Miami-Dade Transit

"Materials Management – Analysis and Recommendations"

Center for Urban Transportation Research
University of South Florida

November 16, 2004

Table of Contents

List of Tables and Figures

Executive Summary

Miami-Dade Transit requested that the Center for Urban Transportation Research at the University of South Florida (CUTR) study and analyze the inventory levels of Miami-Dade Transit. The purpose of this analysis was to determine if inventory levels were comparable to other transit properties of similar fleet size and composition. The analysis was expected to result in recommendations for inventory improvements and performance goals to include: feasible reductions of existing inventory, identification of excess material, changes in inventory quantities purchased, and recommendations on inventory levels.

This project was performed under the existing interlocal agreement between Miami-Dade County and the University of South Florida.

Findings & Final Recommendations
Pending
Steering Committee Work Session
And Agreement

I. Introduction

Miami-Dade Transit (MDT), one of the largest departments of Miami-Dade County government, the 16th largest public transit system in the country, and the largest transit agency in Florida, is responsible for marketing and providing all public transit services in the County. This integrated transportation system consists of four major components: Metrobus fleet, providing service 24 hours per day and connecting most areas of Miami-Dade County; Metrorail, an electrically powered, elevated rapid transit system stretching over 22 miles, from Dadeland through Hialeah to the Palmetto Expressway in Medley; Metromover, a 4.4-mile elevated people mover system that serves Miami's downtown Central Business District, including Omni and Brickell; and, Paratransit, which provides two services: Medicaid Transportation and Special Transportation Services (STS).

To support an operation of this magnitude, a significant effort in the management of parts and materials is required. This responsibility within Miami-Dade Transit rests with the Materials Management Division. The Division operates eight warehouse and storeroom locations, which vary in size from 5,000 to 30,000 Sq. Ft.

There are 98,265 line items in inventory, which consist of a wide selection of electronic, mechanical, and chemical commodities. These are spare parts for the Metrorail, Metromover, Metrobus, Communications, Traction Power, Train Control, and Facilities Maintenance Divisions. The inventory value contained at all facilities exceeds $20 million.

Miami-Dade Transit requested that CUTR conduct an analysis of the current inventory and provide recommendations for inventory improvements and performance goals. This report contains the results of the analysis and the recommendations.

II. Study Approach

An oversight committee was established for the project that included the Chief of the Division of Materials Management as the chair with members that included several of the Division's key personnel, and a representative from each of the following areas:

- Rail Maintenance Division
- Bus Maintenance Division
- Facilities Maintenance Division
- Field Engineering
- Information Technology
- Other functional representatives the Chief designates as appropriate

As a part of the project initiation effort, CUTR began an effort to collect data and document the relevant MDT material management processes and systems. A project initiation meeting with the Oversight Committee was held early in the study to familiarize participants with the nature and scope of the study and to obtain members' assistance and participation in data analysis and decision-making processes. Input from the Oversight Committee was critical in the determination and selection of three peer properties where site visits were conducted to collect relevant information on inventory types and values along with relevant procedures employed for inventory valuation.

A review of best practices was undertaken, and a thorough literature review was conducted. The review included the transit industry and other related industries. In addition, emerging trends in the general area of materials management were researched and documented for presentation to the Division and the Oversight Committee.

III. Literature Review

Inventory represents a significant portion of assets in a transit agency. Effective management of inventory revolves around an ongoing attempt to provide maximum parts availability while keeping inventory investment low. These two objectives often conflict with one another. Accurate and reliable data are necessary to make decisions that will maximize the operating environment and minimize costs. Many inter-related issues exist, some not as obvious as others, and their effects must be considered as a whole. Inventory-related decisions, including budgeting, operating, and other management issues, can only be effective when the location and amount of stored items is properly known.

Prior research illustrates the importance of cooperation among divisions within an agency to achieve a well-managed inventory system. Specifically, a strong relationship between inventory control, parts procurement, and fleet operations and maintenance commonly results in increased efficiency. Advancements in technology, especially computerized and automated systems, often play a big role in achieving desired productivity improvements. Additional methods and concepts have been investigated with respect to better managing, evaluating, and understanding inventory. Studies also suggest that as the role of an inventory management operation progresses from one that is reactive through one that is proactive, the pinnacle of efficiency is attained when a strategic role has been realized.

This study intends to compare MDT's inventory management with peer agencies. The following chapter is organized to look at relevant issues that impact inventory or materials management at transit agencies, as well as at similar types of agencies. A variety of sources is considered, including a past report specifically concerning MDT, several federal transit studies, peer-reviewed journal articles, Transit Cooperative Research Program reports, and US General Accounting Office reports.

Researchers intended to use the material studied here as a basis for developing a guideline for information to be sought during the peer agency site visits obligated by the overall research approach.

Blue Ribbon Task Force Report

In 1986, the Public Transportation Blue Ribbon Task Force was commissioned to study Maintenance, Inventory & Purchasing, and Labor at MDT (1). The Blue Ribbon Task Force Report contained several areas of emphasis, including: history, organization, asset locations, procedures, purchasing specifications, and operations (with particular attention to Metrorail). The report also presented a series of specific findings and recommendations. Because of its relevance to the current study (it can be viewed as a baseline of information,) the Inventory & Purchasing portion is discussed below.

At the time of the Blue Ribbon Task Force report, the Materials Management Division had existed in its current form for approximately 3 years. It consisted of 3 divisions (Inventory Management and Control, Procurement, and Warranty) with the bulk of employees assigned to Inventory Management and Control. The reported inventory assets totaled $12.3 million, which is approximately $19.3 million in 2004 dollars (Table 3.1). One third of the total assets were allocated to the Central Warehouse; one-third was allocated among 4 bus facilities; and, one-third of the total assets were allocated to Metrorail. At the time of publication, Metromover inventory operations were handled through contractual services.

Table 3.1. MDT Materials Management Division Inventory - 1986

Facility	*Total Inventory Assets (2004 dollars)* [a]	*% of Total Inventory Value*	*Total Vehicles*	*Inventory per Vehicle (2004 dollars)* [a]
Central Warehouse	$4,336,913 *($6,820,626)* [a]	35%		
Bus[b] (all facilities)	$3,799,137 *($5,974,871)* [a]	31%	552	*$6,882 ($10,824)* [a]
Metrorail	$4,164,214 *($6,549,024)* [a]	34%	136	$30,619 *($52,938)* [a]
Total	$12,300,264 *($19,344,521)* [a]	100%	688	$17,878 *($28,117)* [a]

Source: Report of the Public Transportation Blue Ribbon Task Force to the Metropolitan Dade County Commissioners, May 14, 1986.
Notes: a. 2004 dollars calculated using the CPI inflation calculator, which uses the average Consumer Price Index for a given calendar year, provided by the U.S. Department of Labor Burear of Labor Statistics. For the current year, the latest monthly index value is used; b. The inventory figures for bus , which includes Central O&I, Coral Way O&I, Northeast O&I, and Central Support, do not include petroleum products, which were the responsibility of maintenance.

Table 3.1 also illustrates that while buses outnumbered rail vehicles by about 4 to 1, the inventory allocation per bus was less than one-fourth of the inventory per Metrorail vehicle.

With regard to staffing, the Materials Management Division had a total of 64 employees. 58 staff were distributed among the bus facilities, while 6 staff were assigned to Metrorail.

During the years preceding the report, the Blue Ribbon Task Force found that MDT had incurred considerable cost building up a large inventory. Specifically, from 1978 to 1985 the value of inventory increased by close to 1400%. In addition, the rate of inventory turnover decreased six-fold from 7.3 in 1978 to less than 1.2 in 1985. The report also found that the value of MDT's inventory incurred a cost of $2.5 million just to keep the inventory on hand. Although the start-up of Metrorail service was a

factor in these high levels, the report concluded that the total value of inventory on hand was "far too large" and the turnover rate was "far too low." MDT was also found to have an overabundance of stock rooms and stock room clerks.

Among the strongest contributing factors to the inefficiencies in the Materials Management Division were a lack of timely and accurate data and the limited use of current technology, especially computers and modern software. The report listed a series of recommendations to deal with the documented inventory problems (Table 3.2). These suggestions included completely "computerizing" the materials management operation, which would increase efficiency, reduce labor costs, and manage purchases more effectively. The Blue Ribbon Task Force advised MDT to implement a system that provided analysis for each stock item and sought fast service from suppliers. At the time this report was written, the concept of "just-in-time" inventory management was not commonly referred to as such, however, many of the recommended improvements amount to advocating this method. The report also advised consolidating the number of stock rooms and stock room clerks.

Additional recommendations for improving the function of the Materials Management Division included modifying purchasing responsibilities to include the purchase of petroleum products and re-evaluation of major rebuild items to consider whether they should be done in-house or contracted. The report also addressed issues related to the possible purchase of 60-foot articulated buses. While the Blue Ribbon Task Force did not firmly advise against purchasing articulated buses, it strongly cautioned MDT about the additional inventory and maintenance costs that would be incurred by adding these vehicles to the fleet. Another suggestion was to develop a formal training program for stock clerks to improve their job knowledge.

The Blue Ribbon Task Force Report also made suggestions in the area of purchasing. Specifically, the report advocated the occasional rotation of buyers to

different commodities or services. This is considered a 'best practice' in the industry. The report also recommended examination of applicable laws and regulations for disadvantaged/minority/female procurements to ensure that the agency was in full compliance with this measure. If necessary, new procedures to help meet the requirements should be established. Following on this, the Blue Ribbon Task Force also advised a reorganization measure, which involved moving the Office of Minority Business Development from the Department of Community Affairs to the Procurement Management Division and consolidating the Office after the move to save on personnel costs.

Additional recommendations included raising the agency's purchase amount from $250 to $4,999, decentralizing the process and reducing duplicated effort, updating bus system purchase specifications, and reviewing vendor lists to remove unqualified or otherwise unsatisfactory vendors.

Table 3.2. Blue Ribbon Task Force Recommendations

Unit	***Recommendations***
Inventory Management & Control	• Analyze demand for stock items and reduce inventory on hand wherever possible • Remove items from inventory that have little or no usage, especially obsolete items • For items with high usage, consider alternate sources of stock. Select confident suppliers that offer fast service • Implement updated computer system with inventory software as soon as possible • Consolidate stockrooms at various facilities • Analyze parts demand by shift and adjust the number of stockroom employees necessary to meet this demand • Carefully monitor quantity & quality of fuel deliveries. Ensure that petroleum products are only used for agency vehicles • Make ordering and stock control of petroleum products the responsibility of the Materials Management Division • Compare in-house vs. outside costs for major rebuild items • Prior to making a firm purchase commitment, carefully consider the many issues associated with adding articulated buses to the fleet • Establish a formal training program for stockroom clerks
Procurement Management	• Occasionally rotate procurement personnel to different commodities • Ensure that the agency is in compliance with all disadvantaged/minority/female procurement rules • Place the Office of Minority Business Development under the responsibility of procurement management and re-examine necessary staffing levels after the move • Allow procurement management greater authority in purchasing. Specifically, allow purchases up to $4,999 without the need for direct County Commission approval • Update specification for bus purchases

Source: Report of the Public Transportation Blue Ribbon Task Force to the Metropolitan Dade County Commissioners, May 14, 1986.

Additional Studies

In general, the primary goal of an inventory operation is to provide the right items at the right location and time, at the lowest cost (2). These goals sometimes conflict, as meeting them requires maximizing 'customer' service and minimizing the total value of inventory. According to TCRP 40, a competent inventory management system will work with the departments it serves in order to increase the availability of parts and decrease the amount of funds tied up in inventory. As this working relationship grows, inventory management broadens its role into one that is more strategic (planning for future requirements) in the organization. Ideally, the result will be an inventory management system that can project near term and long term needs and maintain an appropriate level of stock. Specifically, overstocked items will be minimized and instances of 'emergency' restocks will be limited.

TCRP 40 serves as a general guide for inventory management. While it is not necessary to reiterate the entire contents of the report here, several best practices and recommendations contained in it are worth noting. For example, classifying inventory using the "ABC" method is an effective way for managers to prioritize ordering of items and to determine the required frequency of orders. Items are grouped according to their annual dollar usage or their value, with the highest-ranking items falling in group A and so on. Normally, group A accounts for 70% of total annual inventory dollars, with groups B and C accounting for 20% and 10%, respectively. Other factors, such as storage requirements, scarcity, shelf life, and unit cost, also figure into the determination of an items classification. Items are reclassified as necessary. Agencies may also categorize inventory according to like items. An example of this method would be grouping all bus items in one class, all rail items in another class, and all cleaning supplies in a third class.

Regardless of the classification method used, item descriptions should follow an established numbering and naming system, be unique, and include information such

as key words, size, or any other relevant identifiers. Rather than relying on manufacturers' terminology, agencies are advised to assign their own descriptors to inventory items.

Transit agencies use a variety of methods to replenish inventory. TCRP 40 describes 6 commonly used methods, which depend in part on the type of demand for the materials. Dependently demanded items (items which are planned to be used on a regular basis) are reordered on a fixed-schedule or a fixed-order method. Items with an independent demand (those not planned for on a regular basis) can be restocked in several different ways, including the 2-bin system, the min/max method, the fixed-period quantity method, or the reorder point method.

No matter which reordering methods are used, strong teamwork among the inventory, purchasing, and maintenance departments is necessary to achieve inventory and purchasing performance objectives. Several practices are recommended to help improve inventory performance, including:

- Reducing purchase cycle (and lead) times
- Developing commodity expertise and specialization
- Increasing the use of different purchase order types
- Consolidating purchases and increasing the use of volume discounts
- Qualifying vendors and monitoring vendor performance
- Searching for new products and vendors
- Developing strong supplier relationships

This resource also advocates the use of a central storehouse along with satellite facilities that house parts as close to their use-point as possible. In addition, excess and obsolete items should be dealt with in a timely fashion. Lastly, great care should be taken to maintain accurate inventory records and valuation. The "average cost" valuation method is the most common type used in the transit industry. The

benefits of cycle counting are also pointed out, and benchmark values for inventory performance indicators are listed. They are usually specific to transportation mode and include: inventory turnover, stock-out percent of items, inventory cost per vehicle, items out of balance, percent fill rate, percent obsolete items, days to fill back orders, and inventory value per person. These factors, combined with 'real-world' conditions such as data availability, management decisions, and agency policies, all contribute to inventory management performance, and they bear close scrutiny.

TCRP 40 briefly noted the importance of bringing new technology advances into the fold of inventory management. Mitretek Systems expands on this idea (3). The concept of supply-chain management, which can be described as a group of businesses or agencies that collaborate to maximize the value of their efforts, is the focus of their study. The authors argues that in order for agencies to achieve greater success with managing parts and inventory, they must have the ability to critically assess their capabilities, have the will to make investments in technology and personnel where needed, and have the willingness to outsource, if necessary. By using the techniques of supply-chain management, agencies are put in a position where they must understand the interrelated effects of inventory costs. Decisions must balance actions that efficiently add value with those that add value at too high a cost in terms of dollars or resources. For example, an agency must not only consider the price of supplies, but also storage issues, shipping issues, shrinkage, and obsolescence.

Specifically, TCRP 84 focused on "e-Procurement," which is simply defined as "the purchase and sale of supplies over the Internet." (3) These methods have grown in recent years, and they continue to be refined and improved. Five interrelated areas of e-Procurement are described, including: automation of the buying process, Internet market exchanges (i.e., 'e-markets'); buyers' consortia, industry portals; and

private trading exchanges. Utilization of these methods offers several overall advantages, such as increased speed, better communications, and lower costs.

Automated purchasing systems commonly involve application-specific software. When designed well, the automated process creates an easier and faster purchasing method and allows for better pricing, based on the quantity of materials ordered by the client. Those agencies that were fleet-based used this method in partnership with a main vendor or lead supplier contracted on a multi-year contract. The authors argue that this approach allows the vendor to focus on providing parts and inventory management. If they share information in a communal setting, they are able to develop a supply-chain to better meet their customer's needs. A major challenge sited is the amount of confidence required by all companies involved to develop a level of trust where they can freely share information with each other. Ultimately, the customer is better served because there is less waste, increased savings, and better response times. While the benefits of implementing a supply-chain procurement system are high, there are substantial obstacles preventing its development.

Gillespie points out agencies can save time and money by reorganizing their materials management and supply chain operations (4). One option discussed is utilizing the Internet as a venue for information exchange as well as a marketplace. The Internet functions as a medium that connects suppliers directly to service providers and customers. Online orders have the benefit of being easily tracked; however, not all providers have reliable Internet functionality yet. Internet ordering for transit agencies is still in the process of proving that it is capable of handling complex tasks, and all information systems are not yet fully integrated. Manual data are still necessary to update inventory lists. Other concepts being developed and refined include hand-held devices, supply towers, and unit level barcodes. Hand-

held devices are being used to track individual pieces of inventory. Once the items are scanned the devices are synchronized to a master database.

Abrams, Hide et al also feel that technology can help improve inventory performance (5). Many new information technologies provide support for both inventory management and maintenance activities. For example, many aspects of maintenance can be condensed into one computerized system. This allows real-time information to be used by mechanics, inventory managers, and analysts. The authors advocate the use of life-cycle cost management to aid with inventory decision making. Activity-based cost management can also be used to coordinate inventory functions with maintenance needs. The report briefly mentions the expanding role of outsourcing as part of the procurement process.

Ames argues that outsourcing materials management needs allows more time to focus on customers and other aspects of business (6). The outsourcing partner assumes responsibility for all materials management needs, which likely results in long-term savings. Prior to establishing a partnership the managers must conduct a basic cost analysis. This includes examining future needs, administrative costs, and repair costs. In addition to cost analysis, managers should examine the operations. Specific attention should be paid to initial and future changes. The partner also looks for ways to improve materials management and acquisition functions. Outsourcing allows the agency to potentially become more efficient and successful.

The United States military is involved in ongoing efforts to improve efficiency by monitoring inventory management and reducing inventory costs (7). An example of this is the implementation of the Supply Maintenance Aviation Reengineering Team (SMART). This new system replaces an outdated program and allows for modeling and data sharing. By predicting when new inventory is needed, SMART will be able to decrease the amount of inventory on hand and insure the military remains within

its Congressional budget. The priority is to maintain a level of inventory that will properly facilitate an acceptable level of readiness. The SMART team will examine several key factors to determine the necessary level of inventory.

Draycott and Kilpatrick found that many of the companies studied did not use a statistical method to determine when to replenish inventory (8). Instead, the rule of thumb was commonly used to determine reorder points. Examples of specific methods used included setting fixed times with the vendor and merely doubling the minimum amount of an item needed to establish a maximum. Some companies establish a demand on request only (ORO) system for new items. The authors felt that there is a benefit to using multiple replenishment methods such as fixed delivery, replenishment levels or parameters, and safety stock. Each method can be tailored to a specific item based on a pattern of demand.

The authors examined the effectiveness of inventory management conferring with maintenance to determine a historical demand pattern for materials. They found that this method of forecasting was misleading. The study advised close scrutiny of the quality of information received in order for joint efforts between inventory management and maintenance to be successful.

Monitoring maintenance performance for the benefit of inventory management is discussed in TCRP 22 (9). Such information should allow management to be better able to determine inventory levels. Also, close supervision of maintenance performance will help manage areas in need of improvement. Managers are often left with few options when trying to develop and revise guidelines. The ability of an agency to monitor its maintenance performance depends on the size of the agency and the amount of resources they are able to designate. Larger agencies are usually able to develop more precise methods of monitoring. As discussed earlier, the degree of commitment by management is also a key to success. However, the

study points out that conducting inter-agency analysis presents a challenge because agencies often use different performance measures. Some comparable performance measures are found in the areas of management philosophy, employee productivity, equipment performance, and controlling costs.

Many large federal agencies are in the process of updating their inventory procedures, and as such, they provide good examples from which to learn. For example, many of the inventory processes currently used by the Department of Defense (DOD) are considered obsolete and inadequate (10). Materials are routinely purchase years in advance of their demand. The DOD has strived to adopt some best practices from the private sector and has met with limited success so far. DOD has tested the prime vendor program, but on a very limited basis. Currently, it is not being used to its full capacity to improve response times and fully utilize the storage, ordering, and distribution services available in the private sector. By ordering inventory items when they are needed, the DOD hopes to lower costs, diminish the size of its inventory, and eliminate obsolete materials. By expanding the prime vendor program, the DOD seeks to optimize its customer service capabilities and limit the amount of inventory on hand.

Other modern inventory management techniques have also been considered by the US DOD to reduce inventory costs (12). Currently, the DOD uses the Defense Logistic Agency (DLA) to handle inventory management. The DLA provides items to the military services by filling purchase orders. The study discussed here recommended decentralizing the distribution system. Rather than having one central agency providing the necessary inventory, the authors propose developing industrial parks close to the areas where the items are needed. Because of its close proximity, storage and delivery of items can be streamlined. Another suggestion is to electronically link the client with the distribution center. An interchange system will allow a more efficient ordering, delivery, and payment process. These changes

are recommended because they have been observed as the best practices in the private sector. DOD officials commented that current procurement regulations deter implementation of these recommendations.

With a study of inventory counting procedures, the GAO hoped its findings would help improve the accuracy and reliability of inventory and real property data (12). The effort involved 7 case studies, which documented fundamental practices, procedures, and principals used by large corporations with outstanding records in inventory management. Several of these companies used more than one counting approach, and all of them used either cycle counting or wall-to-wall counting, or both.

The study revealed 12 common factors that are instrumental in providing consistent and accurate physical inventory counting results (Table 2.3). According to GAO, these factors "are an accumulation of continuously improved practices and controls for counting inventory and related property." GAO also found that top-level management at each company studied had a strong commitment to maintain an effective and reliable inventory control system. The strong commitment served as an underlying dynamic that helped tie together each of the key factors.
Management at each company also shared several common characteristics that proved vital to realizing accuracy and efficiency regarding inventory control. These characteristics included:

- Advocating change and empowering employees to make changes
- Alignment of performance measures with company goals
- Investment in technology and seeing a return on the investment
- Developing human capital and working to retain it
- Thoroughly communicating goals and desired results

It is important to note that the study observed these practices actively being followed. Companies initiated concepts such as "participative management improvement groups," industry standard benchmarking, and ongoing tests and improvements.

Another US GAO report examines best practices of the airline industry that have the potential to be implemented by the DOD (13). These methods include ways to monitor inventory, ways to improve response times to inventory requests, giving more responsibility to suppliers, and outsourcing repair, distribution, and storage. Notably, the airlines were able to streamline the inventory management process, rather than having separate features.

Specifically, four key areas that are effective in the private sector have the potential to be successfully used by the DOD within the current parameters required by law. They are: faster repair of items; restructure repair process; partner with suppliers, and outsource logistic services.

By outsourcing the inventory management process, the DOD may be able to develop an environment that fosters competition among bidders. According to the study, outsourced inventory management may prove more cost effective, regardless if the contract is won by the government or a private company.

Table 3.3. Key Factors in Achieving Consistent and Accurate Counts

Factor	Description
Establish accountability	Set performance goals and hold appropriate level of personnel responsible for overall physical inventory process
Establish written policies	Shows management's commitment, provides instruction and process guidelines, basis for employee training
Select an approach	Cycle counting or wall-to-wall. Selection based on reason for count, capability of inventory system, existing controls, and type of inventory
Determine frequency of counts	Depends on which items are being counted, their degree of importance, and the resources available to complete counts
Maintain segregation of duties	Divide key duties among different people to reduce risk of error and fraud
Enlist knowledgeable staff	Counters should be well-trained and experienced and knowledgeable about items
Provide adequate supervision	Includes proper instruction, problem solving, and work review. Increases reliability and accuracy of counts
Perform blind counts	Counter should not have prior knowledge of inventory records
Ensure completeness of count	Consider cutoff procedures, pre-inventory activities, and control methods to ensure count completeness
Execute physical count	Maintain communication with counter, verify item and quantity, perform count, and complete in timely manner
Perform Research	Identify differences in count and seek reconciliation
Evaluate Count Results	Measure results, communicate findings, modify policies and procedures as necessary

Source: Executive Guide: Best Practices in Achieving Consistent, Accurate Physical Counts of Inventory and Related Property. US General Accounting Office, Washington DC, March 2002.

IV. Peer Agency Selection and Review

Early in the project, the Oversight Committee directed CUTR to select peer properties for comparison based on agencies with similar fleet size that had experienced significant growth. Selection of the appropriate peer organizations was extremely important to ensure a valid comparison of inventory levels. CUTR performed separate cluster analyses to determine comparable properties for Metrobus and Metrorail. However, the selection process posed some difficulties due to MDT fleet's unique mix of buses, heavy rail cars, automated guideway vehicles, and related wayside equipment.

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.

CUTR presented the cluster analysis results to the Oversight Committee. With input from the committee, CUTR revised the criteria used in the analysis. Because of the unique characteristics of Metromover, CUTR was unable to select peer agencies for the Metromover system for two primary reasons. Comparable mover vehicles are operated primarily at US airports, and the nature of MDT's operation differs significantly from the straight line shuttle service provided at those airports. In addition, all maintenance of airport mover vehicles is performed under contract by third parties, unwilling to provide comparable data due to proprietary concerns.

CUTR also encountered difficulties in identifying peer systems that operated both bus and rail systems that were comparable to MDT's systems. After a review of existing data, the Oversight Committee agreed to select peer properties based on the 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 management programs of peer 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).

MDT reported 29.4 million Annual Vehicle Miles (AVM) and 283.5 million Annual Passenger Miles (APM) for bus operations (NTD 2001). 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
- 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 hours per VOMS
- 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 8 agencies using service as well as performance measures to determine the three most comparable to MDT (Tables 4.1 and 4.2).

Table 4.1. Comparison of Peer Transit Agencies

Transit Agency	*Vehicles Operated in Maximum Service*	*Vehicles Available for Maximum Service*	*Annual Vehicle Miles (000s)*	*Annual Passenger Miles (000s)*	*Vehicle Maintenance Hours*	*Vehicle Maintenance FTE*
SF-Muni	372	488	14,317	207,328	611,147	294
Denver RTD	639	962	33,875	288,037	854,180	443
MDT	530	666	27,871	270,213	743,038	364
MARTA	580	698	31,853	273,116	1,119,544	459
Mass BTA	769	911	26,032	250,792	952,511	445
Baltimore MTA	649	787	21,597	261,834	752,039	403
Portland Tri-Metro	570	671	26,554	207,760	631,539	353
San Antonio VIA	421	503	22,234	171,628	389,134	220
Milwaukee CTS	461	557	22,074	195,917	449,387	240

Source: NTD 2000 Data Tables 21 &28

Table 4.2. Comparison of Peer Transit Agency Performance

Transit Agency	*VOMS/ VAMS*	*Annual Passenger Miles/ VOMS*	*Vehicle Maintenance Hours/ VOMS*	*Annual Pass Miles/ Veh Maint Hours/VOMS*	*Annual Pass Miles/ Veh Maint FTE*
SF-Muni	0.76	557	1,643	126,199	705,678
Denver RTD	0.66	451	1,337	215,476	649,609
MDT	0.80	510	1,402	192,739	742,343
MARTA	0.83	471	1,930	141,493	595,023
Mass BTA	0.84	326	1,239	202,474	563,577
Baltimore MTA	0.82	403	1,159	225,959	649,389
Portland Tri-Metro	0.85	364	1,108	187,516	588,557
San Antonio VIA	0.84	408	924	185,683	780,128
Milwaukee CTS	0.83	425	975	200,980	816,323

Source: NTD 2000 Data Tables 21 &28

Table 4.1 shows that 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 is using 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* implies that

each vehicle travels more miles.) In 2000, MDT provided more than 27 million vehicle miles. The ranking of the agencies in vehicle miles is presented in Figure 4.1.

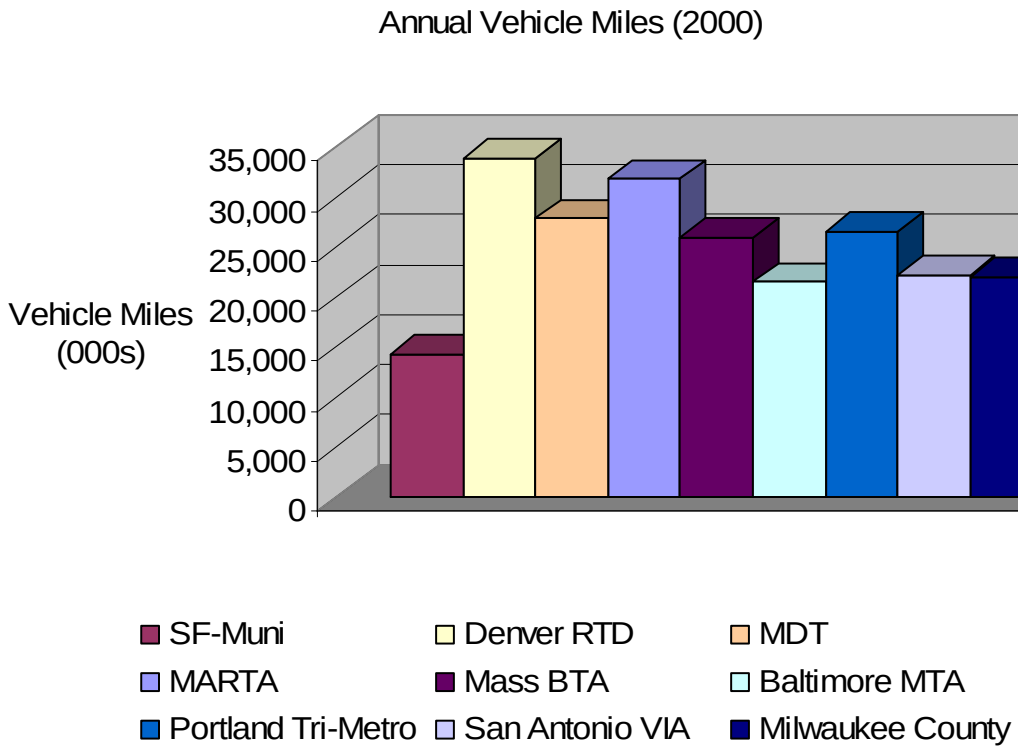

Figure 4.1. Comparison of Annual Vehicle Miles, 2000

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 2000). On average, MDT's vehicle 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. The comparison of passenger miles between the peer agencies is presented in Figure 4.2.

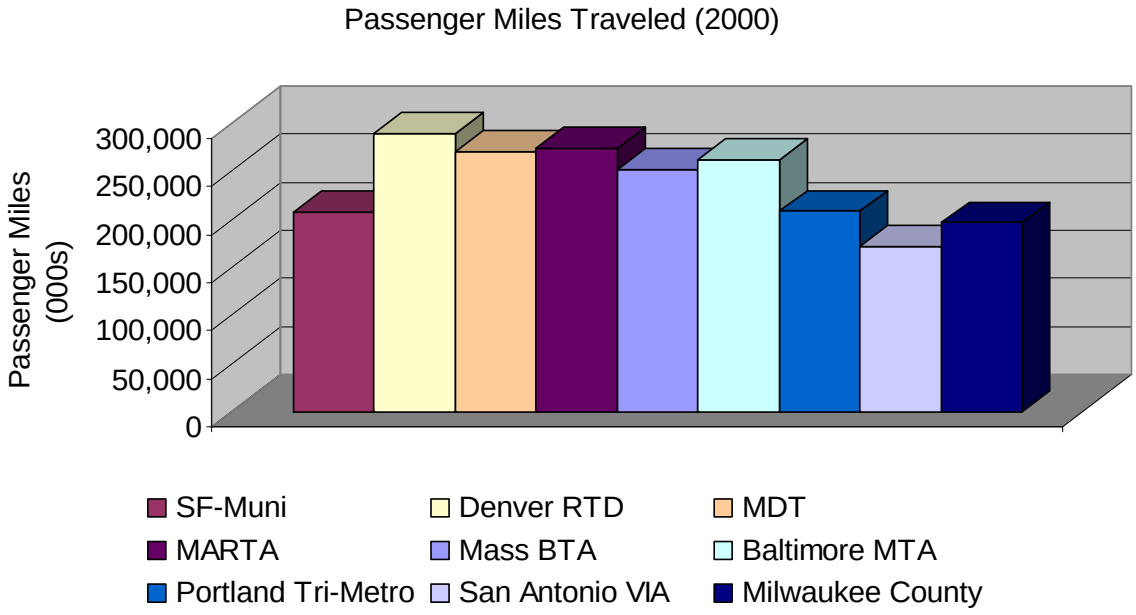

Figure 4.2. Comparison of Passenger Miles for the Peer Transit Agencies, 2000

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 shows how heavily each vehicle is operated and can 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 peer agencies. MDT also spent 743,038 hours maintaining its fleet in 2000. This figure puts MDT exactly in the middle of the ranking among peer 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 agency 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 each bus. As such, a relative measure of maintenance per bus is required for proper comparison of the agencies of different sizes. The analysis presented here used maintenance hours per VOMS to compare maintenance efforts among peer agencies (Figure 4.3).

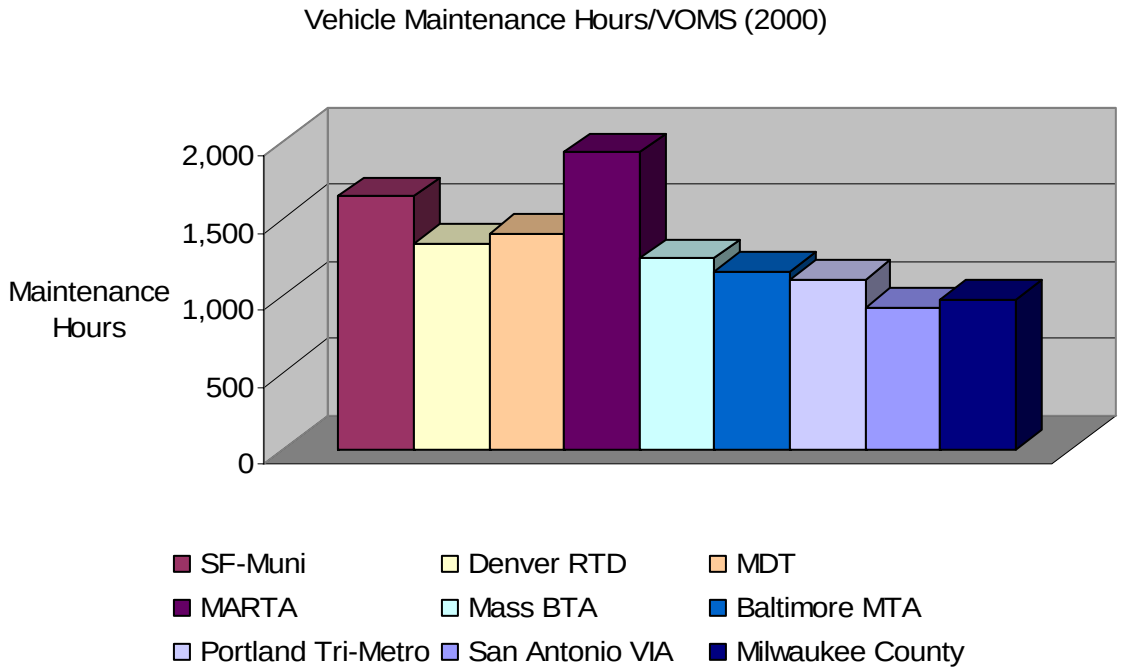

Figure 4.3. Comparison of Vehicle Hours per VOMS, 2000

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 highest reduction (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 is the number of full-time 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 peer agencies. MARTA led the group 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 peer agencies, including MDT, decreased the

number of full-time bus maintenance employees, while the other 5 agencies increased the number of full-time 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 peer agencies experienced a decrease in the number of service interruptions caused by mechanical failures of buses. Denver RTD had the highest decrease (60%). The changes in the number of full-time bus maintenance employees and the number of mechanical failures of buses between different agencies are presented in Table 4.3.

Table 4.3. Number of Bus Maintenance FTE and Service Interruptions Due to Mechanical Failures, 1996-2001

	Number of Maintenance FTE			*Number of Service interruptions due to mechanical failures*		
Agencies	***1996***	***2001***	***% change***	***1996***	***2001***	***% change***
SF-Muni	302	296.3	-1.89%	4,399	4,337	-1.41%
Denver RTD	379.7	439.4	15.72%	1,768	708	-59.95%
MDT	396	374	-5.56%	10,722	9,844	-8.19%
MARTA	418	468	11.96%	7,706	11,383	47.72%
Mass BTA	394	457	15.99%	2,860	1,742	-39.09%
Baltimore MTA	375	401	6.93%	7,795	4,058	-47.94%
Portland Tri-Metro	300.3	350	16.55%	5,104	2,759	-45.94%
San Antonio VIA	218	217	-0.46%	2,923	9,633	229.56%
Milwaukee CTS	262	240	-8.40%	5,624	4,847	-13.82%

Source: NTD 1996, 2001

Figure 4.4 shows the comparison of passenger miles per number of maintenance employees in 2000. 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 peer agencies after Milwaukee CTS with more than 26% growth.

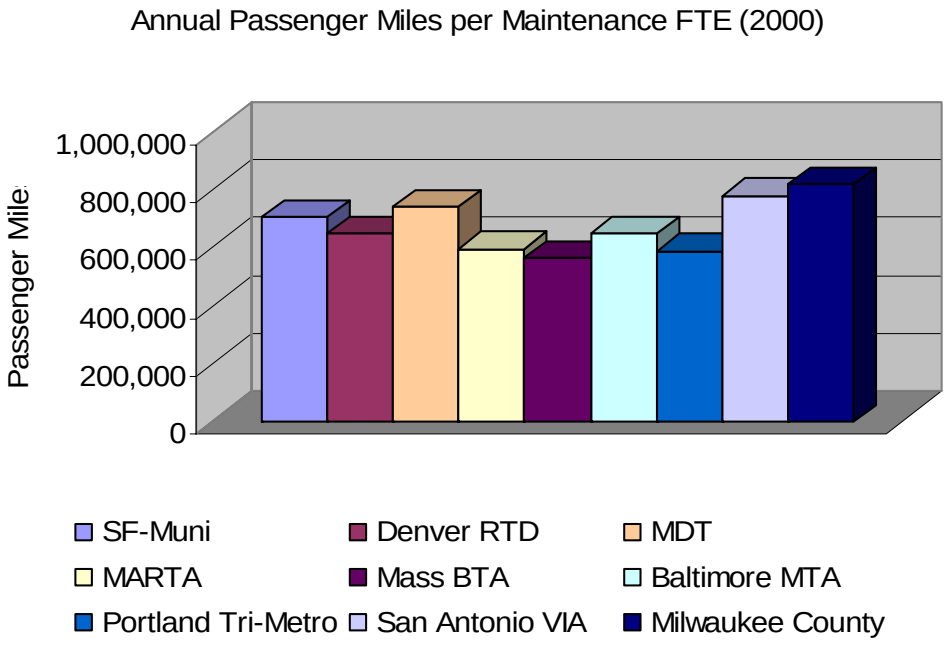

Figure 4.4 - Comparison of Annual Passenger Miles per FTE, 2000

MDT intended to double its bus fleet over a 5-year period, so the agency was interested in studying the experiences of other transit agencies that have 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.) Table 4.4 illustrates the ten fastest-growing agencies from 1998-2001.

Table 4.4. Ten Agencies Experiencing Highest Cumulative Growth Rates, 1998 to 2001 (%)

	VAMS			VMT			Passenger Miles	
	Agency	Growth (%)		Agency	Growth (%)		Agency	Growth (%)
1	NY Tompkins Area Transit	250.0	CA	Lompoc Transit	472.7	AL	Birmingham-Jefferson TA	1634.6
2	AZ Scottsdale Connection	137.5	NY	Tompkins Area Transit	248.7	CA	Lompoc Transit	1457.1
3	FL Pasco County Public Trans	125.0	FL	Pasco County Public Trans	222.5	NJ	Olympia Trails Bus	977.4
4	CA Lompoc Transit	100.0	OH	Lorain County Transit	201.8	KY	TA Lexington-Fayette Cnty	538.8
5	FL Bay Cnty Council on Aging	100.0	NJ	Olympia Trails Bus	178.9	CA	Yuba-Sutter Transit Auth	337.5
6	MD Howard Area Transit Svc	100.0	WI	Waukesha Cnty Transit Sys	162.2	NY	Tompkins Area Transit	332.9
7	OH Lorain County Transit	92.3	MD	Howard Area Transit Svc	158.0	SC	Coastal Rapid Public TA	296.8
8	SC Coastal Rapid Public TA	92.3	NJ	Leisure Line	128.9	FL	Pasco County Public Trans	264.6
9	CA Ventura Intercity Svc TA	80.0	PA	Westmoreland County TA	125.5	SC	Greenville Transit Auth	220.8
10	CA Thousand Oaks Transit	75.0	CA	Ventura Intercity Svc TA	119.7	OH	Lorain County Transit	205.9

Source: NTD 1998, 2001

The results showed three transit agencies that doubled the number of vehicles available for maximum service (Lompoc Transit, CA, Bay County Council on Aging, FL and Howard Area Transit Services, MD). Tompkins Area (NY) 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 were not considered relevantly comparable to MDT. As a result, CUTR rejected these smaller agencies from further analysis. Using 2001 data, CUTR identified agencies most similar to MDT in terms of total fleet, vehicle miles and passenger miles. This process yielded more reasonable potential candidates for comparison to MDT (Tables 4.5, 4.6 and 4.7).

Table 4.5. Three Agencies Most Similar to MDT
VAMS, 2001

		Agency	VAMS
1	NY	New York-GTJC	713
2	GA	MARTA	712
	FL	Miami-Dade Transit	732
3	OH	Greater Cleveland RTA	758

Table 4.6. Three Agencies Most Similar to MDT
Vehicle Miles (000s), 2001

		Agency	VMT
1	OR	Portand Tri-Metro	26,622.60
2	OH	Greater Cleveland RTA	26,792.60
	FL	Miami-Dade Transit	29,365.80
3	GA	MARTA	32,041.70

Table 4.7. Three Agencies Most Similar to MDT
Passenger Miles (000s), 2001

		Agency	Passenger Miles
	FL	Miami-Dade Transit	283,461.50
1	MA	Mass BTA	284,113.80
2	GA	MARTA	284,492.10
3	MD	Baltimore MTA	260,988.00

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

1. Greater Cleveland RTA; Cleveland, Ohio
2. MTA; Baltimore, Maryland
3. MARTA; Atlanta, Georgia
4. Massachusetts BTA; Boston, Massachusetts
5. Portland Tri-Metro; Portland, Oregon

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

Bus Analysis

After reviewing the overall conclusions of the analyses conducted, the Oversight Committee 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.

Preventive Maintenance, corrective maintenance, cleaning and storage of vehicles are performed throughout Miami-Dade County at three (3) maintenance facilities operated by Miami-Dade Transit and one (1) facility managed by Penske Truck Leasing under contract to MDT:

- Central Operating & Inspections Division (O&I)
- Coral Way Operating & Inspections Division
- Northeast Operating & Inspections Division
- Medley Operating & Inspections Division

MDT also operates the Support Services Division, which is composed of the A/C Shop, Major Body Shop, Major Overhaul, and Unit Room. Bus components are rebuilt, power plants are removed and replaced, damage from major accidents is repaired, and all new buses are inspected prior to release to the O&I Divisions from the Support Services Division. Except for the Central O&I, each facility has its own bodywork and painting shops. The composition of MDT's bus fleet by manufacturer is illustrated in Figure 4.5.

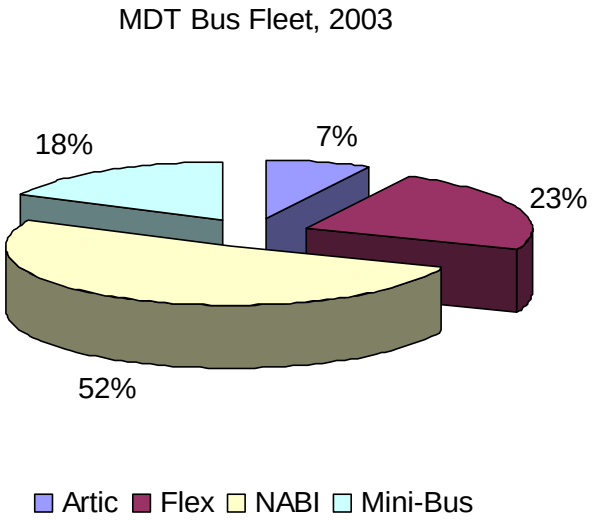

Figure 4.5. MDT's Fleet by Bus Type, 2003

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 American Public Transportation Association. 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 degree of similarity or distance. The distance between the objects being grouped into clusters was measured using squared Euclidean distance – a common measure of distance between objects in multi-dimensional space. The use of pure statistical techniques of cluster analysis minimized subjective involvement in selecting the peer agencies.

Due to the different nature of their operations, separate cluster analyses were performed for bus and rail to determine comparable properties to MDT's Metrobus and Metrorail, respectively. The data used for the analysis contained information on the bus equipment of 266 transit agencies in North America. The data set contained the information on the following parameters:

Parameters – Number of Vehicles with:

1. Operator/Base 2-way radio
2. Operator/Base Telephone
3. Emergency Passenger/Operator Intercom
4. Passenger Telephone
5. Public Address System
6. Interior Audio System
7. Interior Video System
8. Automated Stop Announcement Equipment
9. Air-conditioning
10. Reclining Passenger Seats
11. Personal Reading Lights
12. Outlets for Electrical Devices
13. Passenger Tray/Table Space
14. Passenger Seatbelts
15. Overhead Storage Rack
16. Underfloor Luggage Bay
17. Restroom
18. Newspaper/Magazine Rack
19. Food/Beverage Vending Machine
20. Electronic Farebox
21. Non-electronic Farebox
22. Electronic Destination Signs
23. Automatic Passenger Counter
24. Security Cameras
25. Exterior Bicycle Rack
26. Interior Bicycle Rack/Storage Space
27. Interior Advertising
28. Exterior Advertising
29. Automatic Vehicle Location Equipment
30. Traffic Light Pre-emption Equipment

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 be not 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) and had the highest frequency of non-zero values, were retained for the analysis. The variables chosen for the analysis were:

1. Number of vehicles with operator two-way radios
2. 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

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 6 bus types defined by the bus manufacturer:

1. AII – American Ikarus
2. BBB – Blue Bird Corporation
3. DTD – Dodge Division, Chrysler Corporation
4. FLX – Flexible 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 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
2. 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 group of transit agencies that placed in the same cluster with MDT. Agencies identified through the cluster analysis are presented in Table 4.8.

Table 4.8. Peer Transit Agencies (Bus)

APTA ID	Transit Agency	Location
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 yielded 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 whilst filtering out noise. The results of the analysis generally confirmed the efficiency of the initial set of variables chosen for the cluster analysis.

Rail Analysis

A separate cluster analysis was performed for the rail operations. The data set describing the equipment of various rail vehicles contained 79 observations about 49 transit agencies and reported the following rail operations:

1. Heavy Rail (HR)
2. Light Rail (LR)
3. Commuter Rail (CR)
4. Commuter Rail Locomotive (CRL)
5. Other Rail (OR)

MDT reported only Heavy Rail and Other Rail operations. Therefore, in order to make the comparison between MDT and other transit agencies more worthwhile, only the transit agencies that had either HR or OR operations, or both, were considered. This reduced the data set to 9 transit agencies, with MDT being the only agency to have both HR and OR operations. Those operations were not aggregated into a single category "Rail" but rather were each compared to HR and OR operations of other transit agencies. No rail operations other than HR and OR were considered for the analysis, even when the agencies reported them. Each agency was compared to all others in the data set, regardless whether the agency reported HR, OR, or both.

Cluster analysis was applied using the following grouping variables:

1. Number of vehicles with operator two-way radios
2. 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

The above variables were chosen primarily for two reasons: a) because they had one of the highest frequency of non-zero observations in the data set; and b) these types of equipment were common to MDT's rail vehicles.

Various clustering algorithms and measures of distance between the objects were used to ensure the validity of the analysis. All of them yielded similar results. In general, with few exceptions, all cluster analysis algorithms tended to place the agencies that reported HR operations into a separate group from the agencies that reported OR operations. Thus, MDT's HR and OR operations were consistently placed in different clusters.

MDT's Heavy Rail operations were placed either in the cluster of its own or together with Port Authority Transit Corporation (Lindenwold, NJ). MDT's Other Rail operations were consistently placed in the clusters of the following peers:

1. Puerto Rico Highway & Transport; Santurce, PR
2. Chattanooga Area Regional TA; Chattanooga, TN
3. Jacksonville Transportation Authority; Jacksonville, FL

Alternative methods of the analysis were also explored in an attempt to account for overlooked details. The alternative methods included the aggregation of all rail operations in one category "rail" and the comparison of all transit agencies that reported any rail operations (regardless of the breakdown by mode), as well as the incorporation of the fleet component into the analysis (much the same way as it was done for bus equipment previously discussed). However, none of the alternative techniques produced distinct clusters of transit agencies, and were thus discarded as being inefficient. It also has to be noted that the results of the rail analysis might have suffered from the limitations of the data. Since the data set explaining rail operations is very small, the power of the cluster analysis is rather low. Therefore, extreme caution should be exercised in interpreting the results.

Conclusions of the Analysis

Two transit agencies, Cleveland RTD, and Maryland MTA, were identified as most similar to MDT by both bus operations and bus equipment cluster analysis, while Denver RTA was identified as most similar by the bus equipment cluster analysis. All three agencies met the multi-modal test as they all operate light rail systems in addition to bus, and Cleveland RTA along with Baltimore MTA also operate heavy rail systems. The Oversight Committee concurred with site visits to the following peer agencies:

1. Maryland Transit Administration; Baltimore, Maryland
2. Regional Transit District; Denver, Colorado
3. Greater Cleveland Regional Transportation Authority; Cleveland, Ohio

V. Site Visits and Data Collection

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 to expedite the process. This questionnaire was developed in cooperation with the Chief of the Materials Management Division and the Oversight Committee.

Emphasis was placed on the following areas:

- Inventory size and value
- Inventory valuation methods
- Number and sizes of warehouse facilities
- Automated practices
- Performance measurements
- Process flow
- Staffing levels and hours of duty
- Internal controls

MDT initiated contact with Materials Management 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 one case, CUTR was directed to the appropriate materials/inventory management staff. In all cases, each agency staff member who ultimately assisted CUTR had several years of transit inventory 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 promptly 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 were advised that each meeting would require at least 2 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 4 week time period during August – September 2004. Each site visit consisted of an approximately 2-hour meeting with inventory management personnel and a tour of selected storerooms and inventory facilities. Specifically, CUTR met with the *Inventory Manager* at Cleveland RTA, the *Manager of Materials Management* at Baltimore MTA, and the *Materials Handling and Purchasing Manager* at Denver RTD. In one instance (Baltimore MTA), an *Inventory Supervisor* was invited to participate in the visit to provide additional information and perspective.

Upon completion of the site visits, CUTR summarized the site visit data and presented an overview of the findings to the Materials Management Chief and staff. The data generated new questions, and CUTR was asked to follow-up with all three peer properties to clarify some of the data collected as well as to obtain additional information regarding procurement practices and warranty recovery.

Summary of Site Visits

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 materials management 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.

Researchers used a standardized list of questions during the interviews conducted at the peer properties as well as with Miami-Dade Transit Materials Management staff. Those standardized questions used by the researchers during the site visits were translated into specific areas of discussion. Information obtained as a 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 and materials management best practices that had been identified.

Structure of Organization

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 Board of Commissioners. MDT's structure is unique in relationship to peer agencies, which are more closely aligned with state or regional government. Materials Management functions, including inventory, procurement, and warehousing & stores, are consolidated under the direction of the Chief, Materials Management, who reports to the Deputy Director, Administration. The Miami-Dade Transit organizational structure is outlined in Figure 5.1.

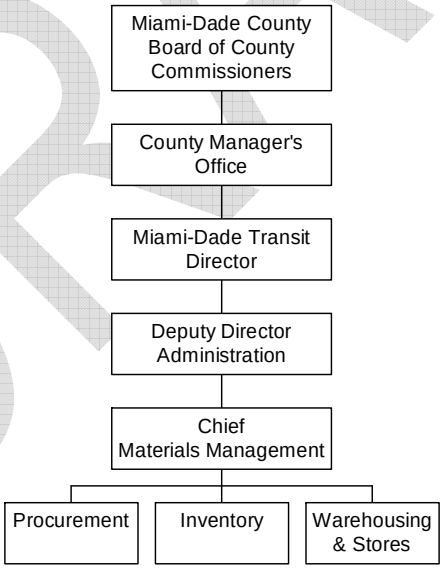

Figure 5.1. Miami-Dade Transit Organizational Structure

Baltimore Maryland Transit Administration (MTA) 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 reports to the Secretary of the Maryland Department of Transportation, who in turn answers to the Governor of the State of Maryland. In 2001, the Maryland Transit Administration Citizens Advisory Committee was established. Members are appointed by the Secretary of Transportation and serve three year terms. Inventory and procurement functions are consolidated under the guidance of the Director of Bus Maintenance while warehousing and stores functions are shared by the Director, Bus Maintenance and the Assistant Deputy Administrator. The Baltimore MTA organizational structure is presented in Figure 5.2.

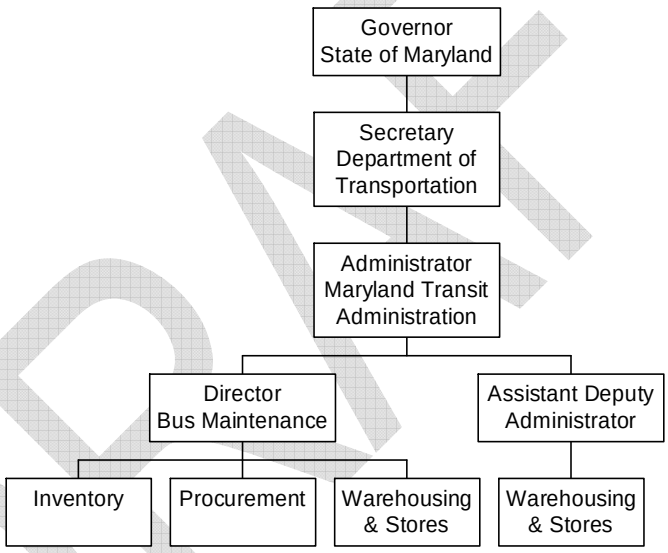

Figure 5.2. Baltimore MTA Organizational Structure

In 1974, legislation established the Greater Cleveland Regional Transit Authority (GCRTA), a political subdivision of the State. GCRTA Chief Executive Officer (CEO)/General Manager reports to the Board of Trustees, a 10 member board. Members serve overlapping 3-year terms with four Cleveland residents appointed by the Cleveland Mayor and approved by the City Council; three members are elected by Mayors and City Managers of Municipal Corporations other than Cleveland within Cuyahoga County; and, three members are appointed by Cuyahoga County

Commissioners (one of three must reside in Cleveland). GCRTA also has a Citizens Advisory Board that consists of 20 volunteer members appointed by the RTA Board of Trustees. Ten are selected by Board Members and 10 are selected from a list of candidates. Inventory as well as Warehousing & Stores functions are managed by the Operations Division, and procurement falls under the supervision of the Finance & Administration Division. Figure 5.3 details the Cleveland RTA Organizational Structure.

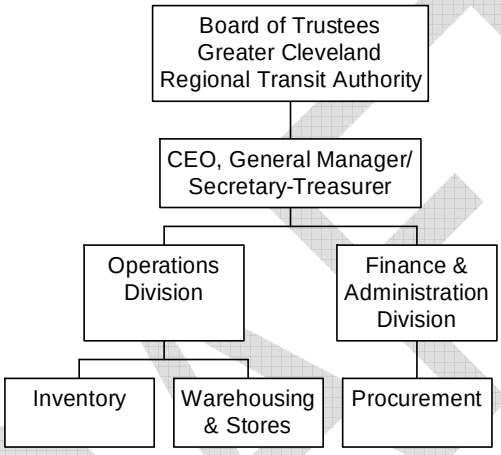

Figure 5.3. Cleveland RTA Organizational Structure

The Denver Regional Transit District was created by the Colorado General Assembly in 1969 and, subsequently, expanded in 1975. The Denver RTD General Manager reports to a Board of Directors, which consists of 15 members publicly elected (1 from each of 15 districts). Members serve a 4-year term with elections staggered so that 8 seats are open in one general election and 7 in the next. As a public transportation system, RTD operates in a 7-county service area and serves 38 municipalities in 6 counties and 2 city/county jurisdictions. While the Administrative headquarters is in Denver, there are four operating facilities: two in Denver, one in Aurora, and one in Boulder. Inventory and procurement are managed under the direction of the Assistant General Manager, Administration. Responsibility for the warehousing & stores function falls under the direction of

Assistant General Managers for Administration, Bus Operations, and Rail Operations. The Denver RTD Organizational Structure is outlined in Figure 5.4

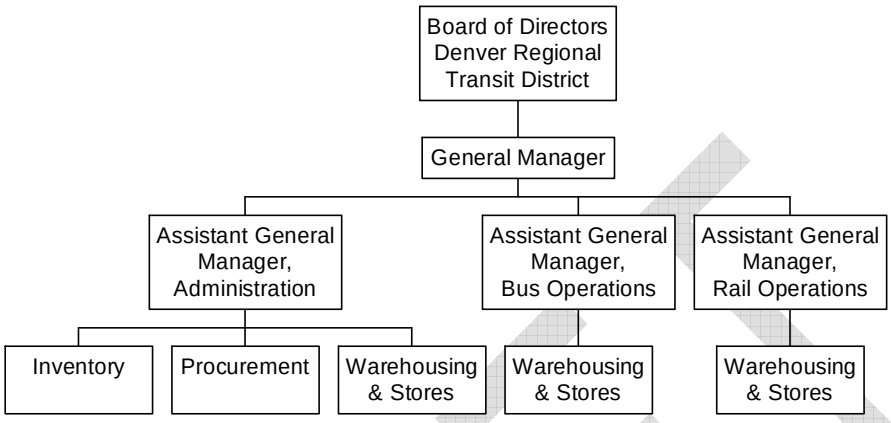

Figure 5.4. Denver RTD Organizational Structure

Facts and Figures

Following is information obtained from the National Transit Database for reporting year 2002. The data provide an overview of Miami-Dade Transit and the three peer agencies that are 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 22. All are multi-modal and provide bus service, demand response service and some form of rail service.

Table 5.1. National Transit Database Agency Information, 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

Peer Agency Performance Data - Bus

Table 5.2. Peer Agency Performance Data - Bus, 2002

Performance Measures - Bus	*Miami-Dade Transit*	*Baltimore MTA*	*Cleveland RTA*	*Denver RTD*	*Average*
Service Efficiency					
Operating Expenses/Vehicle Revenue Mile	$6.25	$8.07	$7.97	$5.58	$6.97
Operating Expenses/Vehicle Revenue Hour	$78.55	$99.43	$99.77	$82.29	$90.01
Cost Effectiveness					
Operating Expenses/Passenger Mile	$0.60	$0.58	$0.92	$0.64	$0.69
Operating Expenses/Unlinked Passenger Trip	$2.59	$2.16	$3.48	$3.03	$2.82
Service Effectiveness					
Unlinked Passenger Trips/Vehicle Revenue Mile	2.41	3.74	2.29	1.84	2.57
Unlinked Passenger Trips/Vehicle Revenue Hour	30.30	46.07	28.66	27.12	33.04

Source: 2002 National Transit Database

MDT's bus operations performed well in comparison with the three peer agencies in the areas of service efficiency and cost effectiveness, reporting the lowest operating expense per vehicle revenue hour in service efficiency. Service effectiveness performance measures show that MDT fell below the agency average for unlinked passenger trips per vehicle revenue mile and hour.

Peer Agency Performance Data – Heavy Rail

Table 5.3. Peer Agency Performance Data - Heavy Rail, 2002

Performance Measures - Heavy Rail	*Miami-Dade Transit*	*Baltimore MTA*	*Cleveland RTA*	*Denver RTD*	*Average*
Service Efficiency					
Operating Expenses/Vehicle Revenue Mile	$8.34	$8.59	$10.76	N/A	$9.23
Operating Expenses/Vehicle Revenue Hour	$209.03	$213.29	$232.60	N/A	$218.31
Cost Effectiveness					
Operating Expenses/Passenger Mile	$0.57	$0.62	$0.42	N/A	$0.54
Operating Expenses/Unlinked Passenger Trip	$4.47	$2.76	$3.18	N/A	$3.47
Service Effectiveness					
Unlinked Passenger Trips/Vehicle Revenue Mile	1.86	3.11	3.38	N/A	2.78
Unlinked Passenger Trips/Vehicle Revenue Hour	46.74	77.19	73.07	N/A	65.67

Source: 2002 National Transit Database

MDT's heavy rail system performed better than peer agencies in the areas of service efficiency, reporting the lowest measures in both of those categories. Cost effectiveness measures showed MDT with the highest level of operating expenses per unlinked passenger trip and the median operating expenses per passenger mile. MDT provided far fewer unlinked passenger trips per vehicle revenue hour and mile than peer agencies.

Peer Agency Performance Data – Demand Response

Table 5.4. Peer Agency Performance Data - Demand Response, 2002

Performance Measures - Demand Response	*Miami-Dade Transit*	*Baltimore MTA*	*Cleveland RTA*	*Denver RTD*	*Average*
Service Efficiency					
Operating Expenses/Vehicle Revenue Mile	$2.03	$3.21	$7.19	$4.51	$4.24
Operating Expenses/Vehicle Revenue Hour	$32.61	$46.61	$98.78	$48.13	$56.53
Cost Effectiveness					
Operating Expenses/Passenger Mile	$1.60	$3.13	$8.68	$3.50	$4.23
Operating Expenses/Unlinked Passenger Trip	$21.27	$23.12	$47.20	$31.26	$30.71
Service Effectiveness					
Unlinked Passenger Trips/Vehicle Revenue Mile	0.10	0.14	0.15	0.14	0.13
Unlinked Passenger Trips/Vehicle Revenue Hour	1.53	2.02	2.09	1.54	1.80

Source: 2002 National Transit Database

MDT's demand response service efficiency were better than peer agencies and less than half of the operating expenses per vehicle revenue mile and passenger mile. As with bus and heavy rail, service effectiveness fell below the average, and MDT provided the fewest unlinked passenger trips per vehicle revenue mile as well as vehicle revenue hour.

Table 5.5. Peer Agency Performance Data - Automated Guideway, 2002

Performance Measures - Automated Guideway	*Miami-Dade Transit*	*Baltimore MTA*	*Cleveland RTA*	*Denver RTD*
Service Efficiency				
Operating Expenses/Vehicle Revenue Mile	$17.37	N/A	N/A	N/A
Operating Expenses/Vehicle Revenue Hour	$189.38	N/A	N/A	N/A
Cost Effectiveness				
Operating Expenses/Passenger Mile	$3.59	N/A	N/A	N/A
Operating Expenses/Unlinked Passenger Trip	$3.69	N/A	N/A	N/A
Service Effectiveness				
Unlinked Passenger Trips/Vehicle Revenue Mile	4.71	N/A	N/A	N/A
Unlinked Passenger Trips/Vehicle Revenue Hour	1.39	N/A	N/A	N/A

Source: 2002 National Transit Database

Unfortunately, the peer agencies selected offered no systems comparable to Miami-Dade Transit's Metromover. Metromover tends to provide less efficient service that is more costly and less effective than the other modes with the exception of unlinked passenger trips, where it is slightly more costly than bus but less expensive than heavy rail and demand response.

In summary, MDT provides more efficient service and more cost effective service when compared to Baltimore MTA, Cleveland RTA, and Denver RTD, but falls behind all three agencies in providing effective service.

Inventory Tools Currently In Use

Miami-Dade Transit

- Use legacy (mainframe) system developed in-house for Y2K
- Implementing Enterprise Asset Management System that will interface with maintenance operations and incorporate barcode technology
- Cycle counts are auto generated daily based on 15 bin trips, transaction discrepancies, variance of certain size and time since last counted (everything at least once every 2 years)
- Prior to computerization in 1987, contracted out wall-to-wall annual count

Baltimore MTA

- Activated Maximo in 1999 for inventory and in 2001 for procurement
- Working on an interface with the State Financial Management Program
- Maximo contains no backorder system
- Barcodes are not used, all parts are assigned an MTA#
- ABC analysis is conducted annually

Cleveland RTA

- Use legacy (mainframe system) developed in-house 24 years ago
- New Ultramain software for a maintenance inventory control system is under development
- Barcodes are not used, a sticker containing the purchase order RTA # is affixed to parts
- Physical count of 80% of dollars (either $2.50 or $5.00 minimum) annually

Denver RTD

- Use a 1977 legacy (mainframe system) that was modified in 1978 and rewritten in 1982; lost most IT staff familiar with system in 2002; made decision not to maintain the system; RFP for new system, including bus maintenance program, in final review process
- Use barcode (Code 39) only on parts/shipments of common shop supplies
- All storerooms conduct blind cycle counts (hand counts); quarterly top 20% most active items (top 5% every quarter, 15 % two times a year, bottom 80% in 3rd quarter

A commonly accepted best practice regarding inventory management tools is the utilization of advanced technology, wherever possible. Specifically, an agency should implement computerized and automated systems, and these systems should be properly maintained and supported. Clearly, MDT and the peer agencies have attempted to meet this practice. Each agency has either fully computerized its

system or is in the process of doing so. In addition, older systems were modified or are currently undergoing modification.

Each agency's commitment to using advanced technology also furthered the best practice of maintaining high data quality standards. The peers demonstrated that they recognize the importance of generating reliable and accurate data. Peer agencies were also at various stages of utilizing or adopting best practice inventory control tools, such as hand-held devices and the use of bar codes.

Outsourcing As An Option

Miami-Dade Transit

- Outsource hardware (nuts and bolts); vendor sets up bins and replenishes stock as necessary

Baltimore MTA

- Outsource hardware; vendor set up bins and does counts as well as sampling to Grade 8 standards
- Considering outsourcing parts packages for brakes and preventive maintenance inspections

Cleveland RTA

- Have never completed a formal "outsourcing" study
- Outsource all liquids to contractors; do releases against the contract, which works well
- 3rd party oversees monitoring of underground tanks
- Looking at expanding to other areas

Denver RTD

- Conducted a thorough study of potential outsourcing and decided it was not economical
- Do provide support to private carriers; they charge back for labor and materials as well as perform warranty work

In the area of outsourcing, best practices frequently suggest the possibilities for outsourcing and proceeding with implementation should be investigated if a substantial financial benefit can be realized. Agencies studied here differ substantially in the area of outsourcing. MDT out sources most rebuilds and some hardware setup. Like MDT, Baltimore MTA engaged in the outsourcing of hardware. Denver RTD completed a thorough study and decided that outsourcing did not meet its needs. Lastly, although Cleveland RTA has not formally studied the issue, it does not consider outsourcing of inventory items beyond the realm of future possibilities. In fact, Cleveland RTA outsources the handling of it consumable liquids.

Inventory Techniques for Consumables

Miami-Dade Transit
- Daily calculations and order quantity for liquids, such as fuel, engine oil and transmission fluid, based on tank size
- Competitive bid on all fuels and lubricants
- Process releases against multiyear annual contracts
- Maintenance track fuel use with an electronic system (cards)

Baltimore MTA
- Liquid inventory items are handled through stores/inventory and managed through inventory management control like all other items
- Petroleum products are handled through the Department of General services under a statewide Department of Transportation contract

Cleveland RTA
- Outsource all liquids
- Do releases against contracts
- Pleased with system, which has never resulted in a shortage

Denver RTD
- Consumables are limited by: tank size, project use, and vendor lead time

The peer agencies displayed a variety of techniques for handling the inventory of consumable products. Cleveland reported satisfaction with its method of outsourcing all liquids in its inventory. Benefiting from its arrangement with the Maryland Department of Transportation, Baltimore is able to purchase liquid consumables under the state contract. This could be viewed as an example of the best practice that encourages strong cooperation among departments and divisions. (In this case, two departments within the state government are in a cooperative agreement.

Usage Patterns

Miami-Dade Transit

- Minimum/Maximum
- Requisition is auto generated and reviewed by inventory control
- Requisition lists usage for past 12 months, purchase history, Min/Max, and quantity on hand
- Analysis is performed during the requisitioning process
- New computer system, as designed, does not include the function of "calculating the re-order point," which is of major concern to Materials Management

Baltimore MTA

- Minimum/Maximum
- Auto report for reorder reviewed by supervisor
- Current problems with auto reorder in new Maximo system, which allows no differentiation for campaigns or lead time

Cleveland RTA

- Minimum/Maximum
- Planners look at history of use
- Key items: 3-4 turns a year but overall on 1.5 turns per year
- Bottom line – they do not want to run out so they maintain a 30-day supply

Denver RTD

- Double exponential algorithm + economic order quantity (different than a fixed order technique)
- Verify by comparing with accumulated mileages = dependent demand
- Items are purchased for direct shipment to each location

Current best practices to deal with inventory depletion and replenishment rely heavily on advanced technology. Specifically, systems capable of demand on request only, automated reorder, and predicted usage are recommended. In addition, automatic delivery to the order-generating point has been shown to increase efficiency. MDT and each of the peers engaged in one or more of these practices.

Maintenance Performance Monitoring

Miami-Dade Transit

- Presently monitor performance by "buses out of service for parts;" goal is less than 2% of the fleet, which they are achieving
- Used to monitor by stock-out rate, but lost ability to track with new computer system installed in 2000
- Turnover Rates

Baltimore MTA

- Turnover Rate – Goal = 3; was 2.7 for several years, but have not calculated recently

Cleveland RTA

- Turnover Rate – Goal = 3, which they can accomplish if fuel purchases are included (fuel is currently contract-out)
- PO processing targets – requisition to PO = 6-10 days, buys 75% bus / requisition to PO = 45-60 days, buys 25% rail / PO to receipt = 10 days

Denver RTD

- Stock-out rate is the only performance measure tracked (stock-out = not available at specific location)
- Roadcall history
- Oil analysis
- Body damage surveys
- Two dozen significant shortcomings of the system – all concern the ability to use maintenance information to project inventory needs (maintenance interface), better IT ability to restore the system, need direct link with electronic parts book, ability to batch up and vendor ID, new warehouse, retire subfleet

Performance monitoring was somewhat limited at most of the study sites. Two peer agencies established the same inventory turnover rate goal; however, neither agency tracked those turnover rates. In an ironic twist on the best practice of implementing new technology, MDT, which had monitored stock-out rate in the past, was unable to do so under its new computer system. Stock-out rate was the only performance measure tracked at RTD, and this was due in part to limitations of its new information technology practices.

Interdepartmental Cooperation

Miami-Dade Transit

- Storeroom supervisors work closely with maintenance to determine material requirements and coordinate with inventory control, which sets stocking levels at central warehouse
- Storeroom stocking levels are set by storeroom supervisors with the coordination of inventory control
- Buyers rotate except in the areas of bus and rail parts due to learning curve required

Baltimore MTA

- Divisions review obsolete items list
- Satellite storerooms offer feedback and direct contact

Cleveland RTA

- Planners work closely with maintenance on campaigns

Denver RTD

- Sr Buyer and Sr Materials Management Specialist rotate to stay sensitive to other jobs; they have the closest day-to-day interface with maintenance
- Inventory Control determines, with facility input, what needs to be stored at the facility – determine list, review use at location, and adjust (add/delete)

Both MDT and Denver RTD engaged in the practice of periodically rotating personnel. Best practices encourage strong communication between divisions, specifically, strong teamwork among the inventory, purchasing, and maintenance departments.

Storehouses and Facility Stock Items

Miami-Dade Transit

- Bus Central Warehouse supplies parts to 4 bus satellite storerooms
- 3 bus satellite storerooms staffed 24 x 7; 1 bus satellite storeroom staffed 8 x 5 (Central Overhaul)
- 1 rail storeroom staffed 24 x 7; 1 mover storeroom staffed 18 x 7 considering elimination of weekend hours
- All storerooms are closed to maintenance staff

Baltimore MTA

- Main Warehouse staffed 24 x 5 + 8 Saturday + 8 Sunday
- 4 bus satellite storerooms: Bush-2 shifts on weekdays; Eastern, Kirk, and Northwest-1 shift on weekdays
- Satellite storerooms for light rail and heavy rail are staffed outside of Materials Management
- Divisions have access to storerooms continually
- Bus (Monroe Street)-20,960 line items; Metro-17,361 line items; Light Rail-12,593 line items

Cleveland RTA

- Central Warehouse plus satellite storerooms: 3 bus, 1 rail, 1 Paratransit, and District Shops
- Reported excessive amount of redundancy – Bus = 100%; each bus division has all of the same parts/inventory regardless of fleet; no redundancy at rail or Paratransit
- 5,000 items at each storeroom; 29,000 line items at Central Bus

Denver RTD

- Line items: Central Warehouse - 441,016; Platte – 57,683; East Metro – 44,824; Boulder – 37,476; Quality Control - 68

MDT was the only agency that staffed its storerooms continuously. In general, storerooms at the peer agencies were accessible continually; however, storeroom staff was present generally during one to two shifts on weekdays. While no specific best practices in this area can be pinpointed, hours of operation at the four agencies can be said to meet the recommendations for fast response times to inventory requests. This helps foster a more efficient and more reliable inventory operation.

Maintenance Facility Storerooms

Miami-Dade Transit

- Bus-Central O&I Storeroom
- Bus-Central Support Storeroom
- Bus-Coral Way O&I Storeroom
- Bus-Northeast O&I Storeroom
- Rail-Lehman Storeroom
- Mover Storeroom
- Materials Management Managers supervise Storeroom staff

Baltimore MTA

- Bus-Main, Body & A/C Shops Storeroom
- Bus-Bush Division Storeroom
- Bus-Eastern Division Storeroom
- Bus-Kirk Division Storeroom
- Bus-Northeast Division
- Rail-Metro Storeroom
- Light Rail Storeroom
- Division Managers supervise Division Storeroom staff

Cleveland RTA

- Bus-Triskett District Storeroom
- Bus-Brooklyn District Storeroom
- Bus-Woodhill District Storeroom
- Rail-Grand District Storeroom
- Paratransit Storeroom
- District Managers supervise District Storeroom staff

Denver RTD

- Bus-Boulder Division Storeroom
- Bus-East Metro Division Storeroom
- Bus-Platte Division Storeroom
- Light Rail Division Storeroom
- Division Managers supervise Division Storeroom staff

The best practice of decentralization is seen at each peer agency. In addition to a central warehouse facility, each agency had at least three satellite storerooms. This practice increases efficiency by storing and providing necessary stock close to the facilities where they are needed. MDT was the only agency of the four where all storeroom staff reported directly to the Materials Management Division.

Central Distribution

Miami-Dade Transit

- Central Warehouse receives all bus parts and supplies and distributes to the storerooms after supervisors review
- Rail and Mover storerooms receive parts and supplies unique to those facilities directly from the vendor
- Procurement prepares requisitions and forwards to Storeroom Supervisors, who review and send; everything is tracked
- If an item goes directly to a storeroom rather than the warehouse, a request to transfer is completed

Baltimore MTA

- Main Warehouse orders for and delivers to satellite storerooms
- Once delivered to the storeroom, items are removed from the inventory

Cleveland RTA

- Central Warehouse stores common supplies
- Satellite storerooms receive shipments directly rather than receiving through the Central Warehouse
- Satellite storerooms are vehicle specific

Denver RTD

- Central Warehouse stores common supplies

As mentioned earlier, each peer agency is engaged in the recommended practice of decentralization. A central warehouse facility is used to store common supplies, and the supplies are distributed to satellite locations as necessary. In some instances, inventory items are shipped directly to the satellite location that generated the order.

Security

Miami-Dade Transit

- Storerooms are closed to maintenance personnel
- Materials is issued on "material issue tickets" and signed by mechanics
- Perpetual inventory is updated at time of issue
- Escorts are required
- Request for CCTV has been submitted

Baltimore MTA

- Card swipe on most external building doors
- Satellite storeroom access 24 x7
- Maintenance completes Work Order – holds part = automatic inventory reduction; not related to installation on a specific vehicle

Cleveland RTA

- Most buildings have card swipe coded by employee
- Varying levels of security, new construction more sophisticated
- Only "Stock Personnel" are allowed in storerooms unless questions arise, them mechanic allowed entry with escort

Denver RTD

- Closed circuit cameras that scan for movement in specific areas; card key access; fence around receiving
- Level of distribution based on level needed; high security equals anything that could be used in a private residence; identify as an unusual variance in cycle counts; inconsistencies are recounted in Central Warehouse
- Mechanic records Work Order and bus # after the fact; item is tracked in inventory system until part is used by the mechanic
- Storerooms are closed at the Division level with the exception of Light Rail, which is open

While each of the four transit agencies compared in this study report similar technologies in use, their security actions vary widely in practice. However, some rules, such as requiring an escort to accompany maintenance personnel inside the storeroom, are followed at each agency. The best practice of utilizing the best available technology can also be applied to security, and this seems to be in effect at varying degrees from agency to agency. Lastly, one can argue that actively and adequately staffed storerooms are more secure. Each peer agency has a broad range of operational hours, and as such, can be said to have an added element of security.

Assignment of Value—Rebuilt Parts

Miami-Dade Transit

- Average cost
- Items rebuilt in-house are valued at average price
- Most major components are outsourced

Baltimore MTA

- No value is attached to in-house rebuilds (this may change in the future)
- Outside rebuilds maintain the dollar value that is invoiced against them
- Rebuilt items are handled like any other item; there is a reorder point assigned; when that threshold is reached, pending rebuilds are sent out (either to in-house or outside vendor)
- Processes are being assessed for improvement
- Major components are repaired in-house, minimal outsourcing

Cleveland RTA

- Shops receive orders directly as do satellite storerooms
- Turn request over in 24 hours and special/emergency request the same day
- Rebuilt parts are valued at zero cost; the accounting structure is such that the pieces used during the rebuild procedure are expensed; the rebuilt item is returned to inventory at zero cost, which helps avoid double counting; once in the inventory, items are tracked from storeroom to bus
- Major components are repaired in-house, minimal outsourcing

Denver RTD

- Value of rebuilt parts depends on item; labor, parts and materials are budgeted at the shop where the rebuild is accomplished; zero value for in-house rebuilds
- Outsourced rebuilds are valued at full value
- If a part/item is modified in-house, then value is full value plus the cost of installed parts
- Major components are repaired in-house, minimal outsourcing

The peer agencies have differing and somewhat complex methods for valuing rebuilt parts. The way in which parts are rebuilt effects how the agency assigns value to them. Those agencies that assign zero value to rebuilt parts that are returned to inventory will tend to report a lower total inventory.

Counts and Discrepancies

Miami-Dade Transit

- Cycle Counts generated electronically daily based on: every 15 bin trips, transaction discrepancies, every item once every two years, and zero balance
- Computer generates recounts for discrepancies over 20 items and/or $50
- Recount discrepancies must be adjusted by supervisors
- Variance is calculated one time a year

Baltimore MTA

- Cycle Count equals ABC analysis: run Maximo one time a year ("A" two times, "B" one time, and "C" one-third one time (standard procedure)
- Storeroom attendants do counts and recounts out of Central Inventory when items move to satellite storeroom

Cleveland RTA

- Physical Count one time a year–80% of dollars, minimum of $2.50/$5.00
- Must be completed by May 1 annually
- Pull staff in from district storerooms to assist
- A great deal of variance: Garage – pieces/parts = 30% variance and dollars = 5-10% variance; Central – pieces/parts = 30% variance and dollars = 0.5% variance

Denver RTD

- Cycle Counts are all blind counts (hand counts): quarterly some portion of the top 20% (most active items) are counted: the top 5% is counted every quarter and the next 15% is counted two times a year; the bottom 80% is counted in the 3rd quarter
- All storerooms do cycle counts on same schedule
- Variances are recounted in Central Warehouse; cycle counts uncover errors
- Low stock-out rate is a good indicator

Cycle counts, an accepted best practice, are clearly the most common among peer agencies. The agencies engaged in a variety of other best practices that help achieve consistent and accurate inventory counts, including: blind counts, physical counts, written policies, accountability, specified frequency of counts, and enlisting knowledgeable staff to participate in the counting activities.

Obsolete Inventory

Miami-Dade Transit

- Generally keep parts on hand, if used on active fleet regardless of history
- Material identified as obsolete is staged for sale at a remote location
- County GSA advertises material to be sold (pennies on the dollar)
- Have just started a program to return excess and obsolete material to vendors – too early to tell what degree of success
- New inventory estimated for Rail Rehab = $17 million

Baltimore MTA

- Develop manual list, if no usage in 2 years, send list to Division to verify, buyers code suspect obsolete items when they can't order, trying to organize to minimize physical inventory
- Auditors, if not used within 2 years, deal with all parts the same way
- Materials Management staff want to classify parts as: Critical – save for the life of the vehicle if no replacement available, Non-critical, and Commodities

Cleveland RTA

- All inactive for 36 months
- Identify what fleets are no longer available and have Operations review parts that can be used elsewhere, list everything else and send to Procurement for bids
- Very poor return (value of $1.5 million got a bid of $1,600 and ended up donating it to a technical school)
- Do try to get credits from vendors and have had some success

Denver RTD

- Look at type of vehicle and supplier
- Big problem with obsolete due to vendor performance (error-43/100 orders)
- Most inventory is kept until related vehicles are retired, RTD tends to keep vehicles long enough so that no other peer agencies have the vehicle
- Attempt to return parts to the manufacturer or sell the parts at auction along with the related vehicle.

While methods differed from agency to agency, each peer transit agency had well-established and detailed methods for dealing with obsolete stock. Best practices dictate that outdated items be dealt with in a timely fashion.

Inventory Management Standards

Miami-Dade Transit

- Turnover Rate – ranged from 0.38 for Metromover to 6.28 for Central O&I in June 2004
- Warehouse and Stores – Re-label 50% of 98,265 bins with bar-coding labels to accompany new computerized Materials Management System
- Bus Down for Parts – goal is 2 ½% vehicle down for parts ratio
- Warranty Administration – maximize level of supplies/manufacturer's compensation received by MDT
- Inventory – reduce vendor backorders from an average of 90 days to a 45-day margin
- Procurement – develop a real-time report of procurement requisitions

Baltimore MTA

- Turnover rate – aiming for 3, was 2.7 several years ago

Cleveland RTA

- Every employee completes a performance plan, which is generic within the agency rather than being position specific
- RTA Goal – a turnover rate of 3, which they can accomplish if fuel purchases are included
- Procurement's main concerns – price/quality/service
- Vendor performance is an issue – no guidelines/no follow-up on receipt of PO from vendor
- Low bid is only factor until something t happens to force the issue

Denver RTD

- Low stock out rate (stock out = not available at specific location) makes it difficult to fudge the count if high service level
- Have not measured inventory turns in a long time; the only current performance measure is the stock out rate
- Required higher safety stock because of poor suppliers: developed Vendor Rating-factored in procurement decision: 1% cost add-on for each 2% performance differential – focus: on-time + correct order

The overall management philosophy of each agency seems to be reflected in the standards established for managing inventory. The peer agencies were all actively engaged in pursuing technology upgrades, maintaining turnover goals, and encouraging time-saving and money-saving practices. Best practices have also been identified for dealing with vendors. Specifically, peer agencies were at various stages in implementing or developing methods to qualify vendors, monitor their

performance, develop stronger relationships with them, and identify new products and new vendors.

Procurement

Miami-Dade Transit

- Materials Management staff are responsible for procurement, inventory control, the central warehouse (bus), satellite storerooms and warranty recovery

Baltimore MTA

- Two different groups handle procurements: 1) Contract Department and 2) Purchasing, which actually does small procurement function as well
- Purchasing does not have a dollar limit on commodity purchases, but there is a $25,000 limit on other items

Cleveland RTA

- Procurement is administered through the Finance & Administration Division
- Two areas of procurement: 1) Small purchases (under $25,000) and 2) Contract purchases (over $25,000 to s specific contractor) require the General Manager's approval

Denver RTD

- The Contract Negotiator, who reports to the Senior Manager of Materials Management, handles negotiated procurements, RFPs, cost analysis, R&D contracts, qualification review, and negotiations for needed services

While specific details vary by agency, the peers generally handled procurement based on item cost. Each agency is obligated by law to follow relevant local statutes. Once a threshold dollar amount is reached (often $25,000), the purchase must be approved by top-level management. Procurement staff is usually grouped according to the financial threshold. In some cases, high value commodity purchases are exempt from approval. No peer agencies actively engaged in procurement activities involving the use of the internet.

Allocation of Staff

Administration

	Miami-Dade Transit	*Baltimore MTA*	*Cleveland RTA*	*Denver RTD*
Chief, Materials Management	1	1	1	1
Admin Secretary	1			1
Total	2	1	1	2

Procurement

	Miami-Dade Transit	*Baltimore MTA*	*Cleveland RTA*	*Denver RTD*
Administrative Assistant		1	1	
Administrative Officer II	2			
Buyer	7			1
Chief Purchasing		1		
Clerk	1		2	
Contract Monitor			2	
Contract Negotiator				1
Manager, Materials Handling & Purchasing				1
Materials Management Specialist				3
Office Support Specialist II	1			
Planner			3	
Procurement & Contracts Manager	1			
Purchasing Staff		8		4
Sr Buyer				1
Sr Materials Management Specialist				5
Supervisor			2	
Transit Contract Compliance Officer	3			
Transit Contracts Specification Supervisor	1		Finance	
Finance Procurement			11	
Total	16	10	21	16

Inventory Control/Central Warehouse

	Miami-Dade Transit	Baltimore MTA	Cleveland RTA	Denver RTD
Administrative Officer II	1			
Central Warehouse Supervisor			1	1
Cost/Price Clerk		9		
Inventory Management Officer	1	1	1	
Lead Cost/Price Clerk		1		
Material Handler Stock Clerk			14	
Material Handler Stock Clerk Lead			2	
Parts Clerk			1	18
Receiving Clerk/Storeroom Attendant		14		
Supervisor		5		
Transit Stock Control Specialist	5			
Warehouse Bus Stock Clerk	13			
Warehouse TPSS	2			
Total	22	30	19	19

Warehousing & Stores (Satellite)

	Miami-Dade Transit	Baltimore MTA	Cleveland RTA	Denver RTD
Bus Stock Clerk	23			
Materials Handling/ServiceCleaning Supervisor				1
Office Support Specialist 1	1			
Parts Clerk			18	2
Rail Stock Clerk	18			
Secretary	1			
Storeroom Supervisor		7		3
Transit Purchasing & Store Supervisor	7			
Warehousing & Stores Superintendent	1			
Total	51	7	18	6

Warranty Recovery

	Miami-Dade Transit	Baltimore MTA	Cleveland RTA	Denver RTD
Warranty Supervisor	1	Quality	Tech	
Clerk IV Warranty Clerk	1	Assurance	Services	
Administrative Officer 2	1			
Sr Quality Control Inspector				1
Quality Control Inspector				1
Warranty Administrator	1			
Warranty Engineer				1
Total	4			3

Department	*Miami-Dade Transit*	*Baltimore MTA*	*Cleveland RTA*	*Denver RTD*
Administration	2	1	1	2
Procurement	16	10	21[a]	16
Inventory Control/Central Warehouse	22	30	19	19
Warehousing & Stores (Satellite)	51	7[b]	18[b]	6[b]
Warranty Recovery	4	0[c]	0[d]	3
Total	**95**	**48**	**59**	**46**

[a] 11 of 21 staff report to Finance
[b] Employees report to a Division rather than to Materials Management
[c] Quality Assurance provides warranty recovery
[d] Technical Services provides warranty recovery

Differences in staff allocation caused the overall number of materials management employees to appear much larger at MDT. In fact, the overall number of employees at MDT was more than double that of Baltimore MTA and Denver RTD and slightly less than twice that of Cleveland RTA. Specifically, MDT had more warehousing & stores personnel; however, each agency had similar quantities of employees in the Administration, Procurement, Inventory Control/Central Warehouse, and Warranty Recovery areas of materials management.

MDT's complement of warehousing staff exceeded that of peer agencies due to the fact MDT's maintains stock personnel in most of their satellite storerooms 24 hours a day, seven days a week, while peer agencies provide stock personnel in satellite storerooms on 1 or 2 shifts during the week.

Inventory

Miami-Dade Transit

- All items stored in Satellite Storerooms are included in the inventory

Baltimore MTA

- Items assigned to the Satellite Storerooms are removed from the inventory at time of transfer
- The value of all items currently stored at the seven satellite shops is not reflected in the inventory dollars identified below

Cleveland RTA

- Inventory figures include repair parts that are generally under $1,000
- The Inventory Manager estimates that approximately $200,000 is not included in the inventory
- Grant (capital items such as engines), Metal Shop and Component Shop items are not included in the inventory dollars

Denver RTD

- All items assigned to Satellite Storerooms are included in the inventory

Inventory	*Miami-Dade Transit*	*Baltimore MTA*	*Cleveland RTA*	*Denver RTD*
Central Warehouse	$6,300,000	$8,500,000	$4,750,000	$4,000,000
Bus	$2,700,000		$800,000	$2,100,000
Heavy Rail	$9,800,000	$6,000,000	$2,800,000	
Light Rail		$10,000,000		$2,600,000
Mover	$3,800,000			
Total Inventory	$22,600,000	$24,500,000	$8,350,000	$8,700,000

The four agencies were split in how they allocated items to the inventory. Stock items in satellite storerooms at both MDT and Denver RTD are included in the inventory. Baltimore MTA removes items from inventory once they are sent to satellite locations. Cleveland RTA also has a portion of stock that is not included in inventory totals. In addition, a variety of valuing practices used by the peers for rebuilt items returned to the inventory impact total inventory value.

In order to obtain a clearer picture of actual inventory values in relationship to vehicles across the four transit agencies, researchers examined currently available data. Unfortunately, the most recent data available for vehicles operated in maximum service is the 2002 National Transit Database. Given the fact that the inventory dollars presented in this report were 2004 dollars, researchers recognized that an adjustment in the 2004 dollars, using the CPI, could provide a more realistic data set and allow calculation of the inventory value for the 2002 vehicle fleets. The following tables (Tables 5.6 – 5.8) reflect an adjustment of the 2004 inventory dollars, 2002 vehicles available for maximum service, and the inventory allocation of the 2002 vehicles using adjusted 2002 dollars.

Table 5.6. 2004 Inventory Dollars Reflected in 2002 Dollars

Inventory	*Miami-Dade Transit* [b]	*Baltimore MTA* [b]	*Cleveland RTA* [b]	*Denver RTD* [b]
Central Warehouse/Bus[a]	$8,415,365	$7,947,845	$5,189,475	$5,703,748
Heavy Rail	$9,163,398	$5,610,244		
Light Rail		$9,350,406	$2,618,114	$2,431,106
Mover	$3,553,154			
Total Inventory	$21,131,917	$22,908,495	$7,807,589	$8,134,854

[a] *Central Warehouse and Bus Storerooms inventories were combined to facilitate comparison*
[b] *reflect 2004 dollars adjusted to 2002 dollars based on the CPI*

Table 5.7. 2002 Vehicles Available for Maximum Service

Inventory	*Miami-Dade Transit 2002 Vehicles* [b]	*Baltimore MDT 2002 Vehicles* [b]	*Cleveland RTA 2002 Vehicles* [b]	*Denver RTD 2002 Vehicles* [b]
Central Warehouse/Bus[a]	969	1,010	748	1,134
Heavy Rail	136	100	108	
Light Rail		53		49
Mover	29			
Total Inventory	1,134	1,163	856	1,183

[a] *Central Warehouse and Bus Storerooms inventories were combined to facilitate comparison*
[b] *Source: 2002 National Transit Database*

Table 5.8. 2002 Inventory Dollars per Vehicle Available for Maximum Service

Inventory	*Miami-Dade Transit Inventory per Vehicle*	*Baltimore MDT Inventory per Vehicle*	*Cleveland RTA Inventory per Vehicle*	*Denver RTD Inventory per Vehicle*
Central Warehouse/Bus[a]	$8,685	$7,869	$6,938	$5,030
Heavy Rail	$67,378	$56,102	$24,242	
Light Rail		$176,423		$49,614
Mover	$122,523			
Total Inventory	$18,635	$19,698	$9,121	$6,876

[a] *Central Warehouse and Bus Storerooms inventories were combined to facilitate comparison*

Given the significant variations in the allocation and valuation of inventory stock, the above analysis offers little in terms of meaningful comparison of the inventory per vehicle across the four transit agencies.

Findings from Site Visits

- MDT's structure is unique in relationship to peer agencies, which are more closely aligned with state or regional government.
- MDT provides more efficient service and more cost effective service when compared to Baltimore MTA, Cleveland RTA, and Denver RTD, but falls behind all three agencies in providing effective service.
- MDT and the peer agencies attempted to meet the best practice regarding inventory management through utilization of advanced technology.
- Best practice inventory tools in place or planned included hand-held devices and bar codes.
- Agencies studied differed substantially in the area of outsourcing. Best practices mandate consideration of outsourcing.
- MDT and each of the peers engaged in one or more uses of advanced technology to deal with inventory supply.
- Performance monitoring was somewhat limited at most of the study sites. Peer agencies primarily relied on stock-out rate and/or turnover rate.
- Both MDT and Denver RTD periodically rotated personnel.
- MDT was the only agency that staffed its storerooms continuously.
- The best practice of decentralization is seen at each peer agency. In addition to a central warehouse facility, each agency had at least three satellite storerooms.
- MDT was the only agency of the four where all storeroom staff reported directly to the Materials Management Division.
- In some instances, inventory items were shipped directly to the satellite location that generated the order.
- While each of the four transit agencies compared in this study report similar technologies in use, security actions vary widely in practice.

- The peer agencies have differing and somewhat complex methods for valuing rebuilt parts.
- Cycle counts, an accepted best practice, are clearly the most common among peer agencies.
- While methods differed from agency to agency, each peer transit agency had well-established and detailed methods for dealing with obsolete stock. Best practices dictate that outdated items be dealt with in a timely fashion.
- The overall management philosophy of each agency seemed to be reflected in the standards established for managing inventory.
- Peer agencies were all actively engaged in pursuing technology upgrades, maintaining turnover goals, and encouraging time-saving and money-saving practices.
- Peer agencies were at various stages in implementing or developing methods to qualify vendors, monitor their performance, develop stronger relationships with them, and identify new products and new vendors.
- While specific details vary by agency, the peers generally handled procurement based on item cost.
- Procurement staff was usually grouped according to the financial threshold.
- No peer agencies actively engaged in procurement activities involving the use of the internet.
- Differences in staff allocation caused the overall number of materials management employees to appear much larger at MDT.
- The four agencies were split in how they allocated items to the inventory.

VI. Inventory Levels

A significant emphasis of the current project focused on MDT's inventory and whether that inventory is of proper size. The Blue Ribbon Task Force Report highlights the Materials Management Division's inventory and procurements practices in late 1985/early 1986. At the time of the report, Metrorail had been in operation a short time, and 55 of the 136 Metrorail vehicles were still under warranty. The Metromover inventory, which was operated by a contractor, was not targeted for transfer to the Materials Management Division until sometime in 1987. 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. Figure 6.1 provides an overview of the inventory split by division in 1986. The Central Warehouse and Metrorail each accounted for slightly more than one-third of the inventory, while the Bus O&I Garages and Major Overhaul, in total, were responsible for slightly less than one-third of the inventory dollars.

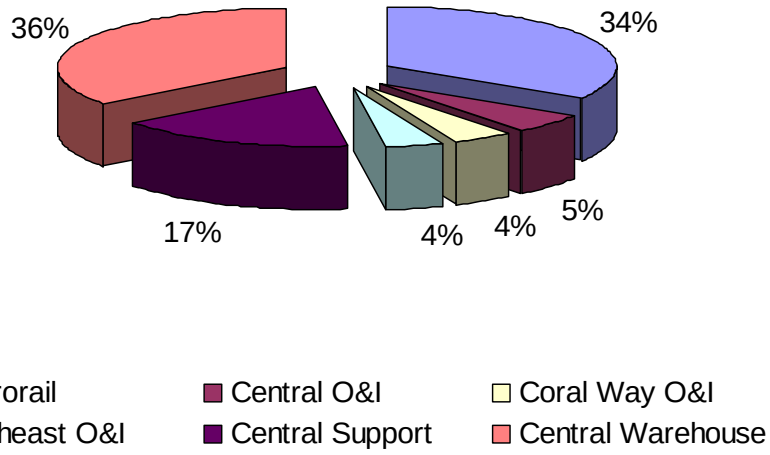

Figure 6.1. 1986 Inventory by Division

The $12.3 million inventory reported by the Blue Ribbon Task Force in 1986 was shared fairly equally between the Central Warehouse, Metrorail and the Bus Garages as shown in Figure 6.2. Since the Central Warehouse, often referred to as the Central Bus Warehouse, stocks primarily bus parts, the Blue Ribbon Commission was correct in their determination that almost two-thirds of the inventory was bus parts.

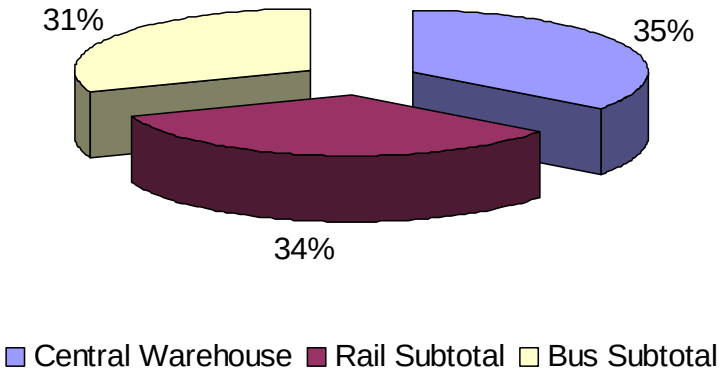

Figure 6.2. 1986 Inventory by Mode

When the warranty on the remaining 55 Metrorail vehicles expired, and responsibility for the Metromover inventory was transferred to the Materials Management Division, a major shift occurred in the allocation of the inventory. A significant increase occurred within Metrorail; Metromover obligated inventory dollars; and, the new Radio Shop established a sizeable inventory. In 2004, Metrorail accounts for 43%, Metromover requires 16%, and the Radio Shop mandates are for 6% of the inventory dollars. Figure 6.3 illustrates the 2004 inventory by division.

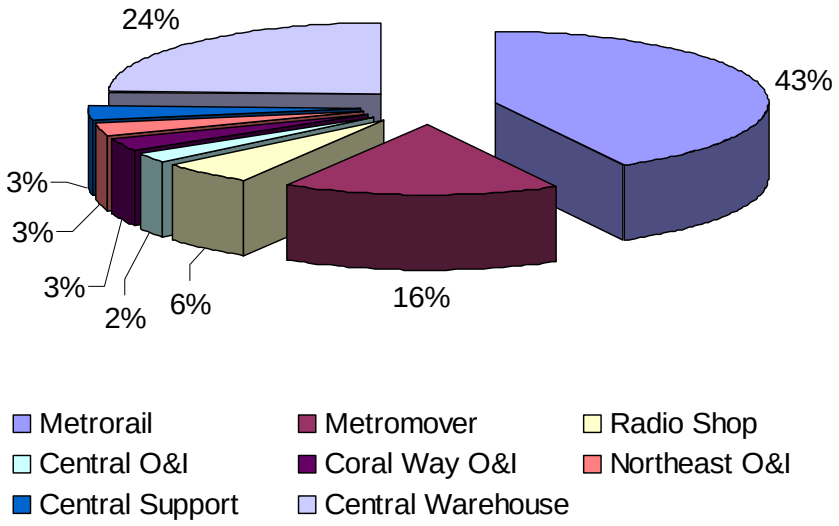

Figure 6.3. 2004 Inventory by Division

By 2000, less than four years after the Blue Ribbon Task Force Report, Rail, which includes Metrorail, Metromover and the Radio Shop, had almost doubled its percentage of the inventory allocation, from 34% to 64%, while Central Warehouse and the Bus Divisions fell to 24% and 12%, respectively, where they remain today. When combined, the Central Warehouse and the Bus Divisions represent one-third of the inventory. Figure 6.4 identifies inventory allocation by mode in 2004.

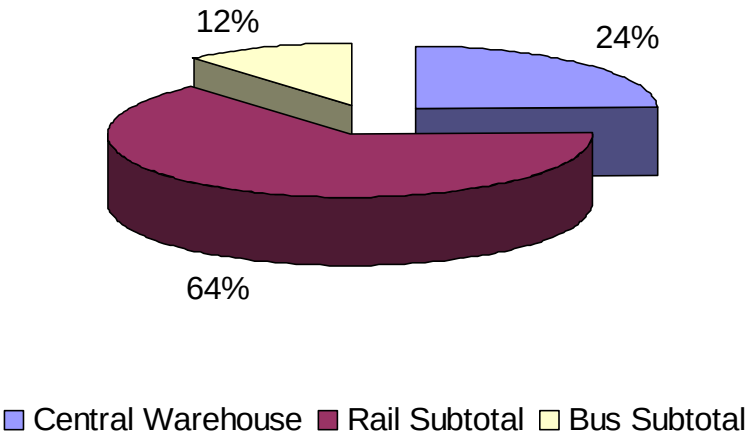

Figure 6.4. 2004 Inventory by Mode

The Blue Ribbon Task Force expressed concern about the size of the inventory in 1986 and urged a reduction in the inventory in conjunction with an overall improvement in the turnover rate of stock, which had fallen to a rate of 1.2. Following is a detailed examination of shifts in the inventory since 1986.

Actual inventory totals by garage are presented in Table 6.1. The 1986 figures were obtained from the Blue Ribbon Task Force Report. For years 2000 through 2003, the Materials Management Division's September Monthly Report was used, as it represented the end of a fiscal year. Year 2004 figures represent the actual inventory dollars on June 30 of this year.

Table 6.1. Inventory Dollars by Division

Division	*1986*	*2000*	*2001*	*2002*	*2003*	*2004[a] Actual $*
Central Warehouse	$4,336,913	$4,427,203	$4,432,834	$4,187,754	$4,742,870	$5,640,970
Metrorail	$4,164,214	$7,577,657	$8,186,703	$8,590,151	$9,210,069	$9,790,420
Metromover		$3,568,935	$3,320,964	$3,164,395	$3,562,654	$3,797,405
Radio Shop		$696,199	$918,763	$977,748	$1,303,783	$1,291,982
Rail Subtotal	$4,164,214	$11,842,791	$12,426,431	$12,732,293	$14,076,506	$14,879,807
Central O&I	$674,232	$459,062	$536,507	$520,783	$507,026	$516,358
Coral Way O&I	$528,170	$531,142	$565,847	$652,783	$740,757	$727,306
Northeast O&I	$503,669	$402,841	$491,630	$484,734	$589,232	$631,216
Central Support	$2,093,066	$862,096	$913,272	$832,014	$932,407	$794,395
Bus Subtotal	$3,799,137	$2,255,141	$2,507,256	$2,490,314	$2,769,421	$2,669,275
Total	$12,300,264	$18,525,135	$19,366,521	$19,410,362	$21,588,797	$23,190,052

[a] *As of June 30, 2004*

The 1986 inventory of $12.3 million has grown to $23.2 million, an increase of 88.5%. The current inventory does include parts and materials for the entire fleet of 136 Metrorail vehicles, parts and materials for the 29 Metromover vehicle fleet, and parts and materials for a new area, referred to as the Radio Shop. Since 1986, the Central Warehouse inventory has increased by 9.4%; the Rail inventory has increased by 257.3%; and, the Bus inventory, exclusive of the Central Warehouse, has decreased by 29.7%. When the Central Warehouse is combined with the Bus Division, inventory growth totals 2.1%. In order to determine the actual growth of the inventory, 2004 inventory dollars were adjusted for inflation. Table 6.2 provides an overview of the inventory by division adjusted for inflation since 1986.

Table 6.2. Inventory by Division Adjusted for Inflation

Division	1986 in 2004 $	2000 in 2004 $	2001 in 2004 $	2002 in 2004 $	2003 in 2004 $	2004 [a] Actual $
Central Warehouse	$6,820,626	$4,703,352	$4,706,212	$4,478,687	$4,927,537	$5,640,970
Metrorail	$6,549,024	$8,050,318	$8,691,586	$9,186,928	$9,568,670	$9,790,420
Metromover	$0	$3,791,549	$3,525,772	$3,384,232	$3,701,369	$3,797,405
Radio Shop	$0	$739,625	$975,425	$1,045,674	$1,354,546	$1,291,982
Rail Subtotal	$6,549,024	$12,581,492	$13,192,782	$13,616,835	$14,624,585	$14,879,807
Central O&I	$1,060,359	$487,696	$569,594	$556,963	$526,767	$516,358
Coral Way O&I	$830,648	$564,272	$600,743	$698,133	$769,599	$727,306
Northeast O&I	$792,116	$427,968	$521,949	$518,409	$612,174	$631,216
Central Support	$3,291,747	$915,870	$969,595	$889,816	$968,711	$794,395
Bus Subtotal	$5,974,871	$2,395,807	$2,661,881	$2,663,322	$2,877,251	$2,669,275
Total	$19,344,521	$19,680,651	$20,560,875	$20,758,844	$22,429,373	$23,190,052

[a] *As of June 30, 2004*

Note: All figures have been adjusted using the CPI inflation calculator , which uses the average Consumer Price Index for a given calendar year. This data represents changes in prices of all goods and services purchased for consumption by urban households

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% increase; and, the Bus inventory, 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 has occurred only in the area of rail. All bus divisions and the Central Warehouse reflect a decline in value (Table 6.3).

Table 6.3. Inventory Growth in Adjusted Dollars

Division	*1986 in 2004 $* [a]	*2004 Actual $* [b]	*+/- %*
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. Date represent changes in prices of all goods and services purchased for consumption by urban households.*
[b] *as of June 30, 2004*

A major contributor to inventory growth is an increase in the vehicle fleet. Inventory needs for 55 additional rail vehicles and 20 mover vehicles occurred after the 1986 Blue Ribbon Task Force Report, and the bus fleet has experienced growth as well, as was shown in the 2002 peer agency analysis. Researchers examined the most recent data available concerning MDT's rail, mover and bus fleets. Current MDT vehicles available for maximum service total 990, with MDT providing all maintenance needs for 891 of those 990 vehicles. MDT currently contracts with Penske Truck Leasing for maintenance of 99 buses. Table 6.4 details the allocation of the vehicles by division.

Table 6.4. Allocation of Vehicles by Division

	1986	*2004 Fleet*					*+/- %*
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%

Since 1986, MDT's rail fleet has more than doubled and the bus fleet, which MDT maintains, has grown by 41%. This significant growth in the fleet has been accompanied by a decline in the inventory value expressed in today's dollars. Even discounting the decline in buying power, inventory per rail vehicle has increased in excess of 75%, while inventory for buses has decreased at all garages by almost 50%, and has declined by 22% when the entire Central Warehouse inventory is charged to the bus division, as shown in Table 6.5.

The Materials Management Division operates on a fixed budget for inventory needs. Given that the nature of the vehicles served by the inventory is quite diverse, materials management must prioritize the expenditure of funds. Rail vehicles constitute a long-term 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 is currently underway to modernize those vehicles over the next five to six years.

Table 6.5. Inventory by Vehicle, 1986 versus 2004

Division	*1986*	*Vehicles*	*Inventory per Vehicle*	*2004[a] Actual $*	*Vehicles*	*Inventory 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	$12,300,264	633	$19,432	$23,190,052	891	$26,027	33.9%

[a] *as of June 30, 2004*

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 quite 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 rehabilitated, the inventory 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 require a mid-life overhaul 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 vehicle is almost $72,000, 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 obsolescence. However, 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 current bus fleet consists 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 is in the range of 5-6 years. The current inventory cost per bus is 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 22-47%.

A factor that can be used to assist in the evaluation of the inventory, which was identified in the literature review and discussed in the Blue Ribbon Task Force's Report, 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. The Blue Ribbon Task Force reported that MDT's turnover rate had fallen 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). Figure 6.4 provides a summary of turnover rates within MDT by division for from October 2003 through June 2004. While MDT does report turnover in their monthly report, they report turnover by division rather than by the agency as a whole.

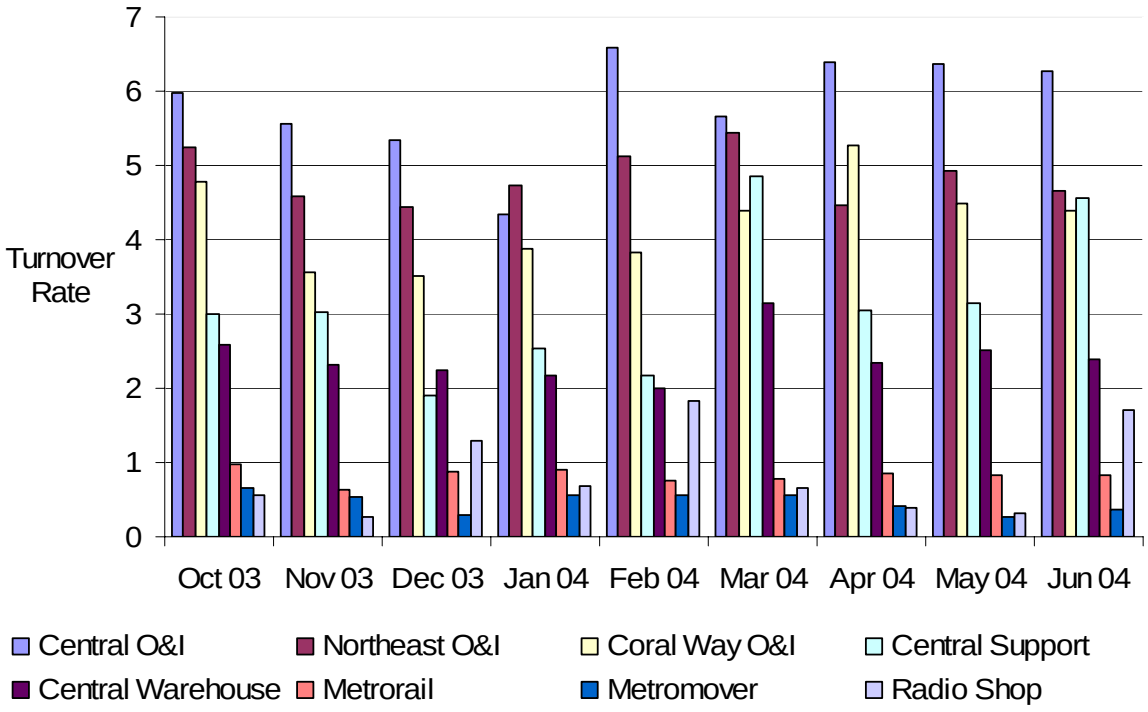

Figure 6.4. Turnover Rates by Division, October 2003-June 2004

Central O&I consistently reported the highest turnover rates and exceeded a turnover rate of 6 during 4 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 4 months of the reporting period. The Central Warehouse generally stayed within a turnover rate of 2-3. 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 is presented in Figure 6.5. 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 trend line confirms that the turn over rate is improving.

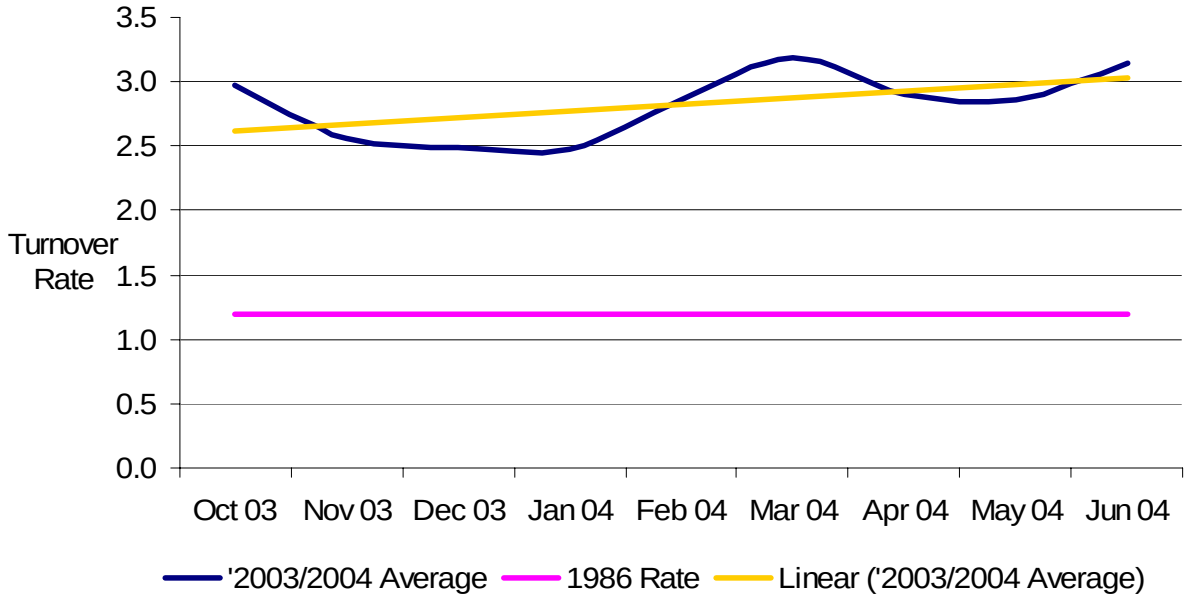

Figure 6.5. MDT Average Turnover Rate, October 2003-June 2004

So far this fiscal year, the average turnover rate has more than doubled the rate reported by the Blue Ribbon Task Force in 1986.

Findings from Inventory Analysis

- Since the Blue Ribbon Task Force Report, Rail, which includes Metrorail, Metromover and the Radio Shop, has almost doubled its percentage of the inventory allocation, from 34% to 64%, while Central Warehouse and the Bus Divisions fell to 24% and 12%, respectively.
- In terms of the value of the dollar, inventory growth has occurred only in the area of rail. All bus divisions and the Central Warehouse reflect a decline in value.
- The current inventory cost per rail vehicle is almost $72,000, while inventory costs per mover vehicle are approaching $131,000. Both costs are expected to increase in the near term.
- The current inventory cost per bus is 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 22-47%.
- Central O&I consistently reported the highest turnover rates and exceeded a turnover rate of 6 during 4 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 4 months of the reporting period. The Central Warehouse generally stayed within a turnover rate of 2-3. 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.
- So far this fiscal year, the average turnover rate has more than doubled the rate reported by the Blue Ribbon Task Force in 1986.

VII. Materials Management Performance Measures

A major task identified in this project was the development of a set of performance measures for presentation to the Oversight Committee. The performance measures were to incorporate the findings of the study and, at a minimum deal with "service critical" and "non-service critical" materials management outcomes. A set of benchmarks for the performance metrics were to be developed and a series of meetings were to be arranged to gain consensus between the Oversight Committee and executive management on appropriate measures of performance.

At the time of development of the scope of work for the project, Materials Management had yet to develop performance measures. During the course of the study, a county-wide strategic plan was implemented, and as part of that process, the Materials Management Division developed performance measures for Fiscal Years 2003 and 2004.

Given that Materials Management staff identified strategic initiatives that they viewed as being critical in their evaluation of the division's performance, the discussion of performance measures will begin with a review of the current measures.

Warehousing and Stores—Performance Measure 1

Strategic Area

Warehouse and Stores

Goal

Re-label 50% of the 98,265 bins with bar-coding labels to accompany new computerized Materials Management System by 9/30/2004; balance to be relabeled the following year

Objective

To increase efficiency and accuracy in the methodology of receiving, stocking, transferring and issuing spare parts and material throughout the seven (7) warehouse and storeroom locations within Miami Dade Transit by utilizing bar-coding and scanning technology

Performance Measures

			Target	
Location	***Line Items***	***Computer Hardware & Software Installed***	***Line Items Re-labeled 09/30/04***	***Line Items Re-labeled 09/30/05***
Central Warehouse	22,372	10/1/2003	11,186	11,186
Central O&I	11,561	10/1/2003	5,780	5,781
Northeast O&I	19,496	10/1/2003	9,748	9,748
Coral Way O&I	13,248	10/1/2003	6,624	6,624
Major Overhaul	12,780	10/1/2003	6,390	6,390
Metrorail	14,282	10/1/2003	7,141	7,141
Metromover	8,344	10/1/2003	4,172	4,172

As noted earlier, computerization and implementation of advanced technology is an identified best practice. In order to take full advantage of the new computerized system, bar code technology must be incorporated into the existing system.

Staff performance in re-labeling the bins is an excellent measure.

Warehousing and Stores—Performance Measure 2

Strategic Area

Warehouse and Stores

Goal

Maintain a 2½% vehicle down for parts ratio; accomplish by 9/30/04

Objective

To maximize storage capacity utilization through efficient stocking, retrieval and distribution methodology for the purpose of having available material at the right location when needed

Performance Measures

	Vehicle Down for Parts Ratio			
Month	***FY 00/01***	***FY 01/02***	***FY 02/03***	***FY 03/04***
Oct	2.33%	1.43%	2.36%	1.35%
Nov	2.69%	1.14%	2.22%	0.95%
Dec	2.18%	1.69%	1.90%	0.76%
Jan	2.09%	2.31%	1.85%	1.10%
Feb	1.18%	1.45%	2.43%	1.27%
Mar	1.49%	1.12%	2.08%	2.06%
Apr	1.37%	1.30%	1.27%	1.71%
May	1.24%	1.48%	1.29%	1.37%
Jun	1.10%	1.86%	1.33%	1.81%
Jul	1.34%	1.84%	1.64%	
Aug	0.92%	1.51%	1.91%	
Sep	1.44%	2.02%	1.60%	

FY03/04 Target = <2.5%

On the surface this appears to be an appropriate performance measure; however, researchers have two significant concerns. The first concern centers on the fact that this goal appears to have been achieved at rate lower than 2½% since November 2000. A performance measure should be a stretch not the norm. If the performance measure is to be retained, the rate of 2½% needs to be re-evaluated.

The second concern centers on coordination of performance targets with Bus Maintenance to ensure that efforts to improve performance are meaningful.

Warranty Administration—Performance Measure 1

Strategic Area

Warranty Administration

Goal

To maximize the level of supplies/manufacturer's compensation received by Miami Dade Transit through the timely replacement, remedy, or repair of all goods, parts and services determined to be defective in accordance with contract provisions

Objective

To collect all necessary reimbursement of warranty related expenses incurred by Miami Dade Transit associated with the repair, removal, replacement, processing, transportation or storage of defective items covered under warranty

Tasks/Activities

1. Provide the basis for rapid, accurate and documental billing of suppliers/manufacturer
2. Establish and maintain records on warranty cost performance and component history
3. Collect the necessary information in sufficient detail and quality to establish suppliers' responsibility for goods, parts and services
4. Monitor reliability, vendor's performance, quality improvements, systems and equipment failures covered under warranty
5. Provide timely reports of monthly and yearly warranty activity

Performance Measures

Fiscal Year	*Claims Submitted*	*$ Value Submitted Claims*	*Claims Honored*	*% Honored*	*$ Value Honored Claims*	*% $ Honored*	*Claims Denied*	*$ Value Claims Denied*
1999/2000	637	$776,571	445	69.9%	$604,240	77.8%	132	$69,718
2000/2001	605	$1,181,382	486	80.3%	$1,036,727	87.8%	97	$76,990
2001/2002	537	$1,159,830	449	83.6%	$1,084,511	93.5%	32	$25,253
2002/2003	421	$898,600	331	78.6%	$814,036	90.6%	24	$10,917
2003/2004[a]	859	$1,096,224	703	81.8%	$1,042,688	95.1%	4	$1,799

[a] *Reflects October 2003 through June 2004*

In 1986, the Blue Ribbon Task Force acknowledged the Material Management Division's outstanding work in this area. A three-person warranty administration unit had been formed in 1985 to recover warranty claims, and, in less than a year, had

already successfully collected over $400,000. Based on the data collected to date, the four-person warranty administration unit of today continues on a successful track, and its efforts return over a million dollars each year to MDT.

Warranty Administration within the Materials Management Division probably will experience some difficulty in establishing improvement targets for future performance due to the high level at which they are currently performing; nonetheless, it is critical that performance targets be established to ensure continued improvement.

Inventory—Performance Measure 1

Strategic Area

Inventory

Goal

Reduce vendor backorders from an average of 90 days to a 45-day margin

Objective

To improve the delivery of materials and supplies needed to support all maintenance of vehicles, communications, and facilities within MDT

Tasks/Activities

1. Provide vendors with a listing of all pending orders over 30 days with a specified date to return a status report
2. Review status of vendors responses
3. Contact vendors that do not respond to initial request
4. Update data in computerized system

Performance Measures

July 2003 – Provide pending order list to approximately 250 vendors
August 2003 – Review vendor responses and update computerized inventory system
September 2003 – Contact vendors that do not respond to initial request
October-December 2003 – Continue review of vendor responses and update computerized inventory system
December 2003 – Ensure there are no orders over the 45-day margin

While this is an excellent goal, the action designed to improve performance focus on vendor contact rather than on the actual reduction of backorders.

Procurement—Performance Measure 1

Strategic Area

Procurement

Goal

Develop a real-time report of Procurement requisitions

Objective

Improve workload distribution and evaluate employees

Tasks/Activities

1. Produce a bi-weekly report of requisitions completed by type for each Buyer
2. Review and make adjustment to workload and evaluate staffing requirements

Performance Measures

August 2003 – Meet with ITS to determine Report format and fields of information
October 2003 – Prepare first draft
October 2003 – Make changes to include new Inventory Control System
January 2004 – Publish report and distribute to staff and manager

This goal appears to be the first step in establishing performance measures for procurement personnel. It appears to be a good first step.

References

1. Public Transportation Blue Ribbon Task Force. *Report to the Metropolitan Dade County Board of County Commissioners.* May 16, 1986.

2. Transit Cooperative Research Program. *Revised Inventory Management Desk Guide*, Research Results Digest No. 40, October 2000.

3. Mitretek Systems and TransTech Management, Inc. *TCRP Report 84: e-Transit: Electronic Business Strategies for Public Transportation Vol. 1, Supply Chain: Parts and Inventory Management*. TRB, Washington DC, 2002

4. Gillespie, Greg. *Various Technologies at Work on the Chain Gang; Use of the Internet, hand-helds and more sophisticated trucking systems are emerging trends in supply chain management*. Health Data Management, Vol 12, No. 1, January 2004, p. 42.

5. Abrams, E., Hide, H., Ho, L., McKnight, C., O'Sullivan, J., Price, J., Schiavone, J., Stark, S., and Venezia, F. *Transit Fleet Maintenance*. Report A3C02: Committee of Transit Fleet Maintenance.

6. Ames, Benjamin B. *Outsourcing for better lift truck fleet management; substantial savings are the bottom line*. *Modern Materials Handling*, Features, Management, Warehousing Management Edition, p.40w5.

7. Brown, P. *Managing Military Inventory*. Inventory Management, Vol IX, No. 3, p. 36, April 2003.

8. Draycott Consulting, Inc. and The Michael Kilpatrick Consulting Group. *Applications for Improved Inventory Management for Public Transit Systems*. In TCRP Web Document 17 (Project E-3A): Contractor's Final Report, TCRP, TRB, National Research Council, January 2001.

9. Federal Transit Administration. *Transit Cooperative Research Program: TCRP Synthesis 22: Monitoring Bus Maintenance Performance, A Synthesis of Transit Practice.* Washington, DC 1997.

10. United States General Accounting Office, *Defense Inventory Management: Expanding Use of Best Practices for Hardware Items can Reduce Logistics Costs*. Washington DC, January 1998.

11. United States General Accounting Office, Report to the Chairman, Subcommittee on Oversight of Government Management, Committee on Governmental Affairs, U.S. Senate. *Commercial Practices: DOD Could Save Millions by Reducing Maintenance and Repair Inventories,* June 1993

12. United States General Accounting Office, *Executive Guide: Best Practices in Achieving Consistent, Accurate Physical Counts of Inventory and Related Property*. Washington DC, March 2002.

13. United States General Accounting Office, Report to Congressional Committees, Inventory Management:: *DOD Can Build on Progress by using Best Practices for Reparable Parts*, February 1998.

14. American Public Transportation Association. *2003 Transit Vehicle Database (Excel version)*. Washington, D.C. June 2003.