. As a result, MDT's standing compared to the top-20 transit agencies changed from 7.8% above the average and 12.9% above the median in 2000 to 7.0% below the average and 1.8% above the median in terms of unlinked passenger trips per full-time vehicle maintenance employee.

Table 6.19 Annual Unlinked Passenger Trips perFull-time Vehicle Employee (000s)

	Maximum	Minimum	Average	Median	MDT
2000	290.5	107.5	167.7	160.2	180.8
2001	263.5	107.7	167.0	158.7	174.9
2002	306.2	97.7	168.4	158.2	165.0
2003	300.9	93.8	168.4	153.3	170.8
2004	305.0	93.9	169.7	155.1	157.9

During the period of 2000-2004, annual passenger miles at MDT increased by 9.9%, while the average number of passenger miles at the 20 largest transit agencies increased by only 0.5%, and the median decreased by 3.7% (Table 6.20). Throughout the observed period, MDT stayed 35.4%-40.9% below the average of the 20 largest transit agencies in terms of passenger miles. However, the average might have been skewed by the presence of some extreme observations (i.e., extremely large agencies in the top-20 list).

Therefore, it is more appropriate to compare MDT to the median rather than to the average. From 2000 to 2003, MDT stayed 0.9%-5.0% below the median of the top-20 agencies in terms of passenger miles, but continued to close the gap from year to year. As a result, in 2004, MDT exceeded the top-20 median number of passenger miles by 8.7%.

Table 6.20 Annual Passenger Miles (000s)

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		Maximum	Minimum	Average	Median	MDT
	2000	1,533,904.3	179,360.8	456,998.0	283,628.3	270,212.7
	2001	1,780,311.6	177,377.7	476,671.8	298,504.2	283,461.5
	2002	1,864,387.0	171,543.3	482,158.8	287,589.9	273,614.0
	2003	1,630,755.0	169,791.0	463,799.3	282,063.0	279,410.6
	2004	1,574,309.0	176,055.3	459,491.2	273,175.9	296,888.7
Source: National Transit Database (NTD) 2000-2004						

For the period of 2000-2004, the number of passenger miles per VOMS at MDT decreased 12.2%, from 509.8 to 447.8 thousand miles per VOMS (Figure 6.16). Despite this fact, MDT exceeded the average and the median of the 20 largest transit agencies in terms of passenger miles per VOMS. In 2000, MDT was 20.1% above the average and 25.9% above the median of the 20 largest transit agencies in terms of passenger miles per VOMS. By 2004, MDT's comparative standing dropped to 10.0% above the average and 9.6% above the median. Due to a 13.8% increase in passenger miles per VOMS at MDT in 2003, MDT stood 33.0% above the average and 35.0% above the median of the top-20 agencies. The spike was followed by an 18.9% decrease in passenger miles per VOMS at MDT the next year (2004).

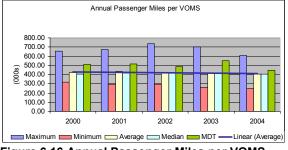


Figure 6.16 Annual Passenger Miles per VOMS (000s)

From 2000 to 2004, the number of passenger miles per full-time employee at MDT decreased by 16.0% from 742.3 to 623.7 thousand miles per employee, while the average and the median of the 20 largest transit agencies increased 1.3% and 3.6%, respectively (Figure 6.17). As a result, the gap between MDT and the 20 largest transit agencies narrowed from year to year, during the observed period. Nonetheless, MDT remained above both the average and the median of the top-20 agencies in terms of passenger miles per employee throughout the observed period.

In 2000, MDT was 21.4% above the average and 25.4% above the median of the 20 largest transit agencies in terms of passenger miles per full-time vehicle maintenance employee. In 2004, MDT was 0.7% above the average and 1.7% above the median of the top-20 agencies in terms of passenger miles per employee. In 2003, MDT recorded 739.2 thousand passenger miles per full-time employee (the highest amount for the observed period), placing it 44.3% above the average and 21.1% above the median of the top-20 agencies in terms of passenger miles per full-time vehicle maintenance employee.

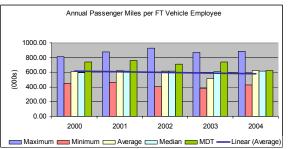


Figure 6.17 Annual Passenger Miles per Full-time Vehicle Employee (000s)

6.2 MDT Ranking: Performance Data

An overview of MDT's ranking in terms of performance data examined in the previous section is presented in Table 6.21. The performance data focused on fleet size, fleet performance in terms of failures, manpower effort, and scope of service. The data provide an overview of MDT's transit operations from 2000 through 2004 in relationship to the other 19 transit agencies that ranked in the top-20.

Table 6.21	Performance	Data.	2000-2004
		,	

		MD	T Rank	ing	
Performance Data	2000	2001	2002	2003	2004
VOMS	18	18	17	18	12
Major Failures	5	6	4	7	7
Other Failures	8	5	5	5	2
Total Failures	8	6	6	7	5
Insp & Maint Labor Hours	17	17	19	19	13
Fulltime Employee Work Hours	17	14	14	13	11
Fulltime Vehicle Maint Employees	17	17	16	16	11
VAMS	18	16	11	10	12
Annual Scheduled Vehicle Miles	12	11	10	9	9
Vehicle Miles	13	13	13	10	10
Actual Vehicle Miles	13	12	11	10	9
Vehicle Hours	14	13	13	9	8
Annual Vehicle Revenue Hours	12	12	12	9	7
Unlinked Passenger Trips	15	16	16	14	10
Passenger Miles	13	13	12	11	9

Expanded service in terms of vehicle revenue miles and hours (from $12^{th}-14^{th}$ of 20 to $7^{th}-10^{th}$ of 20) along with increased unlinked passenger trips and miles (from $13^{th}-15^{th}$ of 20 to $9^{th}-10^{th}$ of 20) moved MDT into top-10 rankings in the service area.



While manpower efforts fell below top-10 rankings, the movement of inspection and maintenance labor hours (from 17th to 13th of 20) and increase in full-time employee work hours (from 17th to 11th of 20) were positive.

MDT ranked 12th in terms of vehicles operated in maximum service in 2004 as compared to 18th in 2000. Unfortunately, growth in the fleet, increased manpower, and expanded service were accompanied by a shift in ranking from 8th to 5th for total system failures, as illustrated in Table 6.21 and Figure 6.18.

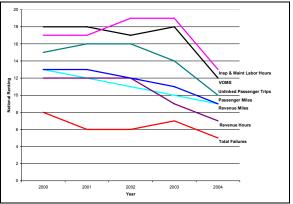


Figure 6.18 MDT Key Performance Data

6.3 MDT Ranking: Performance Indicators

As noted in the literature review, Schiavone found that the most common sources of reference to measure performance usually involved study of NTD data. While Schiavone indicated that comparison of actual performance numbers is difficult, transit agencies can be effectively compared.

Absolute measures, such as the number of vehicles operated in maximum service, total inspection and

maintenance labor hours, and actual vehicle revenue miles. provide meaningful information but are not robust measures of the operational efficiency or effectiveness of the transit agency. Larger transit agencies with more buses may log more inspection and maintenance hours than a smaller agency with a smaller fleet. This however, does not necessarily indicate that a typical bus at the larger agency requires more maintenance than a typical bus of the smaller agency. Gross totals can be a misleading measure because the measure may not provide adequate information about the average maintenance of each bus.

Based on extensive surveys and interviews, Maze and Cook found maintenance managers reported that the most important performance indicators included:

- Fleet reliability: miles per road call
- Work productivity: total regular and overtime maintenance labor hours per month
- Work quality: number of repeat repairs in the same month
- Fleet maintainability: maintenance cost per vehicle mile, road calls per vehicle per month, maintenance labor cost per vehicle mile, and average fuel and oil cost per bus versus the entire fleet

Toward that end, researchers examined the 2000-2004 NTD data to determine the effectiveness of the transit agencies' performance. An overview of MDT's ranking in terms of performance indicators is presented in Table 6.22.

	icuto	13, 2		-00-	
		MD	T Rank	ing	
Performance Indicators	2000	2001	2002	2003	2004
Total Failures/VOMS	1	2	2	2	1
Revenue Miles/Failure	17	18	18	19	20
Fulltime Employee Work Hours/VOMS	13	10	10	4	2
Insp & Maint Labor Hours/VOMS	14	17	17	16	13
Insp & Maint Labor Hours % Total Hours	16	17	17	17	16
VAMS/VOMS	3	2	1	1	4
Vehicle Miles/VOMS	3	2	1	1	3
Revenue Miles % Vehicle Miles	4	9	6	8	8
Vehicle Hours/VOMS	3	3	1	1	1
Revenue Hours % Vehicle Hours	3	5	5	11	6
Unlinked Passenger Trips/VOMS	8	8	10	7	9
Passenger Miles/VOMS	2	3	4	2	6
Vehicle Maint Cost/Revenue Mile	17	14	14	14	17

Table 6.22 Performance Indicators, 2000-2004

While performance data provide an overview of the transit agency that enables comparison of the scope and breadth of one agency to other agencies, measures of performance present a picture of the transit agency's success in achieving goals and objectives. As data are compared, conclusions can be drawn as to the positive and, in some cases, inadequate functioning of the agency.

Two of the above performance indicators that can be used to evaluate fleet reliability are *Total Failures/VOMS* and *Revenue Miles/Failure*. Not only did MDT consistently report more failures per vehicle operated than other top-20 agencies, but also MDT logged the fewest revenue miles between failures. In terms of fleet reliability, as shown in Figure 6.19, MDT performed at a less than satisfactory level.

One factor that can affect fleet reliability is sufficient manpower to maintain the fleet, i.e., a productive workforce. Work productivity can be evaluated using the following performance indicators: *Inspection and Maintenance Labor Hours per VOMS, Number of Fulltime Employee Work Hours per VOMS, and Inspection and Maintenance Labor* Hours as a % of Total Employee Work Hours, as presented in Figure 6.20.

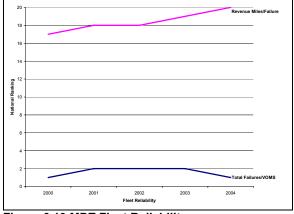


Figure 6.19 MDT Fleet Reliability

ranked 10th-13th MDT in fulltime employee work hours per VOMS during 2000-2002 and then moved to 4th in 2003 and 2nd in 2004, which represents a significant increase in manpower allocation. Nonetheless, MDT's ranking for inspection and maintenance hours per VOMS increased only slightly in 2004 (from 16th-17th of in 2001-2003 to 13th of 20) and the increase in ranking was only modestly better than the ranking of 14th in 2000. Furthermore, the relationship between MDT's inspection and maintenance labor hours to total labor hours ranked 16th. essentially remaining unchanged throughout the reporting period. The increases in manpower produced little, if any, increase in vehicle inspection and maintenance, which calls in to question workforce productivity.

Fleet maintainability can be evaluated using a variety of performance factors. Factors used in the analysis include: *VOMS in relation to VAMS, Vehicle Miles and Hours per VOMS, Vehicle Revenue Miles as a % of Total Miles,*





Vehicle Revenue Hours as a % of Total Hours, Unlinked Passenger Trips and Passenger Miles per VOMS, and the Vehicle Maintenance Cost of a Revenue Mile, as presented in Figure 6.21 and Figure 6.22.

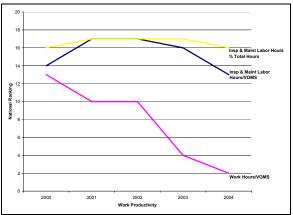


Figure 6.20 MDT Work Productivity

MDT ranked between 1st and 4th in the relationship between VOMS and VAMS throughout 2000-2004, indicating significant use of the available fleet.

MDT also ranked between 1st and 3rd in Vehicle Miles and Hours per VOMS throughout the reporting period, which indicates that MDT generally operates vehicles for more hours and more miles than most other top-20 agencies.

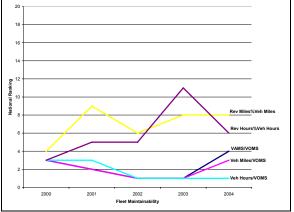


Figure 6.21 Fleet Maintainability

When revenue hours and miles are viewed as a percentage of total hours and miles; however, MDT's ranking falls to 6th and 8th, indicating that MDT's vehicle hours and vehicle miles are less efficient than some of the other agencies.

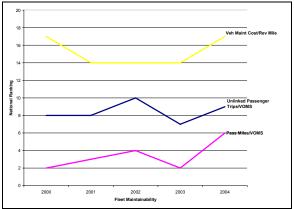


Figure 6.22 Fleet Maintainability

While MDT ranked 9th in unlinked passenger trips per VOMS, which was similar to previous rankings, MDT's ranking for passenger miles per VOMS moved from 2nd in 2003 to 6th in 2004, despite increases in revenue miles and hours per VOMS. It appears that increased revenue miles and revenue hours were not accompanied by increased passenger miles.

MDT's vehicle maintenance cost per revenue mile ranked 17th (from 14th of 20 in 2001 through 2003) for the first time since 2000. MDT's maintenance cost per revenue mile was less than 16 other top-20 properties in 2004.



7. Metrobus Equipment Performance

On a monthly basis, bus and rail maintenance control publish a rather extensive document outlining transit services monthly performance. The report is entitled Transit Services Monthly Performance Report (MDT Rail/Bus Services Performance Report).

The performance report is comprehensive and contains an executive summary in addition to sections concerning:

- 1. Transportation
- 2. Rail Fleet Performance
- 3. Mover Fleet Performance
- 4. Track & Guideway Maintenance
- 5. Wayside Maintenance
- 6. Systems Maintenance Performance
- 7. Rail Operations & Maintenance Absenteeism
- 8. Special Projects & Accomplishments
- 9. Bus Fleet Performance
- 10. Central Division Bus Performance
- 11. Northeast Division Bus Performance
- 12. Coral Way Division Bus Performance
- 13. Paratransit Fixed Routes Minibus Performance
- 14. Medley Division Bus Performance
- 15. Bus Maintenance & Operations Absenteeism
- 16. Bus Maintenance Special Projects/Accomplishments

The executive summary of the performance report is prepared by the assistant director business services and evaluates bus services' performance in relation to established performance measures.

The performance report provides a detailed analysis of monthly performance data within the context of the fiscal year to date along with a comparison to previous years. Bus performance data are presented regarding the bus fleet in total as well as by specific operating & inspection division.

System-wide fleet performance data presented in the performance report include:

- Bus On-time Performance
- Bus Availability
- Preventive Maintenance Inspections, On-time Adherence
- Miles between Mechanical Road Calls
- Late and Missed Runs
- Road Calls by Fleet Type
- Fuel Consumption
- Maintenance Expenses

Bus performance data specific to the divisions include:

- Bus Availability
- Preventive Maintenance, On-time Adherence
- Miles between Mechanical Road Calls
- Late and Missed Runs
- Road Calls by Fleet Type



Performance data are augmented by a presentation and discussion of special projects and accomplishments.

Bus maintenance control also publishes The Transit Services Monthly Performance Report and Director's Executive Summary Report on a monthly basis.

The Director's Executive Summary Report contains the following:

- Executive Summary, including Rail/Mover Services, Bus Services, and FESM
- Rail/Mover Services, including Factsat-a-Glance (Tables and Charts) and Operational Highlights
- Bus Services, including Facts-at-a-Glance (Tables and Charts) and Operational Highlights
- FESM, including Facts-at-a-Glance (Tables and Charts) and Operational Highlights

While there is some overlap with the two reports, there are significant differences in the reports. The Director's Executive Summary Report generally provides fleet rather than division data and focuses much attention on Preventive Maintenance Inspections, including comparative division data.

The Director's Executive Summary Report also includes "Facts-at-a-Glance" that are not included in the performance report. The "Facts-at-a-Glance" present detailed information regarding the following:

- Vehicle Description
- Vehicle Body

- Large Bus Accessories
- Minibus Accessories
- Peak Vehicle Requirement
- Fleet Allocations

The Director's Executive Summary Report provides a list of "buses down thirty or more days," which includes the precipitating cause and location of the inoperable bus.

Researchers conducted an extensive review of performance reports and the Director's Executive Summary Reports from 2003 through 2005. Data contained in the reports were used throughout this analysis for the following performance indicators:

- Preventive Maintenance Adherence
- On-time Performance
- Peak Vehicle Requirement
- AM Peak Vehicle Requirement by Division
- PMI On-time Performance, by Division
- Miles Between Mechanical Road
 Calls by Division
- Maintenance-related Late Runs
 by Division
- Bus Maintenance Absenteeism
- Bus Facility Absenteeism

Following is the analysis of equipment performance by fleet type, which is the final performance indicator included in the performance report that has not yet been reviewed.



7.1 Equipment Performance by Fleet Type

On a monthly basis, MDT tracks equipment performance in terms of percentage of road calls and percentage of total miles logged by fleet type and by division. The percentage of total miles by fleet type is detailed in Table 7.1 and Figure 7.1.

Table 7.1 % of Total Miles by Fleet Type, FY 2004-2005

	Oct03	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct04	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Fleet	Total
Artic94	2.9	3.0	2.7	2.7	2.6	2.8	2.9	2.8	2.4	2.8	2.7	2.6	2.4	2.5	2.2	1.9	2.2	2.4	2.3	2.4	2.4	2.2	1.8	1.7	39	4.0%
Artic95	2.1	2.4	1.9	1.9	1.6	1.7	1.8	2.4	2.4	2.4	2.5	2.6	2.3	2.0	2.2	2.2	2.2	2.1	3.0	2.5	2.0	1.9	1.4	1.2	25	2.6%
Fix90	2.3	0.1	0.0		0.0																					
Fix92	0.6	0.4	0.4	0.3	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6														
Fix93c	7.1	6.0	5.7	5.4	5.2	5.3	5.8	5.2	5.2	4.9	5.0	5.1	5.0	4.3	4.4	3.4	3.3	3.4	3.4	3.2	3.6	3.4	3.0	2.8	40	4.1%
Flx9350	1.7	1.7	1.7	1.5	1.5	1.6	1.7	1.4	1.2	1.2	1.3	1.5	1.4	1.3	1.3	1.1	1.2	1.1	1.1	1.2	1.1	1.0	1.2	1.0	16	1.6%
Flx9411	0.6	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.4	0.3	0.4	0.3	0.3	0.3	0.4	0.4	0.3	0.4	4	0.4%
Flx9450	2.5	2.7	2.4	2.2	2.7	2.6	2.5	2.3	2.2	2.5	2.5	2.7	2.5	2.2	2.1	1.9	2.0	1.9	1.7	2.0	1.8	1.7	2.0	1.9	24	2.5%
NABI97	5.9	5.5	5.2	5.3	5.7	5.6	5.5	5.1	4.7	5.5	5.5	5.2	5.4	4.9	3.7	3.9	4.2	4.1	4.1	3.9	4.4	4.7	4.2	4.1	48	4.9%
NABI98	2.0	2.0	2.4	2.2	2.0	2.2	2.3	1.7	1.3	1.4	1.6	1.7	1.9	3.4	1.7	1.8	2.0	2.0	1.8	1.8	1.8	1.8	1.7	1.8	19	1.9%
NABI99	11.3	11.0	11.7	11.5	11.5	12.2	11.8	11.9	11.9	11.8	11.9	11.8	11.4	9.8	9.5	9.2	9.7	9.4	9.2	9.1	8.8	9.8	9.7	8.7	93	9.5%
NABI00	13.9	13.5	13.3	13.1	13.4	13.3	12.9	12.8	12.6	12.7	12.6	12.3	11.3	10.3	10.1	9.9	9.5	9.9	9.7	9.9	9.5	9.3	8.6	8.4	96	9.8%
NABI02	20.0	19.7	19.7	20.3	19.6	18.9	18.9	19.2	19.6	19.7	18.7	19.4	18.6	18.0	16.2	17.4	16.7	16.6	16.4	17.0	17.0	17.0	16.1	15.6	110	11.2%
NABI03	10.1	15.0	17.1	17.0	16.6	16.2	15.9	15.5	15.9	15.6	15.7	16.1	16.4	15.7	14.8	15.2	15.3	15.2	14.9	14.1	14.2	14.4	15.3	14.1	100	10.2%
NABI04													3.3	8.4	15.0	15.1	14.8	15.1	15.3	15.7	15.5	15.6	15.8	16.3	110	11.2%
NABI05																						0.1	3.0	7.1	67	6.9%
MB-BB99	1.9	1.7	2.2	1.8	1.8	1.9	1.6	1.9	2.2	1.9	2.3	2.1	2.3	2.1	2.1	2.0	1.9	1.9	1.9	1.7	1.6	1.5	1.7	1.4	20	2.0%
MB-BB01	9.6	9.6	7.0	7.1	7.3	7.0	6.9	8.0	8.3	7.8	7.5	6.5	6.6	6.4	5.6	5.7	6.0	5.9	5.8	5.9	6.2	6.2	5.9	5.3	69	7.1%
MB-BB02	4.5	4.3	2.8	2.4	2.3	2.4	2.5	2.1	2.4	2.0	2.4	2.3	2.1	2.2	2.4	2.4	2.2	2.4	2.5	2.3	2.4	2.5	2.3	2.4	28	2.9%
MB-OPT03	1.0	1.1	3.3	4.7	5.2	5.3	6.0	6.7	6.7	6.6	6.8	7.1	6.9	6.2	6.5	6.5	6.5	6.4	6.7	7.2	7.2	6.6	6.1	5.8	70	7.2%
Total Fleet																									978	

The NABI 02 buses, which represented 11.2% of the FY 2005 fleet, consistently provided the largest percentage of miles throughout FY 2004 and FY 2005, until September 2005. The NABI 02 was followed by the NABI 03 (10.2% of the fleet in FY 2005) and the NABI 04, which entered service in October 2004 and accounted for 11.2% of the fleet.

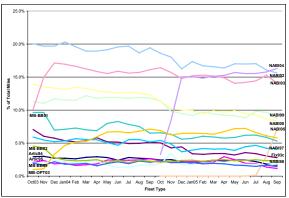


Figure 7.1 % of Total Miles by Fleet Type

The percentage of total road calls by fleet type is detailed in Table 7.2 and Figure 7.2.

Table 7.2 % of Total Road Calls by Fleet Type, FY 2004-2005

	Oct03	Nov	Dec	Jan	Feb	Mar	Apr	Мау	Jun	Jul	Aug	Sep	Oct04	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	2005 Fleet	% of Total
Artic94	6.4	7.4	5.9	2.8	5.3	6.2	8.3	6.1	5.4	5.8	4.9	5.2	5.8	4.8	6.9	4.9	4.7	5.9	5.2	6.5	5.1	5.3	4.2	4.2	39	4.0%
Artic95	5.8	6.3	3.7	4.0	4.1	5.1	5.7	5.5	5.0	6.1	5.5	5.9	6.3	7.2	6.3	6.8	5.5	6.1	6.0	6.1	4.9	3.6	3.6	3.3	25	2.6%
Fix90	6.8	1.5	1.6		0.1																					
Fix92	0.9	1.3	3.0	5.5	2.7	1.8	1.4	1.3	1.7	0.5	0.8	0.5														
Fix93c	9.1	9.1	7.9	9.7	8.7	8.9	6.9	10.1	8.0	10.0	8.2	9.7	7.8	6.5	4.7	5.3	4.0	3.3	4.8	4.0	4.7	5.1	6.0	4.5	40	4.1%
Flx9350	1.6	0.8	2.1	2.7	2.3	2.1	1.7	1.5	1.4	1.5	1.5	1.6	1.8	1.5	2.0	2.5	3.5	1.8	1.6	1.7	2.4	1.6	2.3	1.5	16	1.6%
Flx9411	1.4	1.4	1.8	0.7	0.2	0.4	0.9	1.6	1.6	1.4	1.1	0.8	0.4	1.6	0.7	1.3	1.5	1.4	0.4	0.6	0.9	1.2	0.5	0.6	4	0.4%
Flx9450	2.8	3.6	2.7	4.8	3.8	3.0	3.5	4.2	4.4	4.1	4.4	1.8	1.9	2.2	3.0	3.3	2.0	2.5	2.8	3.2	2.6	2.5	3.5	2.5	24	2.5%
NABI97	7.7	8.1	8.7	6.5	6.7	9.5	8.7	8.3	8.6	8.7	9.5	7.2	8.6	7.2	6.9	5.3	5.7	5.4	6.0	3.3	5.2	5.8	5.6	5.9	48	4.9%
NABI98	3.3	2.5	2.8	4.0	2.6	2.8	3.1	6.9	1.5	0.7	0.6	1.3	1.3	2.5	2.3	1.4	1.1	1.3	2.0	1.4	1.2	1.7	1.1	1.3	19	1.9%
NAB199	15.3	14.7	16.0	16.0	19.6	15.8	17.4	9.0	14.7	16.1	17.3	19.9	19.4	15.8	14.9	15.4	15.7	14.6	15.4	15.7	12.2	13.0	12.5	11.0	93	9.5%
NABI00	17.2	17.5	16.8	16.1	16.3	19.8	16.0	17.2	18.5	15.6	17.5	16.6	14.9	13.6	15.6	15.0	14.5	13.7	13.5	13.4	14.5	15.3	15.2	12.8	96	9.8%
NABI02	8.5	9.2	8.3	8.7	10.2	8.7	10.5	9.3	9.1	9.1	10.1	9.7	9.1	12.3	10.3	9.3	12.8	10.0	10.8	12.8	12.1	11.5	13.2	14.8	110	11.2%
NABI03	4.1	7.8	6.7	6.3	6.3	6.9	7.4	8.3	6.7	8.3	8.3	8.8	7.2	8.1	9.3	10.1	10.7	12.9	9.9	8.9	11.3	10.8	11.6	11.8	100	10.2%
NABI04													2.5	3.4	5.4	5.7	5.3	5.4	6.0	7.6	9.3	9.1	8.3	11.1	110	11.2%
NABI05																						0.0	1.3	1.8	67	6.9%
MB-BB99	2.3	2.2	2.6	1.6	1.9	1.4	1.8	1.7	1.9	2.1	1.7	1.3	1.5	1.8	1.2	1.8	1.2	1.8	1.7	1.0	1.1	1.0	1.3	1.9	20	2.0%
MB-BB01	4.1	4.0	4.3	5.2	4.0	4.2	4.0	4.6	4.8	3.5	3.7	2.8	4.1	3.9	3.7	4.2	3.9	3.7	3.5	4.5	3.5	3.8	3.3	4.0	69	7.1%
MB-BB02	2.1	1.4	1.7	2.4	2.0	1.3	1.4	2.6	1.6	1.7	1.5	2.1	1.9	2.1	1.7	1.5	2.7	3.2	2.1	1.7	3.1	2.4	1.4	1.3	28	2.9%
MB-OPT03 Total Fleet	0.7	1.3	3.5	3.1	3.2	2.3	1.5	1.9	5.1	4.7	3.4	4.9	5.3	5.6	5.1	6.2	5.2	7.1	8.5	7.7	6.0	6.3	5.2	5.9	70 978	7.2%

The NABI 99 (9.5% of the fleet) and the NABI 00 (9.8% of the fleet) recorded the largest percentages of road calls throughout FY 2004 and FY 2005, until September 2005. In September 2005, the NABI 02 logged the largest percentage of road calls.

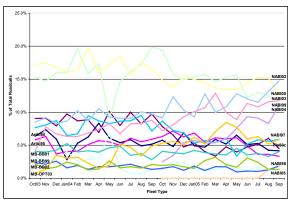


Figure 7.2 % of Total Road Calls by Fleet Type

The difference between the percentage of miles provided and the percentage of road calls logged illustrates the performance of the fleet by type. Table 7.3 and Figure 7.3 detail those differences.

Table 7.3 % of Road Calls Exceeds % of Miles by Fleet Type, FY 2004-2005

	Oct03	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct04	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Artic94	3.4	4.4	3.2	0.1	2.7	3.4	5.4	3.3	3.0	3.0	2.2	2.5	3.3	2.3	4.7	3.0	2.5	3.5	2.9	4.1	2.7	3.1	2.4	2.5
Artic95	3.8	4.0	1.8	2.1	2.5	3.4	3.9	3.1	2.6	3.7	3.1	3.3	4.0	5.1	4.1	4.6	3.3	4.0	3.0	3.6	2.9	1.7	2.2	2.2
Flx90	4.6	1.5	1.5		0.1																			
Flx92	0.3	1.0	2.6	5.2	2.2	1.3	0.9	0.6	1.1	-0.1	0.3	0.0												
Flx93c	2.0	3.1	2.2	4.3	3.5	3.5	1.1	5.0	2.8	5.1	3.3	4.6	2.8	2.3	0.3	1.9	0.7	-0.1	1.3	0.8	1.2	1.7	3.0	1.7
Flx9350	-0.1	-0.9	0.5	1.2	0.7	0.5	-0.1	0.2	0.2	0.3	0.2	0.2	0.5	0.2	0.7	1.3	2.3	0.7	0.5	0.5	1.3	0.6	1.0	0.5
Flx9411	0.8	1.0	1.3	0.1	-0.3	-0.1	0.4	1.1	1.1	0.9	0.6	0.3	0.2	1.3	0.3	1.0	1.2	1.2	0.1	0.3	0.5	0.7	0.2	0.2
Flx9450	0.3	0.9	0.3	2.6	1.1	0.4	1.0	1.8	2.2	1.6	1.9	-0.9	-0.6	0.0	0.9	1.4	0.0	0.6	1.0	1.2	0.8	0.8	1.6	0.6
NABI97	1.8	2.6	3.5	1.2	1.1	3.9	3.2	3.2	3.9	3.2	4.0	2.0	3.2	2.4	3.2	1.4	1.5	1.3	1.9	-0.6	0.7	1.2	1.4	1.7
NABI98	1.4	0.4	0.4	1.8	0.6	0.6	0.8	5.2	0.2	-0.7	-1.0	-0.3	-0.6	-0.9	0.6	-0.5	-0.9	-0.7	0.2		-0.6	-0.1	-0.6	-0.5
NABI99	4.0	3.7	4.3	4.5	8.1	3.6	5.6	-3.0	2.8	4.4	5.3	8.1	8.0	5.9	5.4	6.2	6.1	5.2	6.2	6.5	3.4	3.2	2.9	2.3
NABI00	3.3	4.0	3.5	3.0	2.9	6.5	3.1	4.4	5.9	2.9	5.0	4.3	3.6	3.3	5.5	5.1	5.0	3.8	3.8	3.5	5.0	6.1	6.6	4.4
NABI02	-11.6	-10.5	-11.4	-11.6	-9.4	-10.2	-8.4			-10.6	-8.6	-9.7	-9.5	-5.7	-5.9	-8.1	-3.9	-6.6	-5.6	-4.2	-4.9	-5.5	-2.9	-0.9
NABI03	-6.0	-7.2	-10.4	-10.7	-10.3	-9.4	-8.5	-7.3	-9.2	-7.3	-7.4	-7.4	-9.2	-7.6	-5.5	-5.1	-4.6	-2.3	-5.0	-5.2	-2.9	-3.6	-3.7	-2.3
NABI04													-0.8	-5.0	-9.6	-9.4	-9.5	-9.7	-9.3	-8.1	-6.2	-6.5	-7.5	-5.3
NABI05																						-0.1	-1.7	-5.3
MB-BB99	0.4	0.5	0.4	-0.2	0.1	-0.6	0.2		-0.3	0.2		-0.8	-0.8	-0.3	-0.9	-0.2	-0.7	-0.2	-0.1	-0.7	-0.5	-0.4	-0.4	0.4
MB-BB01	-5.6	-5.7	-2.7	-1.9	-3.3	-2.9	-2.9	-3.4	-3.5	-4.4	-3.8	-3.7	-2.5	-2.5	-1.9	-1.5	-2.2	-2.3	-2.2	-1.3	-2.7	-2.4	-2.6	-1.3
MB-BB02	-2.4	-2.8	-1.1	0.0	-0.3	-1.1	-1.1	0.5	-0.8	-0.3	-0.9	-0.2	-0.2	-0.2	-0.7	-0.9	0.5	0.8	-0.4	-0.7	0.7	-0.1	-1.0	-1.0
MB-OPT03	-0.2	0.2	0.2	-1.6	-2.0	-3.0	-4.5	-4.7	-1.6	-1.9	-3.5	-2.3	-1.6	-0.7	-1.4	-0.3	-1.2	0.7	1.7	0.5	-1.3	-0.3	-0.9	0.1
% of Total Ro	adcalls e	xceed	s % of 1	Total M	ilos																			

The shaded areas in Table 7.3 represent periods of time when the percentage of total road calls exceeded the percentage of total miles. From an efficiency perspective, a vehicle's mileage would ideally exceed road calls.

The newer NABIs, i.e., NABI 02 through NABI 05, appeared to be the most efficient fleet types.

The NABI 98 showed improvement beginning in late FY 2004 that remained relatively consistent throughout FY 2005. On the other hand, the NABI 99 and NABI 00 displayed inefficient performance throughout the entire reporting period and shared that category with the older Artics and Flxibles.

The overall performance of the minibuses appeared to be good; although, the efficiency of the Optare 03 declined in mid FY 2005.

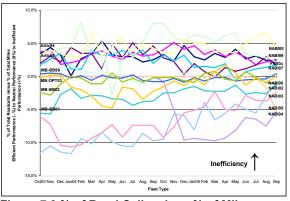


Figure 7.3 % of Road Calls minus % of Miles

Side by side comparisons of the percentage of total miles and road calls by fleet type for FY 2004 and FY 2005 are presented in Figure 7.4 and Figure 7.5.

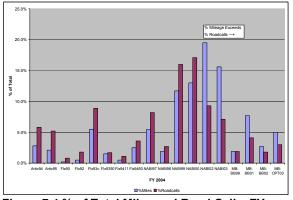


Figure 7.4 % of Total Miles and Road Calls, FY 2004

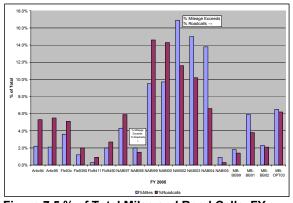


Figure 7.5 % of Total Miles and Road Calls, FY 2005

Figure 7.6 presents a comparison of the percentage of miles and road calls by fiscal year. In FY 2005, the NABI 02 and NABI 03 logged a smaller percentage of miles but a larger percentage of road calls.

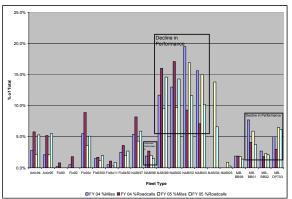


Figure 7.6 % of Total Miles and Road Calls, FY 2004-2005



Performance across shops was also evaluated in terms of equipment performance by fleet type.

Central Bus and Coral Way both operated Artic 94 buses from FY 2004 through FY 2005, as illustrated in Figure 7.7. The percentages of miles and road calls were quite similar between the two garages. Only in January 2004, did the Artic 94 percentage of road calls fall below the percentage of miles, and that occurred at the Central bus facility.

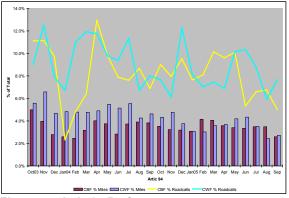


Figure 7.7 Artic 94 Performance

The Artic 95 was operated only out of Central bus. Figure 7.8 shows the relationship between the percentage of road calls and miles. Improvement was noted in July 2005, as the percentage of road calls fell to its lowest level.

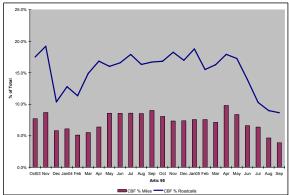


Figure 7.8 Artic 95 Performance

The Flx 90 was operated at Central bus and Coral Way for only two to three months, as illustrated in Figure 7.9. Data from the two facilities were sparse but do appear to be consistent.

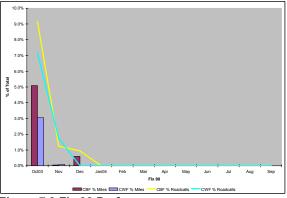


Figure 7.9 Flx 90 Performance

Specific mileage and road call data for the Northeast facility in FY 2004 were unavailable for the present analysis. A such, data regarding the Northeast fleet are limited to FY 2005.

Figure 7.10 details the Flx 93c percentage of miles versus the percentage of road calls at Central bus, Coral Way, and Northeast. The Flx 93c performed slightly better at Central bus than at Coral Way and Northeast.

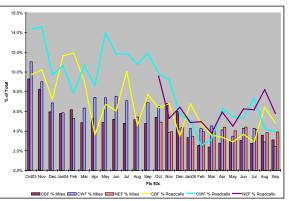


Figure 7.10 Flx 93c Performance



Only the Northeast facility operated the Flx 9350, Flx 9411, and Flx 9450. Mileage and road call data are illustrated in Figures 7.11 through Figure 7.13. In all three cases, the percentage of road calls consistently exceeded the percentage of miles.

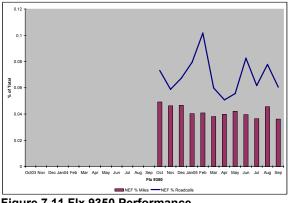


Figure 7.11 Flx 9350 Performance

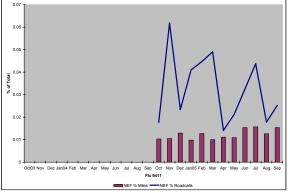


Figure 7.12 Flx 9411 Performance

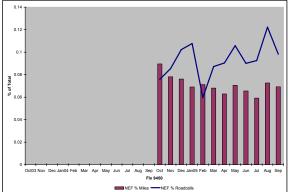


Figure 7.13 Flx 9450 Performance

Central bus, Coral Way, and Northeast operated NABI 97 fleets, as presented in Figure 7.14. Throughout FY 2004, the NABI 97 fleet performed slightly better at Central bus than at Coral Way. In 2005, some improvement in terms of the relationship between the percentage of miles and road calls for the NABI 97 was noted at all three facilities.

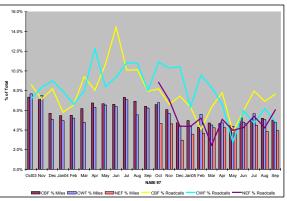


Figure 7.14 NABI 97 Performance

Central bus and Coral Way operated NABI 98 fleets during the first six months of FY 2004, as illustrated in Figure 7.15. The NABI 98 fleet, which performed slightly better at Coral Way than at Central bus, was moved to Medley in April 2004, when the Medley facility opened. NABI 98 performance at Medley was, at best, inconsistent, with the percentage of road calls exceeding the percentage of miles during the last thirteen months.

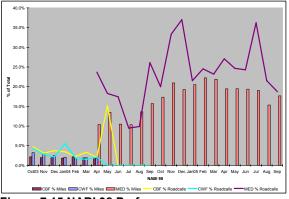


Figure 7.15 NABI 98 Performance

Central bus, Coral Way and Northeast operated NABI 99 fleets, as shown in Figure 7.16. Improvement in NABI 99 performance is noted primarily at Central bus and Northeast. The NABI 99 early positive performance at Coral Way in FY 2004 deteriorated until June 2005, at which time slight improvement was noted.

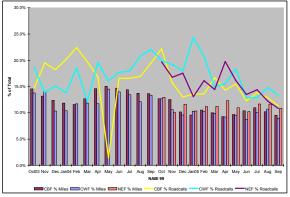
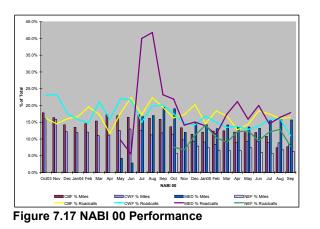


Figure 7.16 NABI 99 Performance

NABI 00 buses were operated by Central bus, Coral Way, Medley, and Northeast, as indicated in Figure 7.17. Despite two rather high road call percentages reported by the NABI 00 at Medley in the summer of 2004, the NABI 00 fleet at Medley achieved a slightly better percentage of miles to road calls than at the other facilities in FY 2005.



Central Bus, Coral Way, and Northeast operated NABI 02 buses, as indicated in Figure 7.18. The NABI 02 percentage of miles exceeded the percentage of road calls at all locations during all months, except one. In September 2005, the NABI 02 percentage of road calls exceeded the percentage of miles at Coral Way.

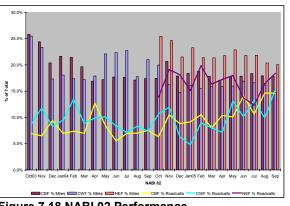


Figure 7.18 NABI 02 Performance

There were four months during which the percentage of road calls exceeded percentage of miles for the NABI 03, as shown in Figure 7.19. Three of the four instances occurred at Coral Way in April 2004, July 2005, and August 2005. The fourth instance was recorded in March 2005 at Northeast. There were no occasions identified where the NABI 03 percentage of road calls exceeded the

CUTR

percentage of miles at Central bus or Medley.

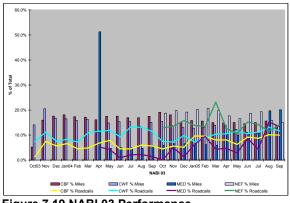


Figure 7.19 NABI 03 Performance

Central bus, Coral Way, and Northeast operated NABI 04 buses, as indicated in Figure 7.20. Despite the fact that the percentage of miles exceeded the percentage of road calls at all locations during all months, the rate of road calls for NABI 04 buses shows a gradual upward trend in the 12-month period of operation.

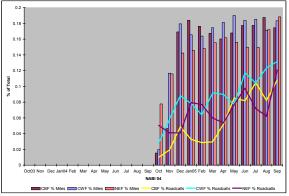


Figure 7.20 NABI 04 Performance

Central bus, Coral Way, and Northeast operated NABI 05 buses for slightly more than two months, as illustrated in Figure 7.21. There is too little information to draw any conclusion about the NABI 05 buses.

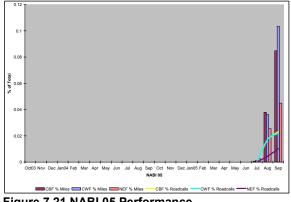


Figure 7.21 NABI 05 Performance

The Minibus BB 99 fleet was operated for five months at Coral Way in FY 2004 prior to transfer to the Medley facility, as shown in Figure 7.22. The Minibus BB 99 fleet percentage of road calls exceeded the percentage of miles at Medley during 16 of 18 months with little improvement at the end of FY 2005.

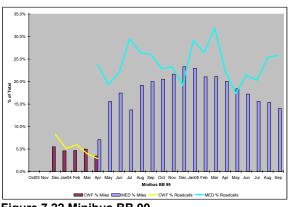


Figure 7.22 Minibus BB 99

Central bus, Northeast, Coral Way, and Medley operated Minibus BB 01 fleets, as indicated in Figure 7.23. Central bus and Northeast appeared to be less successful than Coral Way and Medley in maintaining a higher percentage of miles than road calls with the Minibus BB 01 fleets.



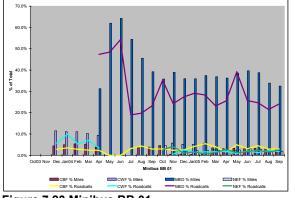


Figure 7.23 Minibus BB 01

Central bus and Coral Way operated Minibus BB 02 fleets fairly consistently as shown in Figure 7.24. Coral Way achieved a few more months where the percentage of miles exceeded the percentage of road calls for the Minibus BB 02 buses.

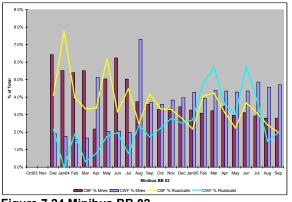


Figure 7.24 Minibus BB 02

Central bus, Coral Way, and Northeast operated Optare 03 fleets, as illustrated in Figure 7.25. While the FY 2004 percentage of miles consistently exceeded the percentage of road calls for the Optare 03 fleets, FY 2005 proved to be a difficult period for all three facilities.

During FY 2005, the Optare 03 percentage of road calls exceeded the percentage of miles for seven months at

Central bus, nine months at Northeast, and five months at Coral Way.

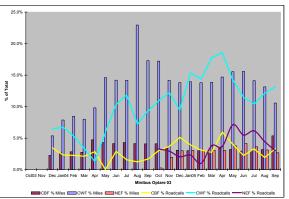


Figure 7.25 Minibus Optare 03



8. Determining Manpower Needs

8.1 Mechanic Manpower Analysis, June 2003

In June 2003, CUTR provided assistance to MDT in developing a methodology to determine future vehicle maintenance mechanic needs. MDT had received a mandate to expand service to a level in 2005 that would almost double 2002 mileage.

Based upon estimated service requirements outlined in the People's Transportation Plan, the bus fleet directly operated by MDT was scheduled to grow from 701 buses to over 1,330 buses with an increase in annual vehicle miles from 30 million to over 55 million miles.

MDT needed to identify manpower requirements to maintain the expanded fleet. Work standards for all elements within individual job classifications did not exist, and a Florida International University project to develop standards was in its beginning stages. In the such of absence standards. determination of the level of manpower required to operate effectively and efficiently had to be established by an alternative methodology.

All transit agencies typically maintain rather detailed records of labor hours expended as well as vehicle related data. Within Miami-Dade Transit, labor hours accrued by all classifications of non-supervisory maintenance staff were recorded, as were vehicle revenue and non-revenue miles.

8.1.1 Mechanic Requirements

CUTR was asked to ascertain the soundness of a methodology, developed in-house by maintenance managers, as a predictor of maintenance staffing levels.

The methodology used identified the number of full-time Mechanics required to provide a defined volume of miles. Actual FY 2001 data used for the analysis included 26,481,222 annual vehicle miles, a complement of 162 full-time mechanics, and 293,559 annual work hours that include overtime hours.

Step 1: Established Annual Work Days for a Fulltime Mechanic

Annual Work Actual Days per Year - Days Off Days = (365 Days - 104 Days Off) = 261 Available Days

Step 2: Established "Unavailable" Work Days for Full-time Mechanic

Total Days Holidays+Annual+Sick Leave = 39 Unavailable Unavailable = (13 + 14 + 12) = 39 Unavailable Days

Step 3: Subtracted Unavailable Days from Annual Work Days to Determine Available Days

Days Annual Work Days - Unavailable Days 222 Available Available = (261 - 39) = 222 Available Days

Step 4: Calculated Daily Available Work Hours

Hours Daily Work Hours - Unavailable Hours = 7 Available Available = (8 Hours - 1 Hour) = 7 Available Hours

Step 5: Translated Annual Days of Availability of a Full-time Mechanic into Annual Hours

Annual Available Available Days x Available Hours = 1,554 Hours Hours = (216 Days x 7 Hours per Day) = 1,554 Hours per Year

In two previous projects for Miami-Dade Transit, CUTR incorporated a methodology, quite similar to the process outlined above, for calculating available hours for Metrorail and Metromover technicians. Based on the



methodology, available hours for a Metrorail technician equaled 1,452 hours, while available hours for a Metromover technician were 1,442. The use of 1,554 available hours for each full-time mechanic appeared reasonable, given the hours calculated for rail and mover technicians. available mechanic hours However. exceeded rail and mover available hours by 102-112 hours per employee per year or approximately 7-8%. CUTR cautioned that the available hours for the mechanic were probably overstated rather than understated, which could yield a conservative estimate of actual need.

Approximately 293,559 work hours were needed to produce 26,481,222 vehicle miles during fiscal year 2001, which translated into 0.01 work hours to provide each vehicle mile.

Step 6: Calculated Work Hours Required for Each Vehicle Mile

Work Hours Total Work Hours/Total Miles = 0.01 Work per Mile = (293,559 Work Hours/26,481,222 Miles) = 0.01 Work Hours per Mile

Employee requirements provide to projected additional miles were calculated in the following tables. Since each mile required 0.01 work hours of the additional miles labor. were multiplied by 0.01 hours to determine the total additional work hours required.

Step 7: Calculated Additional Hours – Projected FY 04 and Annualized

FY 04	Projected Increase in FY 04 Miles	Work Hours per Mile	Additional Work Hours	Annualized Miles	Work Hours per Mile	Additional Work Hours
New Service	4,206,353	0.01	42,064	7,233,195	0.01	72,332

Additional work hours were divided by 1,554 hours, annual productive hours of

each mechanic. determine the to number of full-time mechanics The considered necessarv. methodology for calculating the number of full-time mechanics needed was the same, regardless of the nature of the anticipated miles - projected FY 04 and/or annualized FY 04. The number of full-time mechanics required for new service in FY 04 ranged from 27 to 47, depending on the method used to project miles.

Step 8: Calculated Mechanics Required – Projected FY 04 and Annualized Miles

	Projected FY					
	04 Additional	Available	Mechanics	Annualized Additional		Maahaniaa
FY 04	Work Hours			Work Hours		Required
New Service	42,064	1,554	27	73,332	1,554	47

Projected and/or annualized miles divided by the number of required mechanics yielded 155,400 miles, the number of miles each mechanic was projected to produce annually.

Step 9: Calculated Miles per Mechanic – Projected FY 04 and Annualized Miles

FY 04	Projected Increase in FY 04 Miles	Mechanics Required	Miles per Mechanic	Annualized Miles		Miles per Mechanic	
New Service	4.206.353	. 27	155.400	7.233.195	. 47	155,400	

The following formula was used to determine the number of full-time mechanics required for projected mileage volumes:

In summary:

 The methodology used to determine mechanic manpower requirements appeared to be sound



- A critical component in the calculation of manpower requirements was the level of availability of a full-time employee; the reliability of the data can be enhanced in the future through the use of data from multiple years
- The fact that MDT's EMS reporting captured 270,000 of the 293,000 hours (approximately 92%) identified in the analysis of the labor hours reported lent credibility to the analysis
- When compared across other modes within Miami-Dade Transit, the established level of 1,554 hours appeared reasonable
- The FY 04 shortage of mechanics ranged from 27 to 47, depending upon the method by which miles were projected

The next important step in the evaluative process was a comparison of MDT with comparable transit agencies.

8.1.2 Comparison of Other Transit Properties

In Data Table 21 of the National Transit Database for year 2000, MDT reported 27.9 million annual vehicle miles and 270.2 million annual passenger miles logged by the bus fleet.

CUTR determined agencies comparable to MDT were those agencies that reported annual passenger miles and/or annual vehicle miles for bus similar to those reported by MDT in the NTD 2000. Using Data Table 21, CUTR identified those agencies with annual vehicle miles in the range of 20 to 30 million miles and annual passenger miles in the range of 200 to 300 million miles. Those agencies included:

- San Antonio VIA Metropolitan Transit
- Mass Bay Transportation Authority
- Milwaukee County Transit System
- Metro Atlanta RTA
- San Francisco Municipal Railway
- Portland Tri-County Metro District
- Denver Regional Transportation
 District
- Baltimore MTA-Maryland DOT
- Greater Cleveland RTA
- Alameda Contra Costa TD
- Port Authority of Allegheny County
- Santa Clara Valley TA

CUTR conducted a cluster analysis to identify those agencies most closely related to Miami-Dade Transit in terms of operating characteristics. Nine agencies, including Miami-Dade Transit, formed Cluster One, with the following grouping variables used to estimate similarities among clusters:

- Annual Passenger Miles/Vehicle
 Maintenance FTE
- Annual Passenger Miles/Vehicle Maintenance Hours
- Vehicle Maintenance Hours/VOMS
- Annual Passenger Miles/VOMS

To validate the robustness of results, different algorithms and measures of dissimilarity were applied in the analysis, which produced identical results.

Cluster One included the following agencies:

• San Antonio VIA Metropolitan Transit



- Mass Bay Transportation Authority
- Milwaukee County Transit System
- Metro Atlanta RTA
- San Francisco Municipal Railway
- Portland Tri-County Metro District
- Denver Regional Transportation
 District
- Baltimore MTA-Maryland DOT
- Miami-Dade Transit

A comparative analysis of transit service supplied, full-time vehicle maintenance employees, and vehicle maintenance hours provided was conducted. Following are the results of the analysis:

Agencies were ranked by each of the variables identified in the cluster analysis. The rankings are illustrated in Table 8.1.

Table 8.1 Cluster One Agencies, 2000 NTD Data Ranking

-	Vehicles Operated		Vehicles Available									
	in		for		Annual		Annual				Full-time	
	Maximum	Bu	Maximum	ing	Vehicle	Bu	Passenger	ē	Vehicle	Bu	Vehicle	lking
Cluster One	Service (VOMS)	Ranki	Service (VAMS)	Ranki	Miles (000s)	Ranki	Miles (000s)	Ranking	Maintenance Hours	Ranki	Maintenance Employees	Ranki
Mass Bay TA	769	1	911	2	26,032	5	250,792	5	852,511	2	445	2
Baltimore MTA	649	2	787	3	21,597	8	261,834	4	752,039	4	403	4
Denver RTD	639	3	962	1	33,875	1	288,037	1	854,180	3	443	3
Metro Atlanta RTA	580	4	698	4	31,853	2	273,116	2	1,119,544	1	459	1
Tri-County Metro	570	5	671	5	26,554	4	207,760	6	631,539	6	353	6
Miami-Dade Transit	530	6	666	6	27,871	3	270,213	3	743,038	5	364	5
Milwaukee County	461	7	557	7	22,074	7	195,917	8	449,387	8	240	8
VIA Metropolitan	421	8	503	8	22,234	6	171,628	9	389,134	9	220	9
Municipal Railway	372	9	488	9	14,317	9	207,328	7	611,147	7	294	7
Source: NTD 2000 Data T	able 21 & 28											

Agencies were also ranked by performance variables derived from the NTD data. Performance rankings are detailed in Table 8.2.

Table 8.2 Cluster One Agencies, 2000 NTDPerformance Data Ranking

							Annual		Annual	
			Annual				Passenger		Passenger	
			Passenger		Vehicle		Miles per		Miles per Full-	
	VAMS	g	Miles per	g	Maintenance	g	Vehicle	g	time Vehicle	B
	versus	Ř	VOMS	ž	Hours per	ž	Maintenance	ž	Maintenance	iž
Cluster One	VOMS	Rar	(000s)	Rankii	VOMS	Rankii	Hour	Rankii	Employee	Rankir
Denver RTD	1.51	1	451	4	1,337	4	215,476	2	649,609	5
Municipal Railway	1.31	2	557	1	1,643	2	126,199	9	705,678	4
Miami-Dade Transit	1.26	3	510	2	1,402	3	192,739	5	742,323	3
Baltimore MTA	1.21	4	403	7	1,159	6	225,959	1	649,389	6
Milwaukee County	1.21	5	425	5	975	8	200,980	4	816,323	1
Metro Atlanta RTA	1.20	6	471	3	1,930	1	141,493	8	595,023	7
VIA Metropolitan	1.19	7	408	6	924	9	185,683	7	780,128	2
Mass Bay TA	1.18	8	326	9	1,239	5	202,474	3	563,577	9
Tri-County Metro	1.18	9	364	8	1,108	7	187,516	6	588,557	8
Source: NTD 2000 Data T	able 21 & 2	8								

The following conclusions were drawn from the rankings:

- In maximum service, Miami-Dade Transit operated fewer vehicles and had fewer vehicles available than comparable agencies, while the ratio of vehicles operated to vehicles available equaled that of other agencies
- In terms of annual vehicle and passenger miles, MDT exceeded all comparable agencies in the volume of miles logged, including passengers miles, when compared to vehicles operated in maximum service
- MDT reported more vehicle maintenance hours than comparable agencies both in actual hours and when compared to vehicle maintenance hours per vehicle operated in maximum service
- MDT provided an average number of passenger miles for each vehicle maintenance hour
- MDT reported fewer full-time maintenance employees than comparable agencies; however, the number of passenger miles for each of the employees exceeded comparable agencies

8.1.3 Findings: June 2003 Manpower Analysis

From a vehicle maintenance perspective, Miami-Dade Transit was quite like other transit agencies that provided similar levels of service. MDT appeared to provide slightly more miles with fewer vehicles. Significant deviation from the average and median was most notable in MDT's ratio of passenger miles to full-time vehicle maintenance employees, which was



higher than most other comparable agencies. Based on the analysis, MDT's staffing for vehicle maintenance appeared to be slightly below that reported by other transit agencies providing service at a level similar to MDT.

The methodology used by maintenance to determine additional mechanic and body mechanic manpower needs did appear to be sound. The level of availability of a full-time employee was a critical component in the calculation of manpower requirements, and when compared across other modes within Miami-Dade Transit, the established level of 1.554 hours appeared reasonable. The completion of the ongoing work standards project should provide Miami-Dade Transit with the ability to determine manpower needs based on standard practices. Until that project is completed, MDT should consider using an average of data from multiple years or at a minimum recalculate the number of miles per employee annually to ensure manpower levels are consistent with workforce productivity.

8.2 Manpower Requirements 2006

While the June 2003 Manpower Analysis provided useful data in the determination of manpower needs, the process of determining future needs relied heavily on the number of hours the maintenance workforce was actually able to provide during the previous year. If that workforce performed at less than an optimum level, the actual hours needed to maintain the fleet could be skewed. An inefficient work force could overstate the labor need and result in a demand for additional maintenance personnel. To that end, CUTR looked for other methodologies to determine maintenance manpower requirements that incorporated worker productivity.

8.2.1 Defining Maintenance Manpower Needs

Throughout this report, CUTR has made extensive use of the National Transit Database not only to evaluate MDT's performance as an agency but also to compare MDT's performance to other agencies, peers, and 19 of the 20 largest agencies in the US. When some of the variables are viewed out of from individual context or an perspective, a positive picture of an agency can emerge. Nonetheless, when those same variables are viewed in relationship to other variables, the picture produced can often be less For example, Miami-Dade positive. Transit ranked 11th of 20 in terms of the number of full-time maintenance employees, but fell to 15th of 20 when ranked in terms of number of labor hours provided by each of those employees.

One of the variables included in the NTD is "labor hours for inspection and maintenance." The National Transit Database defines "labor hours for inspection and maintenance" as labor expenses under object class (501.02) charged to function (061) inspection and maintenance of revenue vehicles (Section 6.2 of the Uniform System of Accounts (USOA)).



Activities in this function (061) include:

- Inspecting revenue vehicle components on a scheduled preventive maintenance basis
- Changing lubrication fluids
- Replacing minor repairable units of specific vehicle components
- Making road calls to service revenue vehicle breakdowns
- Towing and shifting revenue vehicles to maintenance facilities
- Rebuilding and overhauling repairable components
- Performing major repairs on revenue vehicles on a scheduled or unscheduled basis
- Replacing major repairable units of revenue vehicles

In addition, the NTD goes on to say that total labor hours for inspection and maintenance (061) comprise only one category of hours that are reported in the total vehicle maintenance category (041). Work hours for the following vehicle maintenance functions are expressly excluded from the "inspection and maintenance labor hour" (061) category:

- (041) Maintenance administration vehicles
 - Maintenance managers, port engineers, superintendents, supervisors and non-working lead workers engaged in directing and supervising maintenance and repairs to vehicles
 - Secretaries and clerk-typists supporting the administration of maintenance activities
 - Garage and shop clerks

- Timekeepers and other clerical people engaged in scheduling and recording vehicle maintenance activities
- Vehicle maintenance training instructors and students
- Engineers and other technicians engaged in vehicle maintenance activities
- (051) Servicing revenue vehicles
 - Service managers, supervisors and lead workers engaged in overseeing the preparation of revenue vehicles for service (excluding repair work)
 - Cleaners
 - Washers
 - Fuelers
 - Oilers
 - Hostlers
 - Secretaries and clerks supporting vehicle servicing activities
- (062) Accident repairs of revenue vehicles
 - All direct and indirect maintenance and administrative labor actually expended or allocated to the repair of accident damage on revenue vehicles
- (071) Vandalism repairs of revenue vehicles
 - All direct and indirect maintenance and administrative labor actually expended on or allocated to the repair of vandalism damage on revenue vehicles
- (081) Servicing and fueling of service vehicles



- Service managers, supervisors and lead workers engaged in overseeing the preparation of service vehicles for operation (excluding repair work)
- Cleaners
- Washers
- Fuelers
- Oilers
- Hostlers
- Secretaries and clerks supporting servicing activities for service vehicles
- (091) Inspection and maintenance of service vehicles
 - Working supervisors, lead workers, inspectors, service staff, greasers, mechanics, apprentices, welders, major component repair staff, electricians, bench hands, machinists, blacksmiths, and others engaged in garage and shop repair and maintenance activities for service vehicles

Vehicle maintenance labor included as inspection and maintenance (061) includes the following:

- (061) Inspection and maintenance of revenue vehicles
 - Working supervisors, lead workers, inspectors, service personnel, apprentices, greasers, mechanics, welders, major component repair staff, electricians, bench hands, machinists, coil winders, sheet metal workers, sanders, painters, body workers, upholsterers, glass installers, carpenters, blacksmiths, others engaged in

repair, maintenance and inspection activities for revenue vehicles

The level of detail that the NTD has provided to the agencies for the "inspection reporting of and maintenance labor hours" should increase the confidence level that reporting agencies are actually providing data that accurately reflect the labor hours used for inspection and maintenance by the agencies.

Researchers returned to the 2000-2004 NTD data analysis used previously in this report to examine agency reporting of inspection and maintenance labor hours. Significant aspects of the top-20 agencies' performance are detailed in Tables 8.3 through 8.7.

Table 8.3 NTD Performance Data, 2004

			Annual		Vehicle				
		Vehicle	Vehicle	Vehicle		Labor Hours for	Labor	Labor	Veh
		Maintenance	Miles	Miles per	Empl per			Hours per	
State	VOMS	Employees	(000s)	Employee	VOMS	Maintenance	VOMS	Empl	I&M Hr
GA	580	459.0	31,852.9	69,396	119.6	1,119,544	1,930.2	2,439.1	28.5
CA	606	439.0	24,529.7	55,876	92.2	905,209	1,493.7	2,062.0	27.1
NJ	1,682	1,218.0	82,148.0	67,445	40.1	2,336,468	1,389.1	1,918.3	35.2
DC	1,179	806.0	42,168.0	52,318	44.4	1,456,541	1,235.4	1,807.1	29.0
тх	441	362.0	22,291.8	61,580	139.6	642,554	1,457.0	1,775.0	34.7
MA	769	445.0	26,032.2	58,499	76.1	788,333	1,025.1	1,771.5	33.0
NY	3,840	2,829.7	115,202.7	40,712	10.6	4,876,065	1,269.8	1,723.2	23.6
PA	1,132	894.0	42,623.3	47,677	42.1	1,512,654	1,336.3	1,692.0	28.2
PA	848	575.7	36,423.0	63,267	74.6	873,525	1,030.1	1,517.3	41.7
IL	477	222.8	21,281.4	95,518	200.2	316,730	664.0	1,421.6	67.2
CO	639	443.4	33,875.4	76,399	119.6	601,549	941.4	1,356.7	56.3
OH	619	387.0	27,317.8	70,589	114.0	501,280	809.8	1,295.3	54.5
IL	1,577	1,354.9	62,758.7	46,320	29.4	1,610,572	1,021.3	1,188.7	39.0
MD	649	403.2	21,597.4	53,565	82.5	467,163	719.8	1,158.6	46.2
MN	785	460.0	32,238.2	70,083	89.3	513,975	654.7	1,117.3	62.7
FL	530	364.0	27,871.1	76,569	144.5	401,562	757.7	1,103.2	69.4
ТΧ	1,017	807.0	43,230.9	53,570	52.7	803,239	789.8	995.3	53.8
CA	1,888	1,704.0	92,451.4	54,256	28.7	1,120,305	593.4	657.5	82.5
OR	570	353.0	26,554.4	75,225	132.0	213,033	373.7	603.5	124.6
WA	931	570.6	40,040.2	70,172	75.4	301,546	323.9	528.5	132.8
Max	3,840	2,829.7	115,202.7	95,518	200.2	4,876,065	1,930.2	2,439.1	132.8
Min	441	222.8	21,281.4	40,712	10.6	213,033	323.9	528.5	23.6
Mean	1,038	754.9	42,624.4	62,952	85.4	1,068,092	990.8	1,406.6	53.5
Median	777	459.5	33,056.8	62,423	79.3	795,786	981.3	1,389.1	44.0



Table 8.4 NTD Performance Data, 2003

			Annual		Vehicle				
		Vehicle	Vehicle	Vehicle		Labor Hours for	Labor	Labor	Veh
		Maintenance	Miles	Miles per	Empl per			Hours per	
State	VOMS	Employees	(000s)	Employee	VOMS	Maintenance	VOMS	Empl	I&M Hr
GA	603	468.0	32,041.7	68,465	113.5	1,194,605	1,981.1	2,552.6	26.8
MA	779	457.0	26,041.9	56,985	73.2	950,560	1,220.2	2,080.0	27.4
NJ	1,704	1,188.0	82,637.2	69,560	40.8	2,346,567	1,377.1	1,975.2	35.2
CO	598	439.4	32,485.5	73,932	123.6	812,336	1,358.4	1,848.7	40.0
PA	848	613.2	38,203.1	62,301	73.5	1,089,824	1,285.2	1,777.3	35.1
DC	1,212	914.0	44,858.7	49,080	40.5	1,609,920	1,328.3	1,761.4	27.9
CA	648	444.0	26,133.3	58,859	90.8	769,231	1,187.1	1,732.5	34.0
OH	614	387.0	26,792.6	69,231	112.8	561,600	914.7	1,451.2	47.7
NY	3,887	3,514.6	117,543.5	33,444	8.6	4,936,123	1,269.9	1,404.5	23.8
PA	1,098	874.0	43,083.9	49,295	44.9	1,196,965	1,090.1	1,369.5	36.0
IL	1,627	1,244.9	64,673.1	51,950	31.9	1,642,075	1,009.3	1,319.0	39.4
IL	473	239.4	22,192.4	92,700	196.0	313,073	661.9	1,307.7	70.9
MD	630	401.0	21,774.8	54,301	86.2	463,002	734.9	1,154.6	47.0
MN	792	463.0	32,207.4	69,562	87.8	510,112	644.1	1,101.8	63.1
TX	1,050	807.8	45,090.5	55,819	53.2	776,051	739.1	960.7	58.1
TX	447	361.0	23,160.7	64,157	143.5	333,219	745.5	923.0	69.5
FL	547	374.0	29,365.8	78,518	143.5	321,190	587.2	858.8	91.4
CA	1,891	1,442.0	86,856.7	60,233	31.9	989,800	523.4	686.4	87.8
OR	568	350.0	26,622.6	76,065	133.9	220,368	388.0	629.6	120.8
WA	976	577.6	40,489.6	70,100	71.8	303,311	310.8	525.1	133.5
Max	3,887	3,514.6	117,543.5	92,700	196.0	4,936,123	1,981.1	2,552.6	133.5
Min	447	239.4	21,774.8	33,444	8.6	220,368	310.8	525.1	23.8
Mean	1,050	778.0	43,112.7	63,228	85.1	1,066,997	967.8	1,371.0	55.8
Median	786	465.5	32,346.5	63,229	79.8	794,194	962.0	1,344.3	43.5

Table 8.5 NTD Performance Data, 2002

State	VOMS	Vehicle Maintenance Employees	Annual Vehicle Miles (000s)	Vehicle Miles per Employee	Vehicle Miles per Empl per VOMS	Labor Hours for Inspection and Maintenance	Labor Hours per VOMS	Labor Hours per Empl	Veh Miles per I&M Hr
GA	590	468.0	31,310.2	66,902	113.4	975,962	1,654.2	2,085.4	32.1
NJ	1,714	1,236.0	84,584.3	68,434	39.9	2,497,950	1,457.4	2,021.0	33.9
MA	775	493.0	27,261.7	55,297	71.4	957,401	1,235.4	1,942.0	28.5
CO	577	423.7	31,239.8	73,731	127.8	799,543	1,385.7	1,887.0	39.1
PA	838	622.3	38,568.9	61,978	74.0	1,152,650	1,375.5	1,852.2	33.5
CA	654	470.0	26,690.2	56,788	86.8	818,457	1,251.5	1,741.4	32.6
OH	544	323.0	23,015.0	71,254	131.0	561,600	1,032.4	1,738.7	41.0
NY	3,915	3,189.1	119,061.7	37,334	9.5	4,772,104	1,218.9	1,496.4	24.9
DC	1,247	752.0	46,573.2	61,932	49.7	1,108,640	889.0	1,474.3	42.0
PA	1,086	882.0	45,114.6	51,150	47.1	1,164,912	1,072.7	1,320.8	38.7
IL	476	254.1	22,133.4	87,105	183.0	335,474	704.8	1,320.2	66.0
IL	1,695	1,240.7	66,913.4	53,932	31.8	1,579,784	932.0	1,273.3	42.4
MN	841	457.0	32,187.8	70,433	83.7	574,286	682.9	1,256.6	56.0
MD	634	413.1	22,521.1	54,517	86.0	495,040	780.8	1,198.4	45.5
ТХ	452	336.0	23,762.7	70,722	156.5	328,035	725.7	976.3	72.4
FL	564	384.0	30,559.2	79,581	141.1	316,300	560.8	823.7	96.6
ТΧ	1,053	833.2	45,079.4	54,104	51.4	655,150	622.2	786.3	68.8
CA	1,925	1,530.0	95,953.5	62,715	32.6	1,074,965	558.4	702.6	89.3
OR	568	362.0	27,210.7	75,168	132.3	238,542	420.0	659.0	114.1
WA	1,186	596.0	42,403.7	71,147	60.0	322,242	271.7	540.7	131.6
Max	3,915	3,189.1	119,061.7	87,105	183.0	4,772,104	1,654.2	2,085.4	131.6
Min	452	254.1	22,133.4	37,334	9.5	238,542	271.7	540.7	24.9
Mean	1,067	763.3	44,107.2	64,211	85.4	1,036,452	941.6	1,354.8	56.4
Median	807	481.5	31,749.0	64,808	78.9	809,000	910.5	1,320.5	42.2

Table 8.6 NTD Performance Data, 2001

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State	VOMS	Vehicle Maintenance Employees	Annual Vehicle Miles (000s)	Vehicle Miles per Employee	Vehicle Miles per Empl per VOMS	Labor Hours for Inspection and Maintenance	Labor Hours per VOMS	Labor Hours per Empl	Veh Miles per I&M Hr
NJ	1,708	1,210.0	84,779.5	70.066	41.0	2,468,469	1.445.2	2.040.1	34.3
GA	555	473.0	30,197.0	63,841	115.0	953,919	1,718.8	2,016.7	31.7
MA	770	469.0	26,117.0	55,687	72.3	897,654	1,165.8	1,914.0	29.1
PA	828	594.0	36,745.2	61,861	74.7	1,093,298	1,320.4	1,840.6	33.6
DC	1,262	788.0	48,003.3	60,918	48.3	1,424,800	1,129.0	1,808.1	33.7
ОН	548	313.0	25,457.6	81,334	148.4	561,600	1,024.8	1,794.2	45.3
CA	654	448.0	27,128.0	60,554	92.6	773,236	1,182.3	1,726.0	35.1
со	589	397.7	30,114.8	75,722	128.6	644,549	1,094.3	1,620.7	46.7
NY	3,893	3,030.2	121,255.9	40,016	10.3	4,819,934	1,238.1	1,590.6	25.2
IL	472	257.0	22,026.7	85,707	181.6	342,631	725.9	1,333.2	64.3
IL	1,719	1,203.5	67,478.0	56,068	32.6	1,577,650	917.8	1,310.9	42.8
MD	633	423.0	22,155.6	52,377	82.7	543,106	858.0	1,283.9	40.8
PA	1,145	868.0	46,268.4	53,305	46.6	1,098,232	959.2	1,265.2	42.1
MN	774	446.0	30,969.4	69,438	89.7	505,327	652.9	1,133.0	61.3
тх	440	303.0	24,615.7	81,240	184.6	312,214	709.6	1,030.4	78.8
FL	506	378.0	32,075.9	84,857	167.7	298,576	590.1	789.9	107.4
ТΧ	1,017	817.2	44,363.1	54,287	53.4	594,793	584.9	727.8	74.6
WA	1,183	590.2	42,838.5	72,583	61.4	392,025	331.4	664.2	109.3
OR	562	355.0	27,467.8	77,374	137.7	227,905	405.5	642.0	120.5
CA	2,004	1,619.0	97,893.5	60,465	30.2	1,010,910	504.4	624.4	96.8
Max	3,893	3,030.2	121,255.9	85,707	184.6	4,819,934	1,718.8	2,040.1	120.5
Min	440	257.0	22,026.7	40,016	10.3	227,905	331.4	624.4	25.2
Mean	1,063	749.1	44,397.5	65,885	90.0	1,027,041	927.9	1,357.8	57.7
Median	772	471.0	31,522.7	62,851	78.7	708,893	938.5	1,322.0	44.1

Table 8.7 NTD Performance Data, 2000

			Annual		Vehicle				
		Vehicle	Vehicle	Vehicle		Labor Hours for	Labor	Labor	Veh
		Maintenance	Miles	Miles per	Empl per	Inspection and		Hours per	
State	VOMS	Employees	(000s)	Employee	VOMS	Maintenance	VOMS	Empl	I&M Hr
MA	774	494	25,073.5	50,756	65.6	1,030,060	1,330.8	2,085.1	24.3
GA	590	439	29,990.8	68,316	115.8	901,685	1,528.3	2,054.0	33.3
PA	997	580	36,570.1	63,052	63.2	1,074,285	1,077.5	1,852.2	34.0
CA	624	396	25,635.9	64,737	103.7	696,946	1,116.9	1,760.0	36.8
NY	3,849	2,929	121,838.7	41,593	10.8	4,793,898	1,245.5	1,636.5	25.4
DC	1,236	755	47,765.1	63,265	51.2	1,235,520	999.6	1,636.5	38.7
OH	544	365	24,551.4	67,264	123.6	555,360	1,020.9	1,521.5	44.2
CO	566	394	30,819.6	78,282	138.3	592,879	1,047.5	1,505.9	52.0
NJ	1,686	1,268	84,737.5	66,828	39.6	1,844,053	1,093.7	1,454.3	46.0
IL	1,710	1,117	67,783.0	60,689	35.5	1,620,687	947.8	1,451.1	41.8
PA	1,165	840	46,158.2	54,950	47.2	1,206,986	1,036.0	1,436.9	38.2
IL	467	246	21,849.1	88,818	190.2	322,239	690.0	1,309.9	67.8
MD	633	429	22,773.2	53,084	83.9	486,830	769.1	1,134.8	46.8
MN	722	422	27,113.0	64,249	89.0	448,061	620.6	1,061.8	60.5
FL	663	476	36,037.7	75,709	114.2	505,264	762.1	1,061.5	71.3
ТΧ	585	386	34,048.7	88,209	150.8	402,692	688.4	1,043.2	84.6
OR	546	342	27,392.0	80,094	146.7	279,221	511.4	816.4	98.1
WA	1,245	595	43,483.1	73,056	58.7	390,632	313.8	656.3	111.3
ТΧ	1,027	779	43,112.1	55,329	53.9	496,051	483.0	636.6	86.9
CA	2,022	1,389	89,777.2	64,634	32.0	839,544	415.2	604.4	106.9
Max	3,849	2,929	121,838.7	88,818	190.2	4,793,898	1,528.3	2,085.1	111.3
Min	467	246	21,849.1	41,593	10.8	279,221	313.8	604.4	24.3
Mean	1,083	732	44,325.5	66,146	85.7	986,145	884.9	1,335.9	57.4
Median	748	485	35,043.2	64,686	74.7	644,913	973.7	1,444.0	46.4

From 2000 through 2004, MDT reported fewer VOMS, fewer vehicle maintenance employees, and fewer annual vehicle miles than the average of the top-20 transit agencies studied.

At the same time, MDT recorded more vehicle miles per employee (12.6% to 22.4% above the average) and more vehicle miles per employee per VOMS (25.0% to 46.4% above the average) than the average of the agencies as illustrated in Table 8.8. This indicates that MDT's ratio of employees and VOMS to vehicle miles logged was lower than the average.

MDT reported fewer labor hours for inspection and maintenance (16.1% to 67.9% below the average), fewer labor hours per VOMS, and fewer labor hours per employee (25.9% to 71.9% below the average). Not only was MDT's ratio of employees to vehicle miles and VOMS lower than average, MDT's employees produced fewer hours than those produced on average by the top-20 transit agencies, as indicated in Table 8.8.

Table 8.8 2000-2004 Performance Variables, MDTversus Top-20 Agency Average

				Inspection	Inspection	Veh Miles per
			Vehicle	and	and	Inspection
	MDT	Vehicle		Maintenance		and
	and Top-20	Miles per	Empl per	Labor Hours	Labor Hours	
Year	Mean	Employee	VOMS	per VOMS	per Empl	Labor Hr
2004	MDT	75,709	114.2	762.1	1.061.8	71.3
2004	Mean	66,146	85.7	884.9	1.335.9	57.4
2004	Median	64,686	74.7	973.7	1.444.0	46.4
	MDT vs Mean	9,564	28.5	-122.8	-274.1	13.9
	% +/-	12.6%	25.0%	-16.1%	-25.8%	19.5%
	MDT vs Median	11.023	39.5	-211.6	-382.2	24.9
	% +/-	14.6%	34.6%	-27.8%	-36.0%	34.9%
2003	MDT	84,857	167.7	590.1	789.9	107.4
2003	Mean	65,885	90.0	927.9	1,357.8	57.7
2003	Median	62,851	78.7	938.5	1,322.0	44.1
	MDT vs Mean	18,972	77.7	-337.8	-567.9	49.8
	% +/-	22.4%	46.4%	-57.3%	-71.9%	46.3%
	MDT vs Median	22,006	89.0	-348.4	-532.1	63.3
	% +/-	25.9%	53.1%	-59.0%	-67.4%	58.9%
2002	MDT	79,581	141.1	560.8	823.7	96.6
2002	Mean	64,211	85.4	941.6	1,354.8	56.4
2002	Median	64,808	78.9	910.5	1,320.5	42.2
	MDT vs Mean	15,370	55.7	-380.8	-531.1	40.2
	% +/-	19.3%	39.4%	-67.9%	-64.5%	41.6%
	MDT vs Median	14,773	62.2	-349.7	-496.8	54.4
	% +/-	18.6%	44.1%	-62.4%	-60.3%	56.3%
2001	MDT	78,518	143.5	587.2	858.8	91.4
2001	Mean	63,228	85.1	967.8	1,371.0	55.8
2001	Median	63,229	79.8	962.0	1,344.3	43.5
	MDT vs Mean	15,290	58.4	-380.6	-512.2	35.7
	% +/-	19.5%	40.7%	-64.8%	-59.6%	39.0%
	MDT vs Median	15,289	63.7	-374.8	-485.5	47.9
	% +/-	19.5%	44.4%	-63.8%	-56.5%	52.4%
2000	MDT	76,399	144.5	757.7	1,103.2	69.4
2000	Mean	62,952	85.4	990.8	1,406.6	55.7
2000	Median	62,423	79.3	981.3	1,389.1	44.0
	MDT vs Mean	13,447	59.1	-233.2	-303.4	13.7
	% +/-	17.6%	40.9%	-30.8%	-27.5%	19.7%
	MDT vs Median	13,976	65.2	-223.6	-285.9	25.4
	% +/-	18.3%	45.1%	-29.5%	-25.9%	36.6%

Combined, these factors accounted for MDT reporting more vehicle miles per labor hour (19.5% to 46.3% above the average) than the agencies' average.

8.2.2 Calculating Maintenance Manpower Needs

The analysis of the 2000-2004 NTD data clearly shows that MDT is a top-20 agency that has expanded service at record levels in the past five years. Nonetheless, the analysis also shows an agency that is falling behind in maintenance performance, which is compounded by the impact of the high mileage accumulated annually by the vehicles.



While, in 2004, MDT did restore labor hours allocated to each vehicle operated in maximum service to the 2000 level, the 2004 labor hours per VOMS remained 16% below the average of the top-20 agencies. In addition, labor hours per employee, which were 72% below the top-20 average in 2003, did improve and fell to only 26% below the top-20 average in 2004.

Study The June 2003 Manpower concluded that each maintenance mechanic could provide 1,554 annually. productive manhours However, an analysis of the inspection and maintenance labor hours from 2000-2004 indicates productivity of only 824 to 1,103 hours per employee a year, while the top-20 agency average was 1,336 to 1,407 hours per employee a year.

It appeared that the June 2003 methodology needed to be modified to incorporate productivity into the manpower calculation.

Toward that end, 2000-2004 data were recalculated, using a reduced productive annual manpower figure of 1,500 manhours (more closely resembles manhour levels used in Metrorail and Metromover). Additional manhours ranging from 144,000 to 268,000 could have been available annually had labor hours per employee reached 1,500 hours, as illustrated in Table 8.9.

Table 8.9 Labor Hours @ 1,500 hours per Employee

Year	VOMS	Vehicle Maintenance Employees	Annual Vehicle Miles (000s)	Labor Hours for Inspection and Maintenance			Hours @ 1,500 per Employee	Increased	Adjusted Veh Miles per I&M Hr
2004	663	476	36.037.7	505.264	1.061.5	71.3	714.000	208.736	50.5
2003	506	378.0	32,075.9	298,576	789.9	107.4	567,000	268,424	56.6
2002	564	384.0	30,559.2	316,300	823.7	96.6	576,000	259,700	53.1
2001	547	374.0	29,365.8	321,190	858.8	91.4	561,000	239,810	52.3
2000	530	364.0	27,871.1	401,562	1,103.2	69.4	546,000	144,438	51.0



Increasing employee productivity to 1,500 hours per year would reduce the number of vehicle miles per inspection and maintenance hour from a range of 71.3 - 107.4 miles to a range of 50.5 - 56.6 miles, a significant improvement. Improved productivity would also place MDT in a more competitive position with the top-20 agencies.

In Tables 8.10 through 8.14, labor hours for inspection and maintenance have been recalculated based on an allocation of 1,500 manhours per year for each full-time vehicle maintenance employee. In the Tables, the line referred to as "FL" represents actual NTD data for MDT, while the line labeled "FL Modified" represents the recalculation using 1,500 manhours for The three agencies that MDT. participated in the peer review are also identified on the tables.

Table 8.10 2004

State	VOMS	Vehicle Maintenance Employees	Annual Vehicle Miles (000s)	Labor Hours for Inspection and Maintenance	Labor Hours per Empl	Veh Miles per I&M Hr
MA	774	494	25,073.5	1,030,060	2,085.1	24.3
NY	3,849	2,929	121,838.7	4,793,898	1,636.5	25.4
GA	590	439	29,990.8	901,685	2,054.0	33.3
PA	997	580	36,570.1	1,074,285	1,852.2	34.0
CA	624	396	25,635.9	696,946	1,760.0	36.8
PA	1,165	840	46,158.2	1,206,986	1,436.9	38.2
DC	1,236	755	47,765.1	1,235,520	1,636.5	38.7
IL	1,710	1,117	67,783.0	1,620,687	1,451.1	41.8
OH ¹	544	365	24,551.4	555,360	1,521.5	44.2
NJ	1,686	1,268	84,737.5	1,844,053	1,454.3	46.0
MD ¹	633	429	22,773.2	486,830	1,134.8	46.8
FL Modified	663	476	36,037.7	714,000	1,500.0	50.5
CO ¹	566	394	30,819.6	592,879	1,505.9	52.0
MN	722	422	27,113.0	448,061	1,061.8	60.5
IL	467	246	21,849.1	322,239	1,309.9	67.8
FL	663	476	36,037.7	505,264	1,061.5	71.3
ТХ	585	386	34,048.7	402,692	1,043.2	84.6
ТХ	1,027	779	43,112.1	496,051	636.6	86.9
OR	546	342	27,392.0	279,221	816.4	98.1
CA	2,022	1,389	89,777.2	839,544	604.4	106.9
WA	1,245	595	43,483.1	390,632	656.3	111.3

¹ Agency participated in the Peer Review

Table 8.11 2003

State	VOMS	Vehicle Maintenance Employees	Annual Vehicle Miles (000s)	Labor Hours for Inspection and Maintenance	Labor Hours per Empl	Vehicle Miles per I&M Hour
NY	3,893	3,030.2	121,255.9	4,819,934	1,590.6	25.2
MA	770	469.0	26,117.0	897,654	1,914.0	29.1
GA	555	473.0	30,197.0	953,919	2,016.7	31.7
PA	828	594.0	36,745.2	1,093,298	1,840.6	33.6
DC	1,262	788.0	48,003.3	1,424,800	1,808.1	33.7
NJ	1,708	1,210.0	84,779.5	2,468,469	2,040.1	34.3
CA	654	448.0	27,128.0	773,236	1,726.0	35.1
MD ¹	633	423.0	22,155.6	543,106	1,283.9	40.8
PA	1,145	868.0	46,268.4	1,098,232	1,265.2	42.1
IL	1,719	1,203.5	67,478.0	1,577,650	1,310.9	42.8
OH1	548	313.0	25,457.6	561,600	1,794.2	45.3
CO ¹	589	397.7	30,114.8	644,549	1,620.7	46.7
FL Modified	506	378.0	32,075.9	567,000	1,500.0	56.6
MN	774	446.0	30,969.4	505,327	1,133.0	61.3
IL	472	257.0	22,026.7	342,631	1,333.2	64.3
тх	1,017	817.2	44,363.1	594,793	727.8	74.6
ТХ	440	303.0	24,615.7	312,214	1,030.4	78.8
CA	2,004	1,619.0	97,893.5	1,010,910	624.4	96.8
FL	506	378.0	32,075.9	298,576	789.9	107.4
WA	1,183	590.2	42,838.5	392,025	664.2	109.3
OR	562	355.0	27,467.8	227,905	642.0	120.5
¹ Agency pa	rticipated	in the Peer Rev	iew			

Agency participated in the Peer Review

Table 8.12 2002

State	VOMS	Vehicle Maintenance Employees	Annual Vehicle Miles (000s)	Labor Hours for Inspection and Maintenance	Labor Hours per Empl	Vehicle Miles per I&M Hour
NY	3,915	3,189.1	119,061.7	4,772,104	1,496.4	24.9
MA	775	493.0	27,261.7	957,401	1,942.0	28.5
GA	590	468.0	31,310.2	975,962	2,085.4	32.1
CA	654	470.0	26,690.2	818,457	1,741.4	32.6
PA	838	622.3	38,568.9	1,152,650	1,852.2	33.5
NJ	1,714	1,236.0	84,584.3	2,497,950	2,021.0	33.9
PA	1,086	882.0	45,114.6	1,164,912	1,320.8	38.7
CO ¹	577	423.7	31,239.8	799,543	1,887.0	39.1
OH ¹	544	323.0	23,015.0	561,600	1,738.7	41.0
DC	1,247	752.0	46,573.2	1,108,640	1,474.3	42.0
IL	1,695	1,240.7	66,913.4	1,579,784	1,273.3	42.4
MD ¹	634	413.1	22,521.1	495,040	1,198.4	45.5
FL Modified	564	384.0	30,559.2	576,000	1,500.0	53.1
MN	841	457.0	32,187.8	574,286	1,256.6	56.0
IL	476	254.1	22,133.4	335,474	1,320.2	66.0
ТХ	1,053	833.2	45,079.4	655,150	786.3	68.8
ТХ	452	336.0	23,762.7	328,035	976.3	72.4
CA	1,925	1,530.0	95,953.5	1,074,965	702.6	89.3
FL	564	384.0	30,559.2	316,300	823.7	96.6
OR	568	362.0	27,210.7	238,542	659.0	114.1
WA	1,186	596.0	42,403.7	322,242	540.7	131.6

¹ Agency participated in the Peer Review

Table 8.13 2001

State	VOMS	Vehicle Maintenance Employees	Annual Vehicle Miles (000s)	Labor Hours for Inspection and Maintenance	Labor Hours per Empl	Vehicle Miles per I&M Hour
NY	3,887	3,514.6	117,543.5	4,936,123	1,404.5	23.8
GA	603	468.0	32,041.7	1,194,605	2,552.6	26.8
MA	779	457.0	26,041.9	950,560	2,080.0	27.4
DC	1,212	914.0	44,858.7	1,609,920	1,761.4	27.9
CA	648	444.0	26,133.3	769,231	1,732.5	34.0
PA	848	613.2	38,203.1	1,089,824	1,777.3	35.1
NJ	1,704	1,188.0	82,637.2	2,346,567	1,975.2	35.2
PA	1,098	874.0	43,083.9	1,196,965	1,369.5	36.0
IL	1,627	1,244.9	64,673.1	1,642,075	1,319.0	39.4
CO1	598	439.4	32,485.5	812,336	1,848.7	40.0
MD ¹	630	401.0	21,774.8	463,002	1,154.6	47.0
OH ¹	614	387.0	26,792.6	561,600	1,451.2	47.7
FL Modified	547	374.0	29,365.8	561,000	1,500.0	52.3
ТХ	1,050	807.8	45,090.5	776,051	960.7	58.1
MN	792	463.0	32,207.4	510,112	1,101.8	63.1
ТХ	447	361.0	23,160.7	333,219	923.0	69.5
IL	473	239.4	22,192.4	313,073	1,307.7	70.9
CA	1,891	1,442.0	86,856.7	989,800	686.4	87.8
FL	547	374.0	29,365.8	321,190	858.8	91.4
OR	568	350.0	26,622.6	220,368	629.6	120.8
WA	976	577.6	40,489.6	303,311	525.1	133.5

¹ Agency participated in the Peer Review

Table 8.14 2000

State	VOMS	Vehicle Maintenance Employees	Annual Vehicle Miles (000s)	Labor Hours for Inspection and Maintenance	Labor Hours per Empl	Vehicle Miles per I&M Hour
NY	3,840	2,829.7	115,202.7	4,876,065	1,723.2	23.6
CA	606	439.0	24,529.7	905,209	2,062.0	27.1
PA	1,132	894.0	42,623.3	1,512,654	1,692.0	28.2
GA	580	459.0	31,852.9	1,119,544	2,439.1	28.5
DC	1,179	806.0	42,168.0	1,456,541	1,807.1	29.0
MA	769	445.0	26,032.2	788,333	1,771.5	33.0
ТХ	441	362.0	22,291.8	642,554	1,775.0	34.7
NJ	1,682	1,218.0	82,148.0	2,336,468	1,918.3	35.2
IL	1,577	1,354.9	62,758.7	1,610,572	1,188.7	39.0
PA	848	575.7	36,423.0	873,525	1,517.3	41.7
MD ¹	649	403.2	21,597.4	467,163	1,158.6	46.2
FL Modified	530	364.0	27,871.1	546,000	1,500.0	51.0
ТХ	1,017	807.0	43,230.9	803,239	995.3	53.8
OH ¹	619	387.0	27,317.8	501,280	1,295.3	54.5
CO1	639	443.4	33,875.4	601,549	1,356.7	56.3
MN	785	460.0	32,238.2	513,975	1,117.3	62.7
IL	477	222.8	21,281.4	316,730	1,421.6	67.2
FL	530	364.0	27,871.1	401,562	1,103.2	69.4
CA	1,888	1,704.0	92,451.4	1,120,305	657.5	82.5
OR	570	353.0	26,554.4	213,033	603.5	124.6
WA	931	570.6	40,040.2	301,546	528.5	132.8

¹ Agency participated in the Peer Review

Miami-Dade Transit's future planning for service is currently based on projected vehicle miles. Toward that end, manpower needs must be tied to anticipated vehicle miles.

For year to year planning, to determine future labor hour needs based on current performance, projected vehicle miles for the upcoming year can be divided by the actual "vehicle miles per inspection and maintenance labor hour" achieved in the current year. Those labor hours, when divided by labor hours per employee (1,500 hours), equal the number of employees required to meet projected vehicle inspection and maintenance needs.

The process of calculating manpower needs for 2003, using 2003 projected mileage and actual 2002 vehicle miles per inspection and maintenance labor hour is illustrated below.

2003 Projected Vehicle Miles	1	1,500 Hours	_	Employees Beguired for
2002 Actual Vehicle Miles per	1	1,500 Hours	-	2003
I&M Hour				2003

When actual data are incorporated, the following calculation shows that 403 employees rather than 378 employees are required to meet the projected 2003 manpower needs. The revised methodology identified a need for 25 additional inspection and maintenance employees.

Since this process relies on an accurate accounting of the current year prior to projecting actual manpower needs, an alternative to this process is the use of an average of vehicle miles per inspection and maintenance hour for the last several years. As an example, planning for 2003 could be based on the average of years 2000 through 2002:

	Veh Miles per		
Year	I&M Hr		
2002	53.1		
2001	52.3		
2000	50.1		
Mean	51.8		

Calculation of manpower needs for 2003, using 2003 projected mileage and an average of the actual 2000 through 2002 vehicle miles per inspection and maintenance labor hour is illustrated below.

2003 Projected Vehicle Miles	Employees 1,500 Hours = Required for
(2000+2001+2002 Actual Vehicle Miles per I&M Hour) / 3	2003

When actual data are incorporated, the following calculation shows that 413 employees are required to meet the projected 2003 manpower needs.

32,075,895	,	1,500 Hours	_	413 Employees	
51.8	1	1,500 110015	-	for 2003	

which methodology Based on is incorporated, achieving a level of inspection and maintenance hours based on 1,500 hours of productive time employee involved for each in inspection and maintenance would result in the need for 403 to 413 employees for 2003.

Incorporating a productivity standard of 1,500 productive hours per inspection and maintenance employee results in the following "vehicle miles per employee" estimates.

	Actual Vehicle Miles per	Projected Vehicle Miles per
Year	Employee	Employee
2005		75,709
2004	75,709	84,857
2003	84,857	79,581
2002	79,581	78,518
2001	78,518	76,569
2000	76,569	

In this model, future years are based on actual mileage achieved during past years. In this case, this is equivalent to using a moving average of the past three years. This approach puts more weight on recent actual mileage, smoothes out short-term fluctuations, and highlights longer-term trends or cycles of actual mileage. Furthermore, allows accounting it for faster convergence to optimal manpower should the proposed levels. methodology be applied on a yearly basis (this assumes that actual mileage will level off to a constant optimal level).

It is significant to note that the current use of 155,400 miles per bus technician is significantly higher than the miles per employee obtained under the current scenario. In addition, bus technicians comprise only one classification of those employees who are included in the Inspection and maintenance labor hour category (061).

The current method of calculating bus technician needs yields the following requirements for technicians.

Year	Annual Vehicle Miles	Miles per Technician	Technicians Required
2005	38,012,000	155,400	245
2004	36,037,702	155,400	232
2003	32,075,895	155,400	206
2002	30,559,197	155,400	197
2001	29,365,753	155,400	189
2000	27,871,134	155,400	179

It appears that bus technicians comprise 48-54% of the inspection and maintenance workforce. Assuming that bus technicians would continue to comprise slightly above half of the inspection and maintenance positions, projected technician requirements using the revised methodology are presented below.

Year	Annual Vehicle Miles	Miles per Technician	Technicians Required	Actual I&M Employees	Techs % of Total I&M	Projected I&M Employees	Projected Technicians
2005	38,012,000	155,400	245		50.9%	502	255
2004	36,037,702	155,400	232	476	48.7%	425	207
2003	32,075,895	155,400	206	378	54.6%	403	220
2002	30,559,197	155,400	197	384	51.2%	389	199
2001	29,365,753	155,400	189	374	50.5%	384	194
2000	27,871,134	155,400	179	364	49.3%		
Mean					50.9%		

The required number of positions for each of the classifications within the group of inspection and maintenance employees could be prorated in a similar manner. Classifications included within the inspection and maintenance labor category are as follows:

Working supervisors, lead workers, inspectors, service personnel, apprentices, greasers, mechanics, welders, major component repair staff, electricians, bench hands, machinists, coil winders, sheet metal workers, sanders, painters, body workers, upholsterers, glass installers, carpenters, blacksmiths, others **engaged in repair**,

maintenance and inspection activities for revenue vehicles

Advantages of using this methodology extend beyond the ability to identify appropriate levels of manpower to fulfill inspection and maintenance needs. Inspection and maintenance positions can be prorated by classification type; MDT can compare system performance and maintenance effort with that of other agencies, and a measure of productivity is incorporated into all inspection and maintenance positions, not just bus technician positions.

requirements for Employee maintenance administration (041), (051), vehicle servicing revenue revenue vehicle accident repair (062), and revenue vehicle vandalism repair (071) could be established using factors such as shift coverage levels and/or work loads rather than mileage-based parameters.





9. Findings

9.1 Best Practices

- Management sought and received employee feedback concerning preferred incentives and benefits to increase employees' effectiveness.
- MDT promotes a cooperative working environment between bus maintenance personnel and bus operators through feedback in problem diagnosis.
- MDT has a written maintenance program and a Bus Maintenance Procedures Manual. Both items are updated regularly by bus maintenance control with assistance from support services, bus maintenance, and FESM.
- MDT uses a three-tiered approach to bus maintenance.
- Performance measures and indicators are in place to assist MDT in achieving identified objectives.
- MDT currently lacks adequate training resources for all levels of staff.
- The Pilot Apprenticeship Program initiated in 2003 provided the first graduates to MDT in the fall of 2005.
- MDT contracted with Florida International University (FIU) to complete a Times Standards Study within bus maintenance.
- While MDT has developed agency-specific objectives and actively strives to meet the objectives, the objectives focus almost exclusively on fleet maintainability.
- MDT's current existing workplace design throughout the maintenance shops limits bus maintenance productivity.
- Lack of routine facility and specialized equipment maintenance negatively impacts bus maintenance activities.
- While MDT has no written policy on specialization, some maintenance technician positions are specialized in the sense that they are "pick positions" that require specialized skills to be accomplished successfully.
- The maintenance division has no specific policy that directs the supervisor's degree of oversight and/or control of assigned staff.



- MDT is in the process of making significant improvements to the established Preventive Maintenance Inspection (PMI) program.
- MDT operates a relatively new, somewhat homogeneous fleet.
- MDT is struggling with adapting to the change required by significant growth of the fleet in response to expanded service mandates.
- Supervisors focus almost exclusively on meeting peak requirements, which precludes them from looking beyond the current duty shift.
- In terms of the use of advanced technology, MDT has integrated the use of laptop computers for diagnostics. Other functions, such as repair orders and fleet status, are completed and tracked manually.
- The impact of a harsh summer climate on the fleet is a major obstacle to MDT in maximizing the efficiency of bus maintenance operations.
- Information sharing with peer agencies is limited.

9.2 Peer Review

- The selection of peer agencies was based on three comparative analyses and yielded the Maryland Transit Administration in Baltimore, Maryland (Baltimore); the Regional Transportation District in Denver, Colorado (Denver); and, the Greater Cleveland Regional Transportation Authority in Cleveland, Ohio (Cleveland) as the most similar peers.
- Miami vehicles logged more miles per vehicle operated in maximum service (VOMS) than Baltimore, Cleveland, and Denver during the 2000-2004 period of study.
- Miami reported the largest number of full-time vehicle maintenance employees in 2004 as compared to the peer agencies. Only Miami and Baltimore 2004 full-time vehicle maintenance employee levels exceeded those of 2000.
- Despite the commitment of record maintenance hours (Miami was the only agency of the four that showed an increase in 2004 vehicle employee work hours in comparison to 2000), Miami achieved fewer passenger miles per vehicle employee work hour than Baltimore and Denver, fell below the 2004 average of the four agencies and showed a 20% decline in performance in 2004 compared to Miami's performance in 2000.
- Miami's total system failures per VOMS exhibited a clear downward trend decreasing from 35.6 failures per VOMS in 2000 to 19.8 failures in 2004, a 45.5%



reduction. Nonetheless, Miami reported nine times more failures per VOMS than Denver, five times more than Cleveland, almost four times more than Baltimore, and over two times the average of the four properties.

- Annual vehicle revenue miles per total system failure were calculated to examine vehicle performance at the four agencies. All agencies displayed considerable improvement in performance from 2000 through 2004, with average revenue mileage growth per failure of over 200%. Miami increased the number of miles between failures from 1,283 miles to 2,375 miles, an 85% improvement. While Miami's increase is significant, it fell well below the 283.3% and 518.7% growth in revenue miles between failures at Denver and Baltimore, respectively.
- In 2004, Baltimore logged three times more revenue miles between failures than Miami; Cleveland logged four times as many; and, Denver reported nine times as many.
- Only Baltimore and Miami showed growth in annual vehicle miles. Since 2003, Miami has logged more vehicle miles annually than each of the peer agencies.
- In 2004, while Miami's vehicles available for maximum service declined, VOMS increased by 31%, suggesting that Miami improved fleet utilization.
- Despite Miami's 2004 growth in inspection and maintenance labor hours per VOMS (29.2% growth versus 2003), Miami provided fewer inspection and maintenance labor hours per VOMS than the peer agencies and was 18.1% below the average of the four agencies.
- Bus operators' involvement in problem diagnosis was found to be relatively minimal among the peer transit agencies. Baltimore bus operators attend monthly bus safety meetings and complete pre-trip inspections. Cleveland bus operators rarely use bus defect cards, and Denver reported minimal operator input. Cleveland has a Problem Identification and Corrective Action (PICA) program, which encourages employees to identify problems in any area. Denver has regular staff meetings, quarterly supervisor-management meetings, and an "open-door" policy.
- While peer agencies indicated that they do not have written maintenance plans, Baltimore technicians are exposed to written maintenance procedures during the formalized training process. Cleveland has written procedures for specialized areas. Denver's procedures in the bus maintenance plan focus on management functions.
- Baltimore has undertaken the development of work standards. Cleveland has developed "in-house" guidelines, and general efforts at Denver include its focus on mechanic training and certification programs.



- Baltimore's MAXIMO system will be utilized to track individual employee's training certifications. All mechanics attend brake training school. In addition to brakes, current in-house training includes engine diagnostics and OEM-sponsored training. Baltimore offers the ASE certification program, which allows maintenance employees to ultimately achieve the level of master technician. A pay increase is associated with this achievement. Technicians must recertify at the master level every five years. At Cleveland, a grading system for training functions somewhat like an apprenticeship program. Cleveland also conducts "train the trainer" sessions for in-house training. Denver has an extensive training program that is tied to employee advancement. Mechanics enter at the bottom of a 6-step pay scale. As training and certification are completed, employees move up in pay. Certification is a two-step process, which includes written and applied components.
- Baltimore, Cleveland, Denver, and Miami include vendor training packages with new bus procurement contracts.
- Baltimore maintenance staff met with local junior colleges about cooperative training for existing employees.
- Each of the three peer agencies indicated it had developed and used performance measures that are guided by the agency's overall objectives. Such performance measures are incorporated into the agency's decision-making process, with respect to developing planned policies, procedures, rules, and programs. Common performance measures among the agencies included: on-time performance, vehicle availability in peak service, PMI on-time adherence, and miles between mechanical road calls.
- Both Baltimore and Cleveland have older facilities located in crowded urban areas, which offer little room for expansion. Cleveland is in the process of modernizing some of its facilities, and a new maintenance facility is under construction. In contrast, bus maintenance facilities in Denver, a region which has experienced tremendous growth over the past few decades, tended to be newer and specifically designed for the tasks at hand. The oldest shop among the Denver facilities was built in 1977. Shops are updated regularly, and there is considerable space for expansion, if necessary.
- In terms of specialization, Baltimore has three degrees of union-level repairmen, i.e., "A," "B," and "C." Only "A" level repairmen are allowed to diagnose problems. Cleveland and Denver also use a combination workforce.
- Denver had a slightly higher supervisor to technician ratio than Miami, Baltimore, and Cleveland.



- Baltimore, Denver, and Miami were centrally managed, while Cleveland operated under a district management concept.
- Baltimore, Cleveland, and Denver were at varying stages in integrating computer technology into their bus maintenance programs for reporting, tracking, cost-benefit analysis and report generation.
- A significant difference in the structure of the peer agencies was in the nature of the technicians' advancement. Baltimore and Denver developed tenure and certification requirements for advancement to higher level positions with additional compensation. Cleveland required proficiency for assignment to specialized shops. Miami relied exclusively on seniority for advancement.
- Although customer satisfaction surveys may potentially be an indicator of employee productivity, neither Miami nor the peer agencies had information from customer surveys that directly related to the bus maintenance program.

9.3 MDT Bus Maintenance

- Communication methods and frequency vary by shop and are influenced by a variety of factors. Regular communication between bus maintenance and bus operators appeared to be based on proximity with increased communication occurring at locations with the closest proximity of the two groups of employees. Communication between shops, within shops, and with support services and FESM was irregular at best.
- An important goal that was identified by the Bus Maintenance Implementation Team was making problem-solving more proactive by increasing the amount of time shop supervisors spent on the shop floor with bus technicians.
- Bus maintenance control provides critical support to bus maintenance.
- Bus triage the process of prioritizing buses requiring maintenance and optimizing the order of repairs was highly variable and especially dependent on the skill level of individual supervisors.
- The manner in which bus defect cards were submitted and processed was found to be variable and less efficient than it should be.
- Direct supervision of and communication with hostlers was reported to be minimal.
- Bus maintenance staff and vehicles were equally distributed among the four divisions with the exception of the Medley division, which was smaller and responsible for fewer vehicles than the other divisions. The Medley division was



managed by a project manager pursuant to the Miami-Dade County/Penske Trucking contract.

- Miami bus maintenance supervisors generally agreed that bus operator training for wheel chair lifts was inadequate.
- There was an ongoing debate about whether or not to assign each service truck to a specific geographic area.
- Bus maintenance supervisors generally agreed that the benefits of using laptop computers for bus maintenance procedures outweighed the problems. Problems that were identified included: incompatibility with connections on newer buses, insufficient storage space for recharging, lack of proficiency on the part of technicians, durability in the harsh maintenance environment, and maintaining the latest software updates.
- A minimum tool requirement for bus technicians negatively impacts productivity; general tool practices vary within the agency; and, a lack of specialty tools at the shops impedes efficiency.
- Supervisors at only one facility identified attempts to use manpower data for employee productivity purposes. Maintenance management staff applied such information to improve morale among new employees by assigning work of specific interest.
- Within bus maintenance, over the past three years, absenteeism for technicians, hostlers, helpers, and supervisors ranged from 14.6% to 19.6%.
- Some supervisors reported that retrofits commonly lacked extensive procedural documentation. As such, in the event that a knowledgeable employee leaves the agency, specific retrofit details stand a good chance of being lost.
- Shop-specific data collection efforts conducted by the O&I shops were infrequent and sporadic. Some bus performance data were collected on an informal basis and minimally documented. Data were rarely used to evaluate the impact of remedial actions.
- Warranty work was a frequent cause for buses to be taken out of service. The removal of vehicles to an off-site location for the warranty work further compounded the loss of the vehicle.
- "Buses down for parts" was one of the most serious issues facing bus maintenance, regardless of shop.



- MDT was in the process of evaluating the structure and focus of the "unit room."
- Some areas encountered difficulty with seasoned supervisors who were resistive to change, particularly in the use of computers and advanced technology.
- Supervisors have become accustomed to inspecting vendors' work closely. Many vendors have experienced high turnover rates, resulting in inadequately trained technicians producing less than acceptable work.
- Two past reporting efforts that were slated to be re-introduced include the Unit Room Production Report and the Engine Reliability Report.
- MDT now allows buses to return to service with defects identified during a PMI as long as the defects are not safety defects.
- Some decline in bus availability was noted at all shops in FY 2005.
- No significant differences in areas, such as parts use and fleet performance, were noted among the shops.

9.4 MDT as a Top-20 Transit Agency, 2000-2004

9.4.1 Ranking: Performance Data

- Expanded service in terms of vehicle revenue miles and hours along with increased unlinked passenger trips moved MDT into top-10 rankings in the service area.
- While manpower efforts continued to fall below top-10 rankings, the increases in inspection and maintenance labor hours and full-time employee work hours were positive.
- MDT ranked 12th in terms of vehicles operated in maximum service in 2004 compared to 18th in 2000.

9.4.2 Ranking: Performance Indicators

- Unfortunately, positive growth in the fleet, recent increases in manpower, and expanded service were accompanied by a shift in ranking from 8th to 5th for total system failures.
- Not only did MDT consistently report more failures per vehicle operated than other top-20 agencies, but also MDT logged the fewest revenue miles between failures. In terms of fleet reliability, MDT performed at a less than satisfactory level.



- MDT ranked 10th-13th in full-time employee work hours per VOMS during 2000-2002 and then moved to 4th in 2003 and 2nd in 2004, which represents a significant increase in manpower allocation. Nonetheless, MDT's ranking for inspection and maintenance hours per VOMS increased only slightly in 2004 (from 16th-17th in 2001-2003 to 13th), and the increase in ranking was only modestly better than the ranking of 14th in 2000. Furthermore, the relationship between MDT's inspection and maintenance labor hours to total labor hours ranked 16th, essentially remaining unchanged throughout the reporting period. The increases in manpower produced little, if any, increase in vehicle inspection and maintenance, which calls in to question workforce productivity.
- MDT ranked between 1st and 4th in the relationship between VOMS and VAMS throughout 2000-2004, indicating significant use of the available fleet.
- MDT ranked between 1st and 3rd in Vehicle Miles and Hours per VOMS throughout the reporting period, which indicates that MDT generally operates vehicles for more hours and more miles than most other top-20 agencies.
- When revenue hours and miles are viewed as a percentage of total hours and miles; however, MDT's ranking falls to 6th and 8th, indicating that MDT's vehicle hours and vehicle miles are less efficient than some of the other agencies.
- While MDT ranked 9th in unlinked passenger trips per VOMS, which was similar to previous rankings, MDT's ranking for passenger miles per VOMS moved from 2nd in 2003 to 6th in 2004, despite increases in revenue miles and hours per VOMS. It appears that increased revenue miles and revenue hours were not accompanied by increased passenger miles.
- MDT's vehicle maintenance cost per revenue mile ranked 17th (from 14th in 2001 through 2003) for the first time since 2000. MDT's maintenance cost per revenue mile was less than 16 other top-20 properties in 2004.

9.5 Metrobus Equipment Performance by Fleet Type, FY 2004-2005

- The NABI 02 buses, which represented 11.2% of the FY 2005 fleet, consistently provided the largest percentage of miles throughout FY 2004 and FY 2005, until September 2005. The NABI 02 was followed by the NABI 03 (10.2% of the fleet in FY 2005) and the NABI 04, which entered service in October 2004 and accounted for 11.2% of the fleet.
- The NABI 99 (9.5% of the fleet) and the NABI 00 (9.8% of the fleet) recorded the largest percentages of road calls throughout FY 2004 and FY 2005, until September 2005. In September 2005, the NABI 02 logged the largest percentage of road calls.



- The newer NABIs, i.e., NABI 02 through NABI 05, appeared to be the most efficient fleet types.
- The NABI 98 showed improvement beginning in late FY 2004 that remained relatively consistent throughout FY 2005.
- The NABI 99 and NABI 00 displayed inefficient performance throughout the entire reporting period and shared that category with the older Artics and Flxibles.
- The overall performance of the minibuses appeared to be good; although, the efficiency of the Optare 03 declined in mid FY 2005.
- In FY 2005, the NABI 02 and NABI 03 logged a smaller percentage of miles but a larger percentage of road calls.

9.6 Metrobus Equipment Performance by Fleet Type by Division, FY 2004-2005

- The Artic 94 performed similarly at Central Bus and Coral Way. Only in January 2004, did the percentage of road calls fall below the percentage of miles, and that occurred at Central Bus.
- The Artic 95, which operated only out of Central Bus, showed improvement in July 2005, as the percentage of road calls fell to its lowest level.
- The Flx 90 was operated at Central Bus and Coral Way for only two to three months. Data from the two facilities were sparse but appeared to be consistent.
- Specific mileage and road call data for the Northeast Facility in FY 2004 were unavailable.
- The Flx 93c performed slightly better at Central Bus than at Coral Way and Northeast.
- Only Northeast operated the Flx 9350, Flx 9411, and Flx 9450. The percentage of road calls consistently exceeded the percentage of miles for the three fleet types.
- Throughout FY 2004, the NABI 97 fleet performed slightly better at Central Bus than at Coral Way. In 2005, some improvement in terms of the relationship between the percentage of miles and road calls for the NABI 97 was noted at all three facilities.
- The NABI 98 fleet, which had performed slightly better at Coral Way than Central Bus, was moved to Medley in April 2004. NABI 98 performance at Medley was, at



best, inconsistent, with the percentage of road calls exceeding the percentage of miles during the last thirteen months.

- Improvement in NABI 99 performance was noted primarily at Central Bus and Northeast. Early positive performance at Coral Way in FY 2004 deteriorated until June 2005, at which time slight improvement was noted.
- Despite two rather high road call percentages reported by the NABI 00 at Medley in the summer of 2004, the NABI 00 fleet at Medley achieved a slightly better percentage of miles to road calls than at Central Bus and Coral Way in FY 2005.
- The NABI 02 percentage of miles exceeded the percentage of road calls at Central Bus, Coral Way, and Northeast during all months except one. In September 2005, the NABI 02 percentage of road calls exceeded the percentage of miles at Coral Way.
- There were four months during which the percentage of road calls exceeded the percentage of miles for the NABI 03. Three of the four instances occurred at Coral Way in April 2004, July 2005, and August 2005. The fourth instance was recorded in March 2005 at Northeast. There were no occasions identified where the NABI 03 percentage of road calls exceeded the percentage of miles at Central Bus or Medley.
- Despite the fact that the percentage of miles exceeded the percentage of road calls at all locations during all months, the rate of road calls for NABI 04 buses shows a gradual upward trend in the 12-month period of operation.
- There is insufficient information on the NABI 05 buses that were operated slightly more than two months at Central Bus, Coral Way, and Northeast to draw any conclusion.
- The Minibus BB 99 fleet was transferred from Coral Way to Medley in April 2004. The percentage of road calls exceeded the percentage of miles at Medley during 16 of 18 months with little improvement at the end of FY 2005.
- Central Bus and Northeast appeared to be less successful than Coral Way and Medley in maintaining a higher percentage of miles than road calls with the Minibus BB 01.
- Central Bus and Coral Way operated Minibus BB 02 fleets fairly consistently. Coral Way achieved a few more months where the percentage of miles exceeded the percentage of road calls for the Minibus BB 02.



Central bus, Coral Way, and Northeast operated Optare 03 fleets. While the FY 2004 percentage of miles consistently exceeded the percentage of road calls for the Optare 03 fleets, FY 2005 proved to be a difficult period for all three facilities. During FY 2005, the Optare 03 percentage of road calls exceeded the percentage of miles for seven months at Central Bus, nine months at Northeast, and five months at Coral Way.

9.7 Determining Manpower Needs

- From 2000 through 2004, MDT reported fewer VOMS, fewer vehicle maintenance employees, and fewer annual vehicle miles than the average of the top-20 transit agencies studied.
- MDT recorded more vehicle miles per employee (12.6% to 22.4% above the average) and more vehicle miles per employee per VOMS (25.0% to 46.4% above the average) than the average of the top-20 agencies. This indicates that MDT's ratio of employees and VOMS to vehicle miles logged was lower than the average.
- MDT reported fewer labor hours for inspection and maintenance (16.1% to 67.9% below the average), fewer labor hours per VOMS, and fewer labor hours per employee (25.9% to 71.9% below the average). Not only was MDT's ratio of employees to vehicle miles and VOMS lower than average, MDT's employees produced fewer hours than those produced on average by the top-20 transit agencies.
- Combined, these factors accounted for MDT reporting more vehicle miles per labor hour (19.5% to 46.3% above the average) than the agencies' average.
- The analysis of the 2000-2004 NTD data clearly shows that MDT is a top-20 agency that has expanded service at record levels in the past five years. Nonetheless, the analysis also shows an agency that is falling behind in maintenance performance, which is compounded by the impact of the high mileage accumulated annually by the vehicles.
- While, in 2004, MDT did restore labor hours allocated to each vehicle operated in maximum service to the 2000 level, the 2004 labor hours per VOMS remained 16% below the average of the top-20 agencies. In addition, labor hours per employee, which were 72% below the top-20 average in 2003, did improve and fell to only 26% below the top-20 average in 2004.
- The June 2003 Manpower Study concluded that each maintenance mechanic could provide 1,554 productive manhours annually. However, an analysis of the inspection and maintenance labor hours from 2000-2004 indicates productivity of



only 824 to 1,103 hours per employee a year, while the top-20 agency average was 1,336 to 1,407 hours per employee a year.

- Since it appeared that the June 2003 methodology needed to be modified to incorporate productivity into the manpower calculation, 2000-2004 data were recalculated, using a reduced productive annual manpower figure of 1,500 manhours (more closely resembles manhour levels used in Metrorail and Metromover). Additional manhours ranging from 144,000 to 268,000 could have been available annually had labor hours per employee reached 1,500 hours.
- Increasing employee productivity to 1,500 hours per year would reduce the number of vehicle miles per inspection and maintenance hour from a range of 71.3 - 107.4 miles to a range of 50.5 - 56.6 miles, a significant improvement. Improved productivity would also place MDT in a more competitive position with the top-20 agencies.
- For year to year planning, to determine future labor hour needs based on current performance, projected vehicle miles for the upcoming year can be divided by the actual "vehicle miles per inspection and maintenance labor hour" achieved in the current year. Those labor hours, when divided by labor hours per employee (1,500 hours), equal the number of employees required to meet projected vehicle inspection and maintenance needs.
- It appears that bus technicians comprised 48-54% of the inspection and maintenance workforce. The required number of positions for each of the classifications within the group of inspection and maintenance employees could be prorated in a similar manner.
- Advantages of using this methodology extend beyond the ability to identify appropriate levels of manpower to fulfill inspection and maintenance needs. Inspection and maintenance positions can be prorated by classification type; MDT can compare system performance and maintenance effort with that of other agencies, and a measure of productivity is incorporated into all inspection and maintenance positions, not just bus technician positions.
- Employee requirements for maintenance administration, servicing of vehicles, as well as accident and vandalism repair could be established using factors such as shift coverage levels and/or work loads rather than mileage-based parameters.



10. Phase Two Recommendations

- Make the Phase One Final Report, *Analysis of Concerns and Attitudes held by MDT Bus Operators and Maintenance Personnel Regarding Current and Potential Benefits, Incentives, and Conditions* available to employees and implement recommendations.
- Formalize bus operator feedback in problem diagnosis. Components of a successful program might include the following types of activities:
 - Establish a team effort at every shop to oversee the program and establish program objectives and performance indicators.
 - Maintain an official record of pre-trip inspections, bus defect cards, and road calls.
 - Track the nature of problem, location, bus operator, date and technician for the last PMI, date and technician for the last repair, and the resolution of the problem.
 - Report progress to bus operators and maintenance staff on a monthly basis.
 - Create a specialized training program for bus operators that includes common terminology, frequent problems, and troubleshooting tips.
 - Mandate problem diagnosis training as part of the orientation program for new bus operators and maintenance staff and provide an annual refresher course.
- Update the written Maintenance Program and the Bus Maintenance Procedures Manual. Prepare official copies for each bus maintenance employee and require a signed receipt. Establish a mechanism for ongoing update and distribution of the documents, perhaps at Toolbox Safety Meetings.
- Review existing agency-specific objectives for bus maintenance and update them to ensure they are measurable, time limited and appropriate to MDT's conditions and needs. These objectives will form the basic elements of the management plan. Once the plan is in place, establish performance indicators to measure progress by shop and by department.
 - While meeting peak vehicle requirements is a significant goal within bus maintenance, it is only one of many goals required to operate a successful bus maintenance operation. Commonly accepted effective measures include on-time performance for meeting peak vehicle requirements, adherence to PMI



schedules, equipment standardization, operator involvement, and customer acceptance.

- Conduct an inventory of training needs for all levels of staff and coordinate the training program with human resources.
 - Prior research has shown that well-trained maintenance employees are happier and take greater pride in their work. The results of the MDT employee survey conducted for Phase One found that MDT maintenance employees were very interested in additional training opportunities.
 - Technology is advancing rapidly. MDT should ensure that manuals and other graphic job aids are available to maintenance personnel for personal reference and should make certain that maintenance personnel are aware of their existence and location. Further, MDT should consider making these materials available electronically and provide in-shop access to employees.
 - Establish training resources within the shops. Review the use of existing office space or consider using mobile or portable facilities. Ensure training space availability is one of the criteria for new maintenance facilities.
 - Implement creative training measures, such as periodic lunchtime seminars, videos, and use of the intranet. Use a simple method for tracking attendance/participation and verifying comprehension (brief tests). Create incentives for employees (monetary, gift, reward, other) who participate. Consider providing online training that can be done at home or after the regular work day. Employees could participate at their leisure and work toward a goal or reward.
 - Establish or assign in-shop instructors. Rather than an informal approach that consists of referring one employee to another, develop a formal plan to recognize selected technicians as certified in-house trainers. This approach will also help to bridge the gap that occurs as the best mechanics become supervisors. Instead, they will remain on floor in a technician capacity, but will be formally recognized as having expertise in certain field(s). A compensation plan could be instituted to reward expertise and encourage highly qualified technicians to remain in positions that take full advantage of their skills.
- *Immediately* modify the apprenticeship program to require completion of a CDL license, safety instruction, and EPA certification prior to graduation (Comprehensive 90-day Review Long-range Goal).



- Review Times Standards Study that was completed by FIU and incorporate time standards for bus maintenance activities where appropriate.
- Initiate a "maintenance facilities modernization initiative." Specifically, make it an agency goal to modernize maintenance facilities to meet the needs of the future. While the initiative must identify goals and objectives, it could also be seen as an ongoing process that is open-ended. Modernization efforts could include a review of available space and utilize innovative ways to create or reorganize space for specific maintenance procedures, training activities, meetings, operator-technician interaction, etc. For example, consider the use of portable buildings as training rooms, and investigate opportunities to expand existing facilities or when building/acquiring new facilities. The initiative will create guidelines for necessary things that must be included, such as wireless networks, training space, meeting rooms, lounges, and storage areas.
- *Immediately* establish a facilities maintenance program for bus maintenance that includes routine maintenance and repair of all buildings and assigned equipment (Comprehensive 90-day Review Long-range Goal).
 - Require Facilities to inspect and repair all hydraulic lifts. (Comprehensive 90-day Review Short-range Goal)
- Investigate the use of "specialty shops" to handle specific repairs or routine activities, such as PMIs, brakes, and retrofits.
- Continue ongoing work to improve the preventive maintenance inspection process to ensure timely and complete inspections of the entire fleet. Establish an acceptable method to ensure that *all defects* noted during the PMI are repaired prior to returning a bus to service.
- MDT's recent bus procurements have enabled MDT to establish a relatively new and homogeneous fleet, which affords MDT the opportunity to maximize maintenance performance, realize savings from reduced inventory needs, and require less specialized technician training. By maintaining a detailed history of performance characteristics and completing trend analyses of current functioning, MDT should be able to anticipate and, thereby, eliminate potential future problems as newer fleets come on line.
- Implement and utilize advanced technology in as many areas as possible.
 - Replace the magnetic bus status control room boards with a modern, efficient system that is able to display all relevant information and to easily perform queries and generate necessary reports. Ideally, this information would be accessible remotely. Bus maintenance control could also input reports directly



into new system. Critical activities, such as PMIs, could be automatically flagged.

- Use portable, wireless, handheld devices wherever possible to eliminate paper. Bus defect cards could be replaced with a handheld device programmed to utilize drop-down menus for defects, conditions, related factors, etc. Make units available at optimal locations for operators to use or assign a maintenance technician or clerk to field operator-identified defects.
- Use portable, wireless, handheld devices on the "hotline." Entries could be immediately transmitted to the supervisors' computer/control room. Expand the use of barcodes and readers to expedite identification and eliminate entry errors.
- Implement a streamlined method for repair orders using advanced technologies. The goal should be for data to be entered at the source of generation and as close to the time of origination as possible. Procure the most appropriate equipment to do this, i.e., handheld devices or laptop computers, which could be acquired through the bus procurement process. Although more costly, consider the use of hardened/durable equipment, which is commonly used by public safety officials.
- Provide a sufficient number of laptop computers for bus maintenance diagnostics. The laptops must be compatible with connections on newer buses, durable in a harsh environment, contain the latest software updates, and have an assigned storage and recharging location. Train technicians to become proficient in the use of the laptops.
- Utilize/install wireless networks in all repair facilities.
- Thoroughly and properly train technicians in the use of advanced technologies and to enter repair order information electronically.
- Utilize advanced technology to modernize the tracking of support service's rebuilt component inventory. Tracking could include available components, components being rebuilt, and status of rebuild.
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- Provide each body shop with a modern digital camera, including all necessary peripheral equipment.
- Use advanced technologies for communications between chiefs, superintendents, supervisors, and the general superintendent. The goal should be instant communication. Replace pagers with agency-assigned cell phones that have instant communication capabilities.



- Research cost effective methods and technology to maximize AC performance and reduce bus down time resulting from failures in AC equipment.
- Share information with peer agencies and seek out information from peer agencies when undertaking new initiatives. Take advantage of web-based programs that are transit specific, such as an on-line Web Board sponsored by the Transportation Research Board's Committee on Transit Fleet Maintenance and a variety of on-line forums established by the American Public Transportation Administration.
- Create a simple and effective customer feedback mechanism and incorporate findings, where appropriate, to improve bus maintenance operations.
- Provide training to bus maintenance supervisors.
 - Require all bus maintenance supervisors to complete a remedial bus maintenance technical program, which includes a certification process, in the near term followed by annual refresher training.
 - Require all bus maintenance supervisors to participate in a management training program for supervisors, preferably through Miami-Dade County.
 - Review and revise bus maintenance supervisor job essentials and specifications to clarify the supervisor's role and responsibilities, including the nature and level of oversight of subordinates (Comprehensive 90-day Review Short-term Goal).
 - Require each supervisor to review all PMIs and repairs completed by technicians under the supervisor's oversight. The supervisor's name and signature should be attached to all paperwork associated with PMIs and repairs completed under the supervisor's oversight to indicate the supervisor's acceptance and approval of the technician's work.
 - Provide Enterprise Asset Management System (EAMS) training for all supervisors (Comprehensive 90-day Review Long-range Goal).
- All aspects of the bus fueling system should be streamlined. There are currently three areas tasked with some aspect of the fueling system. Materials management procures the fuel, bus maintenance accepts delivery and dispenses the product, and bus maintenance control oversees the fuel management system and tracks statistical information. Immediately reassign acceptance of delivery to materials management, which will eliminate the need for the bus maintenance supervisor to leave the shop floor two to three times a shift. Create a task force to study and improve this process.



- Assign clerks to the bus maintenance shops to handle administrative tasks as soon as possible. Enlist the assistance of bus maintenance supervisors to identify their assigned duties (Comprehensive 90-day Review Long-range Goal).
- Implement the "odd day scheduled" bus maintenance clerk to work a 40-hour week, scheduled Tuesday through Saturday. The addition of this clerk will improve productivity and eliminate early week overloads for regular Monday through Friday clerks.
- Formally address the differences between bus maintenance control and Penske procedures through an action team method. Identify objectives, set goals, track progress, and work toward a reasonable solution.
- Prioritize ADA compliance.
 - Create an in-house certification process for technicians to develop expertise in wheelchair lift repair.
 - Develop a training program to educate bus operators in the operation of the various types of lifts currently in use. Components of the training program could include instructional videos, demonstrations/briefings in the dispatch area, and short training sessions. ADA training could be provided to new operators during the orientation period followed by annual refresher training for all operators. Dispatch area briefing sessions could be held on an ongoing weekly or bi-weekly basis. Consider incorporating a certification process into the program.
 - Document all activities and training related to ADA compliance.
- Identify all repeat failures by garage and vehicle type. Implement an auto-response mechanism that flags repeat failures and calls repeat failures to the attention of supervisors, chiefs, and superintendents.
 - Track the nature of the repeat failure, location, bus operator, date and technician for the last PMI, date and technician for the last repair, and the resolution of the problem.
- Establish a cooperative relationship with Field Engineering & System Maintenance and bus maintenance control to troubleshoot parts failures.
- Revise the tool policy in bus maintenance to mirror existing policies at rail and mover.
- Consider incorporating performance factors into contracts for parts, rebuilt components, and warranty work. Determine the cost to the agency of the vendor's



failure to perform a service or deliver a product on-time as requested. Establish performance factors up front to minimize the negative impact to the agency. Continued failure on the part of the vendors to perform in the agreed upon manner could result in a reduction in costs to the agency or the loss of agency business on the part of the vendor. Denver was quite successful in developing a vendor rating mechanism that enhanced vendor performance.

- Take active steps to improve employee attendance. Reissue employee guidelines regarding attendance to all bus maintenance employees. Provide a refresher course for all supervisors and managers that includes attendance guidelines, approved actions for dealing with frequent absences, and a summary of each employee's status. Each manager/supervisor should meet with assigned subordinates, review attendance patterns to date, and reiterate agency guidelines. Employees with perfect attendance over a specified period of time should be acknowledged.
- Implement goals identified by the Comprehensive 90-day Review. MDT could benefit from incorporating most of the mid-range and long-range goals in the near term. Provide employees with continual status reports of progress to date and incorporate changes in the maintenance plan.
- Continue the efforts of the Bus Maintenance Implementation Team. As with the Comprehensive 90-day Review, provide employees with continual status reports of progress to date and incorporate changes in the maintenance plan.
- Incorporate productivity standards into the calculation of manpower requirements for vehicle inspection and maintenance.
- MDT needs to establish and monitor performance metrics for bus maintenance beyond the percent of the fleet that makes daily "pull-out." Struggling to have a sufficient number of vehicles available daily is a symptom of the maintenance operation that results from a combination of all of the findings discussed earlier in the report. Establishing a few essential performance metrics and working to improve results in the areas recommended in this report will serve to move the agency to a very efficient and effective bus maintenance operation. If undue priority is placed only on making pull-out, many old practices will continue that will subvert the improvement of the operation.



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